MADISON-MORGAN CONSERVANCY

P.O. Box 752
Madison, GA 30650
Phone: 706-342-9252
Email: info@mmcgeorgia.org
Online: mmcgeorgia.org

Madison-Morgan Conservancy Development Review Report

To: Morgan County Planning Commission
Morgan County Board of Commissioners
City Councils of Bostwick, Buckhead, Madison, and Rutledge

From: The Madison-Morgan Conservancy

Re: Banks Farm Application for Rezoning

Date: March 29, 2010

Application Information

Application #: 2010.4.A

Name of Applicant: *Jefferson Lamar Banks and JCLL Partners, LP*

Current Use of Property:	*Agricultural*	Current Zoning of Property:	*AR*
Proposed Use of Property:	*Landfill*	Proposed Zoning of Property:	*I-2*

Introduction

On behalf of the Board of Directors of the Madison-Morgan Conservancy, we thank you for the opportunity to comment on the above referenced application for rezoning. The purpose of this report is to set forth for Planning Commission Members and the Board of Commissioners important information and authoritative resources worthy of consideration in the process of evaluating the above referenced application. When reading this report, it is important to take note of the endnotes and attached reference material, which account for the length of the document.

The mission of the Madison-Morgan Conservancy is to provide public education on conservation matters and to protect and enhance the heritage and quality of life of the residents of Morgan County by preserving historic sites, greenspace, farmland and timberland. In an effort to meet our mission, the Conservancy has formed a Development Review Committee (DRC) to serve as a resource to the county and municipal planning departments. The DRC is made up of ten of the Conservancy's almost 400 members and includes two real estate lawyers, a real estate broker, a real estate developer, a cattleman/business owner, an ex-Planning Commission member, two foresters, a horseman, and a land conservationist.

On February 19th, 2010, the Madison-Morgan Conservancy's DRC, as a part of its formal process, invited the applicant to meet with the DRC on March 1, 2010. The DRC's invitation was declined on February 23rd, 2010; therefore, the DRC met on March 1, 2010, to review the application without the applicant.

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The DRC reported to the Conservancy Board of Directors on March 8, 2010, about their March 1 review of the above mentioned application. The following recommendations are a result of the DRC's and Board of Directors' careful review of the application and include the following six considerations:

1. General Landfill Siting Issues
2. Demand for Landfill Space Regionally
3. Potential Site-Specific Environmental Issues
4. Technological Issues
5. Long Range Planning and Economic Development Issues
6. Property Values and the Stigma Effect

The need for Morgan County to have a functional and cost effective waste management plan is recognized. We are of the opinion that Morgan County's current landfill ordinance is sufficient to meet our county's waste disposal needs. Even if there were a need for additional waste management capacity, the development of a landfill on the subject property would not be in the best interest of the county.

After careful study of the subject property and its issues, the Conservancy presents this analysis to be used in your consideration of the rezoning application referenced above.

1. General Landfill Siting Issues

Communities across the country are faced with doing business with a burgeoning multi-million dollar waste management industry in their effort to site landfills. The siting process is usually contentious, filled with citizen resistance and legal battles, and is often very costly for the host county or municipality. Morgan County finds itself in this situation, but we are not alone, and we can learn from other communities' experiences.

There is a proliferation of landfills in the South, which are usually sited in rural counties with relatively low land prices, on parcels owned wholly by one landowner as to avoid multiple landowners' resistance. "In 2008, the [average] tipping fees posted at the gate were $35.15 per ton of waste for MSW landfills and $23.72 for C&D landfills in Georgia – half as much as tipping fees in some Northeastern and Mid-Atlantic states."[ii] In fact, "Georgia ranks tenth of all fifty states for the highest number of active municipal landfills."[iii]

The waste management industry may see this site in Morgan County as standard and optimal for a landfill for the following reasons: relatively low land prices (relative to national land prices), rural county (outside Metropolitan Atlanta), sizeable acreage owned by one owner (potentially approximately 1,500 acres total), opportunity for expansion in the future, rail access, interstate access, state and county road access, proximity to utilities, and an existing landowner willing to champion their cause in return for a significant financial gain.

Aspects of the subject site that make it unsuitable for a landfill are: the general unsuitability of the site in relation to surrounding agricultural and residential uses, the existence of numerous aquatic resources (the confluence of two major streams and the resulting wetlands and floodplain in addition to groundwater resources), the proximity of the site to one of the State's most heralded historic sites (City of Madison's Historic District), the proximity to one of the State's most visited heritage tourism sites (City of Madison and surrounding Morgan County), the relatively high value of adjacent and nearby properties, and the proposed future land use of the site as a megasite/I-3[iv]. The waste management industry is not necessarily interested in these aspects of the site, and is probably unaware of the unsuitability of the site based on these factors; they are simply depending on the applicant to acquire the rights/zoning to build a landfill, so that the site is then primed for their construction and management of that landfill.

2. Demand for Landfill Space Regionally

It is difficult to determine the real demand for waste management in our region due to the changing dynamics of waste management technology, expansions of existing landfills, the potential reductions in waste through recycling and source reduction programs, and population growth. This moving target is best reached by assessing the current capacity of existing waste management facilities and projecting reasonable expectations in recycling and source reduction programs. We submit the following for your consideration:

- Georgia ranks tenth of all fifty states for the highest number of active municipal landfills.[v]
- Currently, Morgan County hauls the county's municipal solid waste to the Oak Grove Landfill in Barrow County, a landfill with over ten years of capacity.
- Oak Grove Landfill has recently expanded its capacity, which has added ten additional years to its projected lifetime.
- Elbert County approved a waste-to-energy facility/incinerator in February, 2010, which will dispose of 1,000 tons of trash per day.[vi]
- Morgan County's recycling efforts have begun and could dramatically decrease the amount of solid waste the county produces.
    - Morgan County saw an increase in recycling of 12% from FY08 to FY09 and recycled 288.11 tons or 2.9% of its garbage in FY09. The EPA's national goal for municipal recycling is 35%, and as much as 80% of household waste can be recycled.[vii]
- Source reduction efforts and/or composting efforts have not yet begun, which could reduce even further the amount of waste generated in the county.
- If the county saw the need to build a landfill to dispose of its own trash, the current landfill ordinance would be sufficient, and variances to height, size, buffers, and hours of operation would not be required.[viii]

3. POTENTIAL SITE-SPECIFIC ENVIRONMENTAL IMPACTS

According to research, the myriad of environmental issues that result from landfills include potential contamination of both groundwater and surface water supplies, which creates public health and economic burdens on the local government; noxious odors emanating from the site; interruption of riparian and, therefore, wildlife corridors; increased air pollution; risks of disposal of hazardous waste; increased litter and trash along the roads; methane and volatile organic compounds (VOC) migration, creating public health hazards, explosions, and toxicity to plants; fire; illegal roadside dumping near landfills; truck traffic; noise; dust and wind-blown litter; vultures, ticks, mosquitoes, rodents, and other insects and birds; potential condemnation of adjacent property for future landfill-related land use; decrease in property values; and impaired views.[ix]

The subject site for the proposed landfill is an unsuitable site for any size or type of landfill for a variety of reasons and has the potential to create the following significant site-specific environmental impacts:

- ❑ The application includes mention of plans for a Construction and Demolition (C&D) landfill on the premises. Currently, there are no federal regulations for C&D Landfills, and the State of Georgia does not require a liner for C&D Landfills, yet the waste that goes into a C&D landfill is largely unregulated and many construction materials, such as leftover paint, adhesives, grease, and batteries, are toxic.[x]
    - o Newton County (in its county-owned landfill) has discontinued disposing of C&D waste in its C&D portion of its landfill and has begun disposing of C&D waste in its MSW landfill that has a liner.[xi]
- ❑ Groundwater and surface water contamination from landfills is well documented.[xii] Little Indian Creek feeds Eatonton-Putnam drinking water supply downstream.
    - o Groundwater contamination has occurred at the Morgan County landfill on Hwy 441. Now closed, this landfill is responsible for an ever-growing plume of groundwater contamination.
    - o If water contamination occurs at the subject site, the impact could be catastrophic. The county would have to, in essence, rescue landowners by either running water lines to all contaminated areas or purchasing surrounding properties. Not only costly for the county, the impact on the agricultural industry in the area would make it cost prohibitive to irrigate and would ruin those agricultural enterprises.
    - o The subject site is near two groundwater recharge areas:
        - ▪ The largest Groundwater Recharge Area in the county, which encompasses the City of Rutledge, is approximately one mile to the west from the subject site.

- The Groundwater Recharge Area that encompasses part of the City of Madison is approximately two miles to the north from the subject site.

- ❑ The subject site lies at the confluence of two major streams (Four Mile Branch and Little Indian Creek). Given the sensitive nature of aquatic ecosystems, this type of land use could critically damage that ecosystem.
  - o The stream buffer included in the application is not sufficient to absorb the impact of the landfill and filter the water before it enters the stream; therefore, on-site and downstream communities (plant, animal, and human) would be negatively affected.
- ❑ A landfill on the subject site would put Little Indian Creek at serious risk of long term and possibly irreversible contamination.
  - o Little Indian Creek is already classified as "impaired" and is listed on Georgia's 303(d) list (waters not meeting their designated use because of contamination).[xiii]
  - o Additionally, in 2009, the municipal water treatment facility was built and began discharging effluent into Little Indian Creek, posing even more risk to the stream's 303(d) rating. Adding water contamination from a landfill to the list of contaminants already present in this stream would solidify its contaminated nature for decades.

4. TECHNOLOGICAL ISSUES

The proposed landfill utilizes the "Containment Approach" of storing waste. This approach includes using liners to control the leaching of waste into the ground (leachate), and capping the landfill daily with soil to keep rainwater out of the landfill (to reduce the amount of leachate produced). The fundamental flaw in the strategy is that this dry storage of waste inhibits the degradation of the waste and prolongs its stabilization into an inert state. In essence, this type of waste management is simply storing trash rather than disposing of trash. The technical issues that arise from this type of storage of waste include but are not limited to:[xiv]

- ❑ The questionable durability of artificial and clay liner systems
  - o Stabilization of waste to an inert state has not occurred in most landfills 20 years after completion and capping, creating an environment within the landfill where leachate continues to exist.[xv]
  - o The corrosive effect of leachate, especially under the extreme temperatures caused by the storage of trash, is extremely uncertain, making the durability of the synthetic liners uncertain.[xvi]
  - o Improper installation of the synthetic liners and careless dumping practices allowing leachate to penetrate down to groundwater resources are causes of liner damage and therefore groundwater contamination.[xvii]
  - o Regardless of installation, dumping practices, and liner imperfections, and while leachate leakage may be minimal at first, it is the long-term durability

of the liner system over periods of tens, maybe hundreds, of years, under conditions that are ultimately unpredictable, that leaves ground for concern.[xviii]

- ❑ Unsuitability of Sites
  - o Most sites do not include an underlying geological barrier to control leachate migration in order to give secondary protection to the groundwater in the event of liner failure.[xix]
- ❑ Impact of waste degradation rates
  - o The prevention of rainwater infiltration, designed to minimize the production of leachate, leads to the generation of a highly concentrated toxic leachate, which in contact with the artificial membrane over a long period of time, may have an extremely corrosive effect on the membrane, leading to its degradation.[xx]
- ❑ Aftercare
  - o Landfill operators are responsible for the landfill for as long as the waste is active and has a potential to cause pollution. A long-term, largely unpredictable, maintenance and monitoring scenario then exists for the landfill operator, the bond company, and the local government, should one of the former be unable to perform its duties.[xxi]
- ❑ Financial and social costs
  - o It has become uneconomic to develop small landfills, and the trend is now towards developing superdumps serving large catchment areas.[xxii]
  - o The loss of social harmony within communities confronted by the prospect of a superdump in their backyard is a cost that cannot be quantified.[xxiii]
- ❑ Failure of this generation to deal with its waste
  - o A fundamental consequence of encapsulating landfill waste and significantly reducing the degradation rate, is that this generation's waste will still be active and posing problems certainly for the next generation, and even perhaps for several future generations.[xxiv]

Alternative waste management technologies exist that dispose of 60% more waste than the containment landfill technology allows. These technologies are being implemented more often and include, but are not limited to:

- ❑ Waste-to-Energy Biomass Facilities/Incinerators
  - o Elbert County, GA, has recently approved the construction of a waste-to-energy incinerator, which will incinerate up to 1,000 tons of trash, wood waste, and sewage sludge per day.[xxv]
  - o The byproduct of this incineration process is electricity (enough to power at least 35,000 homes) and ash that is stored in the adjacent landfill.[xxvi]
- ❑ Geoplasma
  - o St. Lucie County, Florida is implementing geoplasma technology, and predicts that in addition to vaporizing 3,000 tons of waste per day, the geoplasma facility will vaporize all the waste stored in their MSW landfills (4.3 million tons of trash collected since 1978) in 18 years.[xxvii]

- Geoplasma technology has higher implementation costs than the containment landfill technology, but significantly lower operating costs.
- Salable solid residues are produced from geoplasma technology (gravel, sand, aggregate for concrete, asphalt and concrete pavers).
- Geoplasma disposal fees are cost-competitive with landfill tipping fees throughout most of the U.S.
- The need for landfills is eliminated if using geoplasma technology.
- Mike Ellis, graduate of Morgan County High School, VP of Geoplasma, can be reached via www.geoplasma.com.[xxviii]

5. LONG-RANGE PLANNING AND ECONOMIC DEVELOPMENT ISSUES

Chapter 29.3 of the Morgan County Zoning Ordinance, section 29.3.1, sets forth seven standards governing the exercise of the Board of Commissioners' zoning power. We have the following comments on each standard.

CHAPTER 29.3 CRITERIA FOR CONSIDERING ZONING AMENDMENTS[xxix]

Section 29.3.1 Required Findings for Zoning Map Approval. The following standards governing the exercise of the Board of Commissioners' zoning power are adopted in accordance with O.C.G.A. §36-66-5(b), as amended, to be used by the Director, Planning Commission and the Board of Commissioners in reviewing, recommending, and acting upon applications for map amendments for approval, conditional approval, or disapproval as appropriate so as to balancing the interest of the public health, safety or general welfare against the unrestricted use of property:

***(a) Compatibility with Adjacent Uses and Districts**: Existing uses and use districts of surrounding and nearby properties, whether the proposed use district is suitable in light of such existing uses and use districts of surrounding and nearby properties, and whether the proposal will adversely affect the existing use or usability of adjacent or nearby properties.*

- ❑ The subject property is adjacent to agricultural and residential uses. A landfill is not compatible with such uses.
  - There will be a reduction in the value of property in the general area of a landfill and a resulting loss of property tax revenue (see Section 6 Property Value and the Stigma Effect for specifics and references to resource material).
  - Noise, odor, truck traffic, and increased rodents, would negatively affect the general activities required by adjacent and nearby agricultural and residential uses.
- ❑ Nearby uses include commercial, light industrial, residential and mostly agricultural uses.
  - There exists a real risk of losing future industrial enterprises near the subject property if a landfill is sited in the area. In a letter dated February

23, 2010, from Stone Mountain Industrial Park, Inc. Mr. Rusty McKellar requests the BOC "consider the long term impact of the proposed landfill on the economic viability of the area"[xxx] and goes on to describe the industrial park that is at risk:

- 324 acres for construction of first class light industrial park
- 2,500,000 square feet of space
- total investment of $200,000,000
- will employ at least 500 people
- would produce $1,600,000 annually in real and personal property taxes

  - Exit 114 on I-20 is the site of many businesses, hotels, and restaurants that would be negatively impacted by odors, litter-strewn roads, and the general stigma of a landfill.

- ❑ Nearby uses include Heritage Tourism (City of Madison) within 1.5 mile.
  - A landfill would negatively impact the heritage tourism industry in Madison and Morgan County, which generates a total of $5.76 million annually.[xxxi]

(b) ***Property Value****: The existing value of the property contained in the petition under the existing use district classification, the extent to which the property value of the subject property is diminished by the existing use district classification, and whether the subject property has a reasonable economic use under the current use district.*

- ❑ Agriculture is Morgan County's largest industry, and given that the subject property is zoned Agricultural Residential and agricultural uses are permitted on the property, it is safe to conclude that the value of the property under the existing use classification is not diminished and that the subject property has a reasonable economic use as Agriculture. Additionally adjacent properties are successfully being used as agricultural and residential.
- ❑ Despite the claim in the application that the "subject property does not have reasonable economic use under its current AR zoning classification," the applicants have been successful in selling land adjacent to and nearby the subject property over the last ten years. Examples of such sales include but are not limited to:
  - Banks sold Parcel 046109 to City of Madison on 5/12/05 (12.202 acres for a total of $183,030 equaling $15,000 per acre).
  - Banks sold Parcel # 047001A to Elizabeth Pattillo Parker on 7/10/08 (94.275 acres for a total of $472,000 equaling $5,007 per acre)
  - Banks sold Parcel # 047001A to REES 667, LLC on 7/10/08 (242.237 acres for a total of $3,738,202 equaling $15,342 per acre)

(c) ***Suitability****: The suitability of the subject property under the existing use district classification, and the suitability of the subject property under the proposed use district classification of the property.*

- ❑ When comparing the suitability of the subject property as Agricultural Residential (current use) and as a landfill (proposed use), the current use is more suitable for the area than the proposed use.

(d) ***Vacancy and Marketing:*** *The length of time the property has been vacant or unused as currently used under the current use district classification; and any efforts taken by the property owner(s) to use the property or sell the property under the existing use district classification.*

- ❑ The applicants have been successful in selling land adjacent to and nearby the subject property over the last ten years. Examples of such sales include but are not limited to:
  - Banks sold Parcel 046109 to City of Madison on 5/12/05 (12.202 acres for a total of $183,030 equaling $15,000 per acre)[xxxii]
  - Banks sold Parcel # 047001A to Elizabeth Pattillo Parker on 7/10/08 (94.275 acres for a total of $472,000 equaling $5,007 per acre)[xxxiii]
  - Banks sold Parcel # 047001A to REES 667, LLC on 7/10/08 (242.237 acres for a total of $3,738,202 equaling $15,342 per acre)[xxxiv]
- ❑ Despite the applicant's claim of marketing the property through the Georgia Readiness for Accelerated Development (GRAD) program, the subject property has never been marketed through the GRAD program. According to GRAD officials, the property does not meet at least one of the criteria for marketing: "an industrial zoning designation is an absolute requirement for GRAD application."[xxxv] The subject property does not have (nor has it ever had) that industrial zoning designation.

(e) ***Evidence of Need:*** *The amount of undeveloped land in the general area affected which has the same use district classification as the map change requested. It shall be the duty of the applicant to carry the burden of proof that the proposed application promotes public health, safety, morality or general welfare.*

- ❑ When assessing Morgan County's current zoning map and future land use map, it appears that there are many areas designated for existing or potential I-2 zoning. Morgan County has not excluded the opportunity for this type of requested land use.
- ❑ The applicant's duty to "carry the burden of proof that the proposed application promotes public health, safety, morality or general welfare" has not been performed through the submission of this application. Deficiencies include: the reference to the suitability of a site in Madison County (not Morgan) for this proposed landfill; the inclusion of photos of buffers that do not depict current conditions; and the assertion that the property had been marketed through the GRAD program which is inconsistent with reports from GRAD.

(f) ***Public Facilities Impacts:*** *Whether the proposal will result in a use, which will or could cause an excessive or burdensome use of existing streets, transportation facilities, utilities,*

schools, parks, or other public facilities and services.

- ❑ The applicant's transportation plan shows that the intersection of Hwy 441 and Pierce Dairy Road will fail under the projected increase in truck traffic.[xxxvi]
- ❑ In addition to a general increased burden on road infrastructure from an increase in heavy truck traffic (projected approximately 148 vehicles per day and 296 trips per day, the majority being transfer trucks/traffic trailers)[xxxvii], the proposed landfill would require:
    - Redesigning at least three intersections in order to accommodate the turning radii of large trucks:
        - 1) Hwy 441 and Indian Creek Road
        - 2) Aqua Road and Indian Creek Road
        - 3) Aqua Road and Pierce Dairy Road
    - Widening Indian Creek Road, which may include condemnation of property adjacent property
    - Building a new bridge on Indian Creek Road
    - Building a railroad overpass or underpass on Indian Creek Road
    - Installing traffic signals at a minimum of one intersection
    - Increasing roadside trash clean up

(g) ***Consistency with Comprehensive Plan****: Whether the proposal is in conformity with the policy and intent of the locally adopted comprehensive plan.*

- ❑ Comprehensive Plan includes many goals and objectives to create a sense of place in which residents and businesses would like to locate, none of which call for a landfill.
- ❑ Landfill will negatively impact heritage tourism, local agricultural industry, a number of historic resources, two major riparian resources, and the general quality of life, all of which are important resources to protect, according to the Comprehensive Plan.
- ❑ The Comprehensive Plan includes the Morgan County Greenprint, and provides goals and objectives for the protection of many resources. None of those goals and objectives call for developing a landfill. On the contrary, the landfill would negatively impact many resources listed on the Greenprint in addition to many more natural, agricultural, and historic resources that are not listed on the Greenprint.
    - Resources that will be negatively affected include (note: these sites are listed here as they are listed in the Greenprint, and the underlined portion of each item is what would be affected):[xxxviii]
        - *3. Scenic Highway - 83 from Jasper County to I-20.*
        - *4. Scenic Gateway to Madison - Highway 83 from I-20 to downtown Madison.*
        - *13. Potential scenic corridors 83, 441, 278, I-20, Old Dixie.*
        - *14 Proposed path following creek corridors.*
        - *18. Scenic Road - Pierce Dairy Road.*

- *28. Scenic view.*
- *33. Old Pierce Dairy Barn, recently restored, represents an opportunity as a historic site.*
- *40. Old farmstead, Old Crew Place. (#23)*
- *48. Historic home circa 1850's. (#16) Wood Veterinary Clinic*
- *Developing Community Node of Madison Lakes*
- *Exit 113, I-20 Gateway into Morgan County*
- *Exit 114, I-20 Gateway into Morgan County*

- ❑ The Morgan County Future Land Use Map (FLUM) sites I-3 zoning as the preferred future zoning on the subject property. The I-3 zoning classification was created specifically for a "Megasite" which is designed for medium to large businesses with a large workforce that will significantly support the tax base. Megasites are usually in close proximity to a significant workforce and have access to rail and other transportation networks. Morgan County's Megasite is one of the top five such sites in the state.
  - o The zoning ordinance states the purpose and intent of the megasite as: "The intent of the district is to achieve development which is consistent with the land use goals of Morgan County, to provide for a review process which facilitates the development of new sites allowing for the flexibility to achieve the best possible development, both in terms of achieving the site's economic development potential and in terms of protecting and enhancing the quality of life of the citizens of Morgan County."[xxxix]
  - o To site a landfill in the middle of this potential megasite would eliminate Morgan County's chance to recruit a business or collection of businesses that would be appropriate to site in the megasite and that would significantly contribute to the tax base and to the employment base.

(h) ***Other Conditions****. Whether there are any other existing or changing conditions affecting the use and development of the property that give supporting grounds for either approval or disapproval of the proposal.*

Other conditions which exist include, but are not limited to:

- ❑ Impact on future development
  - o Future development which would be beneficial to Morgan County's tax base and employment base would not locate near this proposed landfill is at risk of not being developed (see ***(a) Compatibility with Adjacent Uses and Districts*** above).
- ❑ Community Opinion
  - o There is an overwhelming, almost unanimous, consensus by Morgan County residents that the proposed landfill is not in the best interest of their health, safety, and general welfare.
- ❑ Buffering of proposed boundaries
  - o The applicant has submitted information in the application that qualifies existing buffers/boundaries as opaque; upon investigation it has been found

that many of those buffers have recently been timbered and are less than opaque.

- The applicant has submitted information through other channels that state a reduction in buffers would be requested in the future conditional use permitting phase. The reduction of buffers would be inappropriate, and we submit that an increase in buffers would be necessary to protect the public from noise and water quality contamination.

6. Property Values and the Stigma Effect

Due to the controversial nature of landfills, many appraisals have been conducted to assess the impact of the development of a landfill on property values. Although the majority of the appraisals show that the development of a landfill will decrease property values, the waste management industry consistently cites one of just a few appraisals that show the opposite. We have included in our attached reference material a review of those appraisals in order to shed light on the different outcomes ("Evaluating the Potential Impact of a Proposed Landfill" by Shawn E. Wilson, MAI).[xl] The research shows the following:

- "The values of individual properties are determined to some degree by the reputation of the area where they are located. The association of properties with hazardous, noxious, or repugnant conditions, including perceptions of health and environmental risks, can adversely impact values."[xli]
- "Local governments will be less affected by the presence of certain environmental factors than are homeowners in the short run; that is, the external costs of certain disamenities are internalized more by individual property owners than by local taxes. On the other hand, we demonstrate the interrelationship of property values and property taxes. The presence of a public bad [or disamenity] in a community may therefore undermine the tax base in the long run by lowering property values."[xlii]
- "Waste disposal and management sites are among the most stigmatizing land uses."[xliii]
- "Authors link 'the landfill with a stigma effect of public opinion about the desirability of housing and property' nearby. They estimate the resulting loss in property value to be 8%-10%."[xliv]
- After a study concluded that there was a 6%-12% reduction in property value within two miles of a landfill, the author states that "given a choice between two sites offered for the same price and identical in every respect, except that one is closer to a landfill, home buyers will choose the site that is farther away."[xlv]
- In addition to these appraisals and studies, and given the burgeoning local foods market in Georgia (and in the country), we see the potential for this stigma effect to inhibit our farmers' ability to sell their products at a competitive price. The perception that their products might be tainted or contaminated would be enough to render their business untenable.

CONCLUSION

Chapter 1.1 of the Morgan County Zoning Ordinance states "This ordinance is for the purpose of setting forth standards and permissible uses designed to conserve and protect the natural, economic and scenic resources of Morgan County, the County's health, aesthetics, morals, convenience, order, prosperity and general welfare; to provide adequate light and air; to protect natural resources; to prevent the overcrowding of land; to promote desirable living conditions and stability of neighborhoods; to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other public requirements by dividing the unincorporated areas of Morgan County into districts of such size and shapes as may be best suited to carry out the purposes of the legislative act and of this ordinance."[xlvi]

After careful consideration of the purpose and intent of our zoning ordinance and the above information, the Madison-Morgan Conservancy sees that the cons greatly outweigh the pros of developing a landfill on the subject site. We, therefore, respectfully request that the Planning Commission recommend denial of the applicant's rezoning application and that the Board of Commissioners deny said rezoning application.

[i] Madison-Morgan Conservancy Development Review Committee Mission, Goals, Objectives, and Policy.
[ii] http://www.gavoters.com/documents/ReduceandBetterManageSolidWaste.pdf.
[iii] Ibid.
[iv] Morgan County Zoning Ordinance, Chapter 9.3 Large Site Industrial Zoning District (I-3) (Megasite).
[v] http://www.gavoters.com/documents/ReduceandBetterManageSolidWaste.pdf.
[vi] Joe Vanhoose, Athens Banner Herald. "Elbert Co. signs off on energy plant." Online Athens, February 9, 2010. http://onlineathens.com/stories/020910/new_560302040.shtml.
[vii] Data from Morgan County and Keep Morgan County Beautiful.
[viii] Morgan County Zoning Ordinance, Chapter 15.14 Landfills.
[ix] G. Fred Lee, PhD, PE, BCEE and Anne Jones-Lee, PhD, "Guidance on the Evaluation of the Potential Impacts of a Proposed Landfill." October, 2008.
[x] GA Department of Natural Resources, Environmental Protection, Solid Waste Management, 391-3-4-.07 Landfill Design and Operations. Amended. http://rules.sos.state.ga.us/docs/391/3/4/07.pdf.
[xi] Phone conversation with John Middleton, Administrative Officer, Newton County Board of Commissioners.
[xii] Shao-gang Dong, Zhong-hua Tang, Bai-wei Liu. "Numerical modeling of the environment impact of landfill leachate leakage on groundwater quality – A field application. July 4, 2009.
[xiii] Georgia Environmental Protection Division list of 2010 303(d) Streams, page 83, http://www.gaepd.org/Files_PDF/305b/Y2010_303d/Y2010_Streams_DRAFT.pdf, and Description of the 305(b) and 303(d) List of Waters, http://www.gaepd.org/Files_PDF/305b/Y2010_303d/Description_of_305b_303d_List_Y2010.pdf
[xiv] A. Allen. "Containment landfills: the myth of sustainability." April 16, 2000.
[xv] Ibid.
[xvi] Ibid.
[xvii] Ibid.
[xviii] Ibid.
[xix] Ibid.
[xx] Ibid.
[xxi] Ibid.
[xxii] Ibid.
[xxiii] Ibid.
[xxiv] Ibid.
[xxv] Joe Vanhoose, Athens Banner Herald. "Elbert Co. signs off on energy plant." Online Athens, February 9, 2010. http://onlineathens.com/stories/020910/new_560302040.shtml.
[xxvi] The Flagpole Company. "Elbert County Considers Controversial Waste-to-Energy Plant." January, 20, 2010.
[xxvii] USAToday.com. "Florida county plans to vaporize landfill trash." September 9, 2006.
[xxviii] Letter dated January 17, 2007 from Mr. Mike Ellis to Mrs. Mary McCauley.
[xxix] Morgan County Zoning Ordinance, Chapter 29.3 Criteria for Considering Zoning Amendments.
[xxx] Letter dated February 23, 2010, from Rusty McKellar (Stone Mountain Industrial Park, Inc.) to Commissioner Ellen Warren.
[xxxi] Heritage Tourism Calculation via Madison-Morgan Chamber of Commerce.
[xxxii] Morgan County, GA, Public GIS Portal and Deed Book 374 Page 115. http://morgan.binarybus.com/lookup/property_card.asp?cmd=SHOWPARCEL&PID=046%20%20%20%20109%20A

[xxxiii] Morgan County, GA, Public GIS Portal and Deed Book 451 Page 1006. http://morgan.binarybus.com/lookup/property_card.asp?cmd=SHOWPARCEL&PID=047%20%20%20%20001%20A

[xxxiv] Morgan County, GA, Public GIS Portal and Deed Book 451 Page 987. http://morgan.binarybus.com/lookup/property_card.asp?cmd=SHOWPARCEL&PID=046%20%20%20%20109

[xxxv] Georgia Ready for Accelerated Development (GRAD) Site Program Criteria. http://www.edsuite.com/proposals/proposals_192/grad_sites_program_-_site_criteria_fi_2278.pdf

[xxxvi] Banks Farm Application/Traffic Study.

[xxxvii] Ibid.

[xxxviii] Morgan County Comprehensive Plan, 2004, Appendix A: Morgan County Greenprint Concept Map.

[xxxix] Morgan County Zoning Ordinance, Chapter 9.3 Large Site Industrial Zoning District (I-3) (Megasite).

[xl] Shawn E. Wilson, MAI. "Evaluating the Potential Impact of a Proposed Landfill." The Appraisal Journal, Winter, 2009.

[xli] James Flynn, PhD, Donald G. MacGregor, PhD, Wayne Hunsperger, MAI, SRA, C.K. Mertz, and Stephen M. Johnson, PhD. "A Survey Approach for Demonstrating Stigma Effects in Property Value Litigation." The Appraisal Journal, Winter, 2004.

[xlii] Diane Hite, Wen Chern, Fred Hitzhusen, Alan Randall. "Property-Value Impacts of an Environmental Disamenity: The Case of Landfills." Journal of Real Estate Finance and Economics, Mar-May, 2001.

[xliii] Shawn E. Wilson, MAI. "Evaluating the Potential Impact of a Proposed Landfill." The Appraisal Journal, Winter, 2009.

[xliv] Ibid.

[xlv] Ibid.

[xlvi] Morgan County Zoning Ordinance, Chapter 1.1 Objectives.

MADISON-MORGAN
CONSERVANCY

Madison-Morgan Conservancy
Development Review Committee

Mission:

To support the Madison-Morgan Conservancy's mission of "providing public education on conservation matters and of protecting and enhancing the heritage and quality of life of the residents of Morgan County by protecting historic sites, greenspace, farmland, and timberland."

Goals and Objectives:

1) To serve as a resource to the county and municipal planning departments
2) To review applications submitted to the Morgan County Planning Commission to assess quality of design, consistency with the Greenprint and Comprehensive Plan, and appropriateness, as they relate to the Conservancy mission
3) To present comments to the Planning Commission, Board of Commissioners, and/or appropriate City Council
4) To recommend zoning ordinance and development regulation changes/improvements

Policy:

1) Meet with Morgan County Planning Commission staff to assess development projects in the pipeline
2) Thoroughly vet the details of rezoning applications with the planning staff before the meetings to avoid lengthy and perhaps complex and detailed discussions at the PC, BOC and City Council meetings
3) Meet as a group the first Monday after the Planning Commission's 45 day application submission deadline
4) At monthly meeting, address both old business and new business
5) Be available to meet with developers or other interested parties during regular meetings and if at all possible during additional meetings
6) Submit comments to Planning Commission before work session (work session is Friday before regular Planning Commission meeting)

Reduce and Better Manage Solid Waste

Fast Facts

Georgia ranks tenth of all fifty states for the most active municipal landfills.

According to Georgia DCA, nearly 2.6 million tons - about 40% - of MSW Georgians throw away each year are common recyclable materials with reuse markets inside the state.

In 2004, Georgia residents and businesses spent an estimated $90 million to dispose of common recyclable materials. Based on recycling market values, if these items were recycled, the resulting raw materials would be worth more than $250 million.

More than ten percent of the waste – almost two million tons – disposed of in Georgia's landfills was imported from other states in FY07. The vast majority, 1.6 million tons of waste, went to MSW landfills.

In 2008, tipping fees posted at the gate were $35.15 per ton of waste for MSW landfills and $23.72 for C&D landfills in Georgia – half as much as tipping fees in some Northeastern and Mid-Atlantic states.

For More Information:
Sierra Club, Georgia Chapter,
Mark Woodall

What's at Stake?

Waste discarded by Georgia's industrial, commercial and residential sectors that is not reused or recycled is deposited in landfills. The low cost of waste disposal in our state encourages the inefficient use of landfill capacity, burdens taxpayers with clean-up costs and leads to the poor use of our natural resources.

Landfills pose a threat to public health and our environment as chemicals and microbes are released as the waste is decomposed. These chemicals can contaminate the air, water and soil. The U.S. Environmental Protection Agency has repeatedly stated that all landfills eventually leak and their "leachate" can threaten our drinking water supply.

Challenges

Garbage and trash from households is sent to municipal solid waste (MSW) landfills while waste from construction, repair and demolition of residential and commercial buildings, roads and bridges is sent to Construction & Demolition (C&D) landfills.

In 2003, the Georgia Department of Community Affairs reported the state has 25 years of remaining permitted MSW landfill space. Logically, this should be enough space to handle the trash Georgia produces through 2028. However, with large amounts of waste imported from other states and few incentives to reduce our waste stream, it is likely the remaining landfill space will not last nearly as long as projected – without undertaking controversial measures such as expanding existing landfills into the surrounding communities or permitting new landfills.

Large solid waste corporations have incentive to fill their landfills as quickly as possible. Importing waste from Florida and Northeastern states helps their bottom line, but harms Georgia's capacity for managing solid waste. Allowing materials to be deposited in a MSW landfill that can otherwise be disposed, like yard trimmings, also reduces critical landfill capacity.

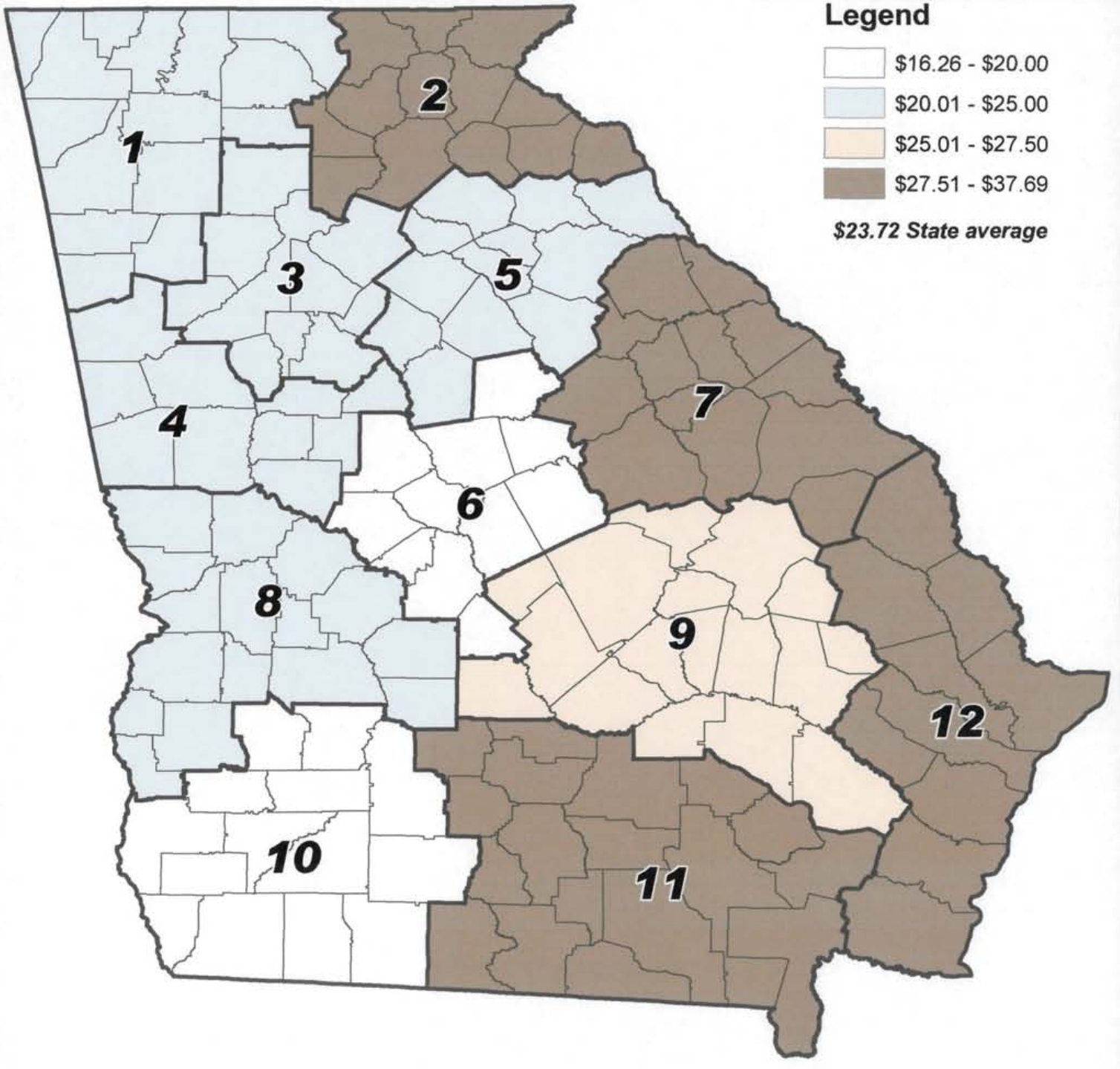
Weak state and local regulations leave Georgia's natural resources at risk in regards to landfills. For example, current state regulations allow for the construction of landfills in poorly suited locations, such as 100-year floodplains.

Large solid waste corporations often look for rural counties that have the two attributes: lenient land use requirements (or lack of zoning) and cheap land. Georgia's current state requirements do not require liners for construction and demolition landfills. Yet the waste that goes into a C&D landfill is largely unregulated and many construction materials, such as leftover paint, adhesives, grease and batteries, are toxic.

Next Steps

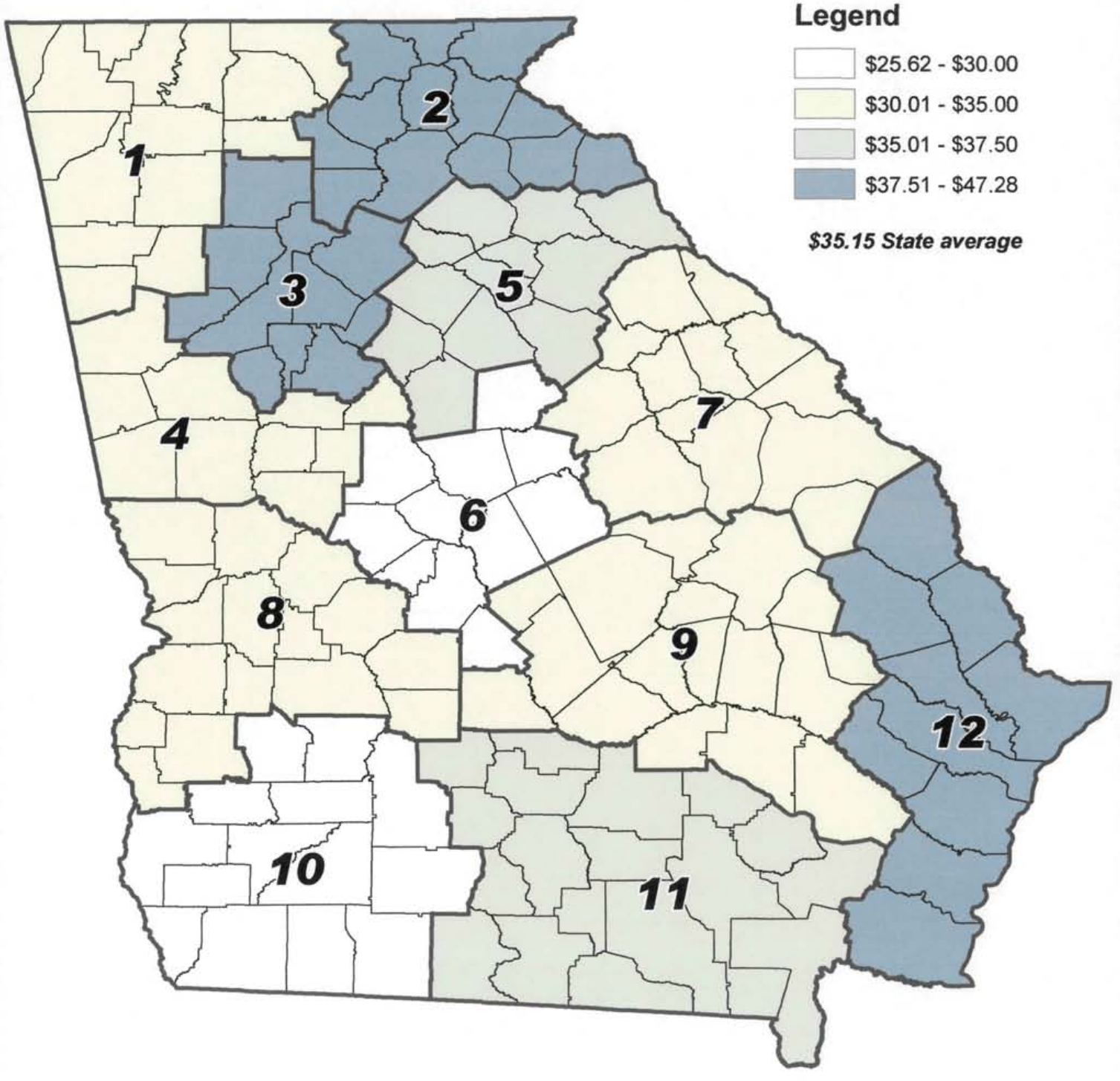
- Create strong, effective incentives for waste reduction and recycling.
- Oppose efforts to remove the ban on yard trimmings in MSW landfills.
- Fully fund the Solid Waste Trust Fund, which helps clean up abandoned landfills and aids local government efforts to reduce solid waste.
- Increase local host fees from $1 to $3 per ton of disposed solid waste and increase the state host fee from $0.50 to $3.50 per ton of disposed solid waste.
- Remove the EPD Director's ability to waive the requirement that C&D landfills have liners and leachate collection systems.
- Counties should adhere to local comprehensive solid waste management plans, further define restrictions on solid waste disposal and management, and identify sites not suitable for solid waste handling facilities.

GA C&D Landfill Tipping Fees 2008



Data Source: DCA - Office of Environmental Management - phone survey, 2008
Map prepared by: Georgia Department of Community Affairs, 2008

GA MSW Landfill Tipping Fees 2008



Data Source: DCA - Office of Environmental Management - phone survey, 2008
Map prepared by: Georgia Department of Community Affairs, 2008

CHAPTER 9.3 LARGE SITE INDUSTRIAL ZONING DISTRICTS (I-3)

Section 9.3.1 Purpose and Intent.
The intent of the Large Site Industrial Zoning District is to establish zoning standards suitable to the scale of development on large sites, where potential impacts on the surrounding community are proportionally greater than those generated by small, individual parcels and therefore require the application of standards scaled beyond the standards found in the general districts of the Zoning Ordinance.

Further, the intent of the district is to achieve development which is consistent with the land use goals of Morgan County, to provide for a review process which facilitates the development of new sites allowing for the flexibility to achieve the best possible development, both in terms of achieving the site's economic development potential and in terms of protecting and enhancing the quality of life of the citizens of Morgan County.

Accordingly, the Board of Commissioners finds that the application of the standards contained in this district will help develop the harmonious development of the county, increase the desirability of residence and investment in the county, increase the opportunity to attain the optimum use and value of land and improvements, positively effect the stability and value of property, positively affect the peace, health and welfare of the county, and create a proper relationship between the taxable value of property and the cost of local government services.

Section 9.3.2 Definitions.
In addition to the definitions contained in Article 3 of this Ordinance, the following definitions shall apply to this Section:

Access Management The management of vehicular access in and out of sites from public streets and roads. The intent of access management is to reduce traffic congestion, accidents and loss of street capacity through the intelligent location and design of public street and driveway connections to the roadway, as well as site design practices internal to each development site.

Areas of Natural Topography and Vegetation: Those areas of the site undisturbed at the time of development which contain significant numbers of existing trees with a caliper of 12" or greater; areas with significant slopes (topography) and existing vegetation; areas with existing watercourses; areas including combinations of the above; or such other natural features as may have a documented horticultural, natural or geologic significance.

Bufferyards: The required landscaped buffer area between the proposed development and any adjacent land uses.

Concurrency Review: The review undertaken by Morgan County, as part of the site plan review of large tract development sites to ensure that the public facilities and services needed to support development shall be available concurrently with the

Elbert Co. signs off on energy plant

By JOE VANHOOSE - joe.vanhoose@onlineathens.com

Published Tuesday, February 09, 2010

ELBERTON - A proposed waste-to-energy incinerator in Elbert County cleared a major hurdle Monday night, gaining approval from county commissioners to locate there.

Richard Harris

Chip Rousey wears a "NO incinerator! NO landfill!" sticker during a public meeting Monday at the Elbert County Courthouse.

Elbert commissioners voted unanimously to allow GreenFirst LLC to build a $330 million waste-to-energy plant and adjoining landfill.

► Click HERE for photo gallery

They also voted to change the county's solid-waste management plan to allow the plant, which will be called Plant Granite.

The vote angered many of the 100-plus residents who filled the Elbert County Superior Courtroom Monday evening, many of them wearing yellow stickers that read, "NO incinerator! NO landfill!" Dozens of them spoke out against the proposed plant at back-to-back public hearings before the vote. Opponents wanted the commission at least to delay the vote and do an independent study on the plant.

"There is a tremendous public uproar," said Bob Matthews, who lives in Hartwell but owns a farm in Elberton. "Whether they're right or whether you're right, you don't need to rush this decision. It's not your decision to make."

Citizens for Public Awareness, a grassroots opposition group, turned in a petition with more than 3,500 signatures - enough signatures to force county leaders to put the plant up for a vote in a special referendum, said CPA spokesman Kevin Lewis.

Lewis also argued that, since GreenFirst turned in a draft host agreement - a document basically allowing the company to build a plant in Elbert County - on Feb. 2, commissioners did not have enough time to make an informed decision.

But anti-incinerator stickers, posters and speeches weren't enough to sway commissioners. They voted unanimously and without any discussion.

"Four of you all are up for re-election this year," said Elberton resident Tracy Rousey. "I hope you realize that none of you guys are getting re-elected."

GreenFirst still needs more than a dozen water, air and solid-waste permits before it can start building the incinerator. The plant and adjoining landfill likely would not open before 2014, GreenFirst President Ernest Kaufmann said last week.

The 40,000-square-foot incinerator would burn about 1,000 tons of trash and timber waste each day to generate steam to turn turbines and create electricity that would be sold to utilities. Leftover ash would go into a 39-acre landfill the company would build on the same site, which is off Georgia Highway 72 west of Elberton. More than 100 trucks would haul garbage into Elberton every day, according to the plant's traffic impact study.

The incinerator did have its supporters in the crowd Monday. Audrey Hardin, a lifelong Elberton resident, looks forward to the jobs and revenue the plant will bring to the county.

"This is the best thing that's ever happened to Elbert County," she said. "(The incinerator) is clean, it is safe, and it is good for the county."

Originally published in the Athens Banner-Herald on Tuesday, February 09, 2010

Reader Comments

Posted by: **scratch170** at Feb. 9, 2010 at 7:36:59 am

What could have prevented this? Perhaps a county zoning ordinance?

Posted by: **twofeet** at Feb. 9, 2010 at 7:56:05 am + 2 Rating

The county previously voted a special exemption and changed the existing ordinance to specifically allow an incinerator of just the type Greenfirst proposed.

Posted by: **catman306** at Feb. 9, 2010 at 7:58:45 am

Elbert county, like Clarke, also has an unelected Real Government (TM). Zoning, elections or public demonstrations have no effect. Next time try a Federal Court Order.

Posted by: **penny2009** at Feb. 9, 2010 at 8:29:19 am

Elbert county voted on zoning a year ago It takes alot of time for the rules and regulations to be put into place.I really do not think zoning would have stopped it.The people that are elected to protect and serve our county are the ones that have the power to do that.They are not listening to the public and I am afraid they will not be voted back in of course by then the damage is done to our county.I really do not understand why the big rush to do this.Thats the question alot of people asked last night.I wonder if they were offered a bonus to have this by a certain date?There are so many question not answered by our commissioner.I pray for them this is the worst thing I have ever see happen in our county I really think if we were allowed to vote everyone would be against it.

Posted by: **cyou299** at Feb. 9, 2010 at 8:33:57 am + 1 Rating

that is rather amazing. Why were they in such a hurry? 9 out of 10 Elbert residents are against this, yet their elected reps ignored them.

My understanding is it will now have to be on the ballot and the people will have a direct vote on the matter. Curious to see if the commish's try to stop the direct vote of the people...

Something awful fishy going on with the commissioners.

It's not the SIZE of a government that is a problem. It is the willful disregard of the government for the people it represents.

Posted by: **hoodoo** at Feb. 9, 2010 at 8:48:43 am

This is an example of Railroad Democracy. Their jamming of two public hearings back to back on the same day broke their own procedural regs, I'm told.

Posted by: **ppensyl** at Feb. 9, 2010 at 9:11:18 am

"that is rather amazing. Why were they in such a hurry? 9 out of 10 Elbert residents are against this, yet their elected reps ignored them."

Doesn't amaze me one bit...what would amaze me is if elected officials actually followed the will of the people.

7

Subject: Keep Morgan Beautiful information
Date: Thursday, February 18, 2010 9:59 AM
From: Dan & Linda Thoman <dlthoman@bellsouth.net>
To: <info@mmcgeorgia.org>

Christine, I do have end of year FY 09 Morgan County numbers. (FY09 ends June 09) Keep in mind that these numbers do not include Madison or Rutledge municipal recycling. KMB has worked with volunteers and little funding, but we want to provide the assistance our community needs. We've talked to the city and plan to include them in our service area. We have been talking to the Chamber about partnering with them, since the county has been reluctant to do so. Right now those talks have been postponed due to illness of key participants.

Attachment #1 has FY 09 numbers. I will try to get some more info from the county today, considering dollars. Note: The Not So Good News: Morgan County only recycled approximately 2.5% of our total solid waste in FY 08. We went up to approximately 2.9% in FY09. We are improving, increasing recycling, but slowly. The EPA national goal for municipal recycling is 35%. It is possible to recycle as much as 80% of household waste.

Lynn Cobb, Keep Georgia Beautiful state coordinator advised our Board of Commissioners "You will not be able to sustain a viable recycling program without ongoing recycling education". Morgan County's only program is a handful of dedicated but under resourced volunteers, municipal initiatives like "Madisonfest" and the "Sustainability Expo" and public school programs that promote environmental awareness.

Attachment #2 has FY 08 thru Feb 09. Note:Lynn Cobb, Keep Georgia Beautiful state coordinator advised our Board of Commissioners "You will not be able to sustain a viable recycling program without ongoing recycling education". Morgan County's only program is a handful of dedicated but under resourced volunteers, municipal initiatives like "Madisonfest" and public school programs that promote environmental awareness.

Attachment #3 has Has info on all of Keep America Beautiful initiatives. This document has some interesting national numbers & quick facts.

Attachment #4 is about what KMB is doing in our community.

Hope this helps, Linda

--
www.buckheadwoodcrafters.com
www.thomanstudio.blogspot.com

From Monica Hayden

Recycling Efforts in Morgan County

Morgan County has expanded the county's recycling services offered to its residents. In addition to the usual recycling of paper, bottles and cans, the County now accepts such items as used motor oil, household paint and pesticides, used cooking oil and used electronic equipment. Also available is a secure drop-off station for used license tags, as well as a Goodwill donation center. All these services are located at the County's Transfer Station, 2480 Athens Hwy., in Madison.

The following electronic equipment is acceptable for recycling: computers, printers, copiers, fax machines, phones, cell phones, typewriters, intercoms, monitors, disk drives, DVD players, VCRs, radios, etc. NOT ACCEPTABLE are: large appliances, air conditioners, irons, heaters or TV's.

The service is free to all Morgan County residents. However, at this time no commercial recycling can be accepted, due to the strict EPA regulations involved in this type of activity.

Residents can also drop off their recycled paper and cardboard, as well as plastic (#1 & 2), aluminum and glass containers at the following locations:

- **2153 Greensboro Hwy/US 278**
- **4691 Buckhead Road**
- **1020 Doster Road**
- **2240 Newborn Road**
- **1721 Prospect Road**
- **1182 Wellington Street**
- **1001 Clack Road**
- **1770 Kingston Road**
- **1000 Newton Road**
- **Seven Islands Road**
- **4861 Lower Apalachee Road**
- **2480 Athens Hwy.**

Cardboard boxes must be flattened before placed in the dumpsters.

The County has also partnered with the Morgan County School System to encourage recycling at each of the schools, by providing free pick-up service for paper, bottles and cans.

All County offices are now actively recycling paper and plastic and metal containers, as well as sending out documents for shredding and getting credit for the recycling of the shredded materials.

The County actively participates in The Great American Cleanup each year in collaboration with the City of Madison and a citizens group called “Keep Morgan Beautiful.”

CHAPTER 15.14 LANDFILLS

Section 15.14.1 Permitted Locations.
Landfills are only permitted in the Heavy Industrial (I-2) Zoning District as a conditional use. Landfills are not permitted in any other zoning district under any circumstances or under any other use.

Section 15.14.2 Definitions.
Landfills are classified into the following three types as defined below:

Construction/Demolition Waste Landfill: A landfill accepting only waste, building materials, and rubble resulting from construction, remodeling, repair, and demolition operations on pavements, houses, commercial buildings and other structures. Such wastes include but are not limited to wood, bricks, metal, concrete, wall board, paper, cardboard, inert waste landfill material, and other nonputrescible wastes which have a low potential for groundwater contamination.

Inert Waste Landfill: A landfill accepting only wastes that will not or are not likely to cause production of leachate of environmental concern. Such wastes are limited to earth and earth-like products, concrete, cured asphalt, rock, bricks, yard trimmings, stumps, limbs, and leaves. This definition excludes industrial and demolition waste not specifically listed above.

Solid Waste Landfill: A landfill accepting any garbage or refuse; sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility; and other discarded material including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities, but does not include recovered materials; solid or dissolved materials in domestic sewage; solid or dissolved materials in irrigation return flows or industrial discharges that are point sources subject to permit under 33 U.S.C. Section 1342; or source, special nuclear, or by-product material as defined by the federal Atomic Energy Act of 1954, as amended (68 Stat. 923).

Landfill Cell Area: The areas where the trash is stored within the landfill, each cell contains the compacted trash of one day.

Section 15.14.3 Hazardous Waste Restrictions.
Hazardous waste landfills are prohibited, and hazardous waste as defined by the Georgia Department of Natural Resources (DNR) may not be disposed of in inert, construction/demolition, or solid waste landfills.

Section 15.14.4 Dimensional Requirements.
Any landfill must be located on a minimum of two hundred and fifty (250) acres. The landfill "cell" area (that is, holding actual waste) may not exceed thirty (30%) of the total acreage, with landfill operations areas (i.e., "cells" plus scales, offices, storage, other buildings, etc.) not exceeding forty (40%). No landfill cell may exceed sixty (60) feet in

height from the original grade, when fully filled, covered and vegetated. No more than ten (10) acres of the property can be active landfill cell at any one time.

Section 15.14.5 Fencing Requirements.
All landfill cell areas and landfill operations areas must be surrounded by a chain link fence at least six feet high, topped with anti-climbing devices. The boundary of the landfill property (either inside or outside the vegetated buffer) must be surrounded by a wooden privacy fence, at least eight feet high.

Section 15.14.6 Buffer Requirements.
In addition to any buffer and landscaping requirements required in Article 19 of this Ordinance, all landfills must be surrounded by a vegetated buffer at least five hundred (500) feet thick, located on the landfill property. The buffer must be sufficiently vegetated to be completely opaque and prevent viewing of any landfill cell at all times of the year. If the preexisting natural buffer is insufficient, the buffer shall be enhanced with appropriate trees dense enough to achieve the required opacity, on a vegetated berm at least six (6) feet high and fifty (50) feet wide at the top.

Section 15.14.7 Location Related to Adjacent Land Uses.
No landfill cell may be located within two thousand (2000) feet of residentially used property (so used at the time of application for the permit). For the purposes of this section, the phrase "residentially used property" shall mean the property on which the residence is located and not more than one acre of land, determined as if the residence was situated in the center of said tract. No landfill cell may be located within one hundred (100) feet of a wetland, groundwater recharge area, lake or other body of water, floodplain, stream or river.

Section 15.14.8 Lighting.
All lighting of the landfill shall meet the standards set forth in Chapter 22.1 of this Ordinance.

Section 15.14.9 Hours of Operation.
Hours of operation of any landfill shall be no greater than 8:00 a.m. to 5:00 p.m. Monday to Friday, 8:00 a.m. to 4:00 p.m. Saturday. No operation allowed on Sunday.

Section 15.14.10 Access Requirements.
A landfill shall only be permitted where all County roads used for access have been built to a standard sufficient to withstand the projected number of trips per day at maximum weight for the vehicles expected. If a landfill is proposed adjacent to County roads that are not sufficient to withstand the loads, or were not designed for such loads, the landfill owner must pay to bring such roads up to standard from the entrance(s) of the landfill to the nearest County or State road of sufficient strength; or the landfill shall be denied. Truck traffic shall be restricted to roads of sufficient strength and width.

Section 15.14.11 Application Requirements.
An application for a conditional use permit for a landfill shall also submit the following information, in addition to other conditional use requirements:

(a) A topographic site plan showing the proposed landfill, all surrounding uses in a ½ mile radius, the zoning on all adjacent parcels, the location of the landfill cells, all buffers and fences, highlighting land sloping 25% or more, and showing such other information as may be required by the Director.

(b) A report from a geologist of the soil conditions on the landfill, discussing the topography (especially any steep slopes), the substrata, and any geologic hazards or relevant conditions on the property, as well as giving an opinion as to the property's suitability for the type landfill proposed.

(c) A site plan prepared by a qualified engineer depicting all floodplains, streams and rivers, watershed areas, wetlands, and groundwater recharge areas within ½ mile of the subject property (including on the subject property), as well as showing the location of the landfill and the landfill cells to those features, showing all buffers and setbacks. The plan shall also depict all water wells within ½ mile of the landfill cells.

(d) A plan showing access, ingress and egress, including mechanisms to keep dust down and dirt off county roads. All access roads to landfill cells must be paved, and a truck cleaning station must be used at any exit. An estimate of daily truck traffic shall be provided, and entrances shall be located to minimize traffic hazards, with accel/decel lanes provided.

(e) A traffic plan showing ingress and egress, number of trips per day, vehicle type, and maximum weight of vehicles expected.

Section 15.14.12 Additional Criteria for Application Consideration.
In addition to the conditional use criteria in Chapter 31.3 of this Ordinance, in considering an application for a landfill, the following additional criteria shall also apply:

(a) Is the property and general area suitable for a landfill, considering geography, wetlands, streams and rivers, watersheds, groundwater recharge areas, adjacent uses and zoning, airports, national historic sites, jurisdictional boundaries and similar criteria?

(b) Does the property and site plan meet all the buffer requirements relating to landfills?

(c) Will the landfill have any negative impacts on the adjacent properties?

(d) Are access, ingress and egress adequately provided for, considering the volume of traffic expected?

(e) Is the use consistent with the comprehensive plan and the pattern of development in the area, and the applicable solid waste management plan?

Guidance on the Evaluation of the Potential Impacts of a Proposed Landfill

G. Fred Lee, PhD, PE, BCEE and Anne Jones-Lee, PhD
G. Fred Lee & Associates, El Macero, CA
(530) 753-9630
gfredlee@aol.com www.gfredlee.com
October (2008)

The typical approach followed in developing a new municipal solid waste (MSW) landfill for urban areas is to attempt to locate the new landfill for the municipal solid wastes in a rural area where there is limited population and financial resources to conduct a comprehensive review of the proposed impacts of the landfill. While it is possible to develop truly protective landfills, federal, state and local landfilling regulations do not require that a landfill be located, designed, operated, closed and receive postclosure monitoring and maintenance to protect those within the potential impact zone of the landfill for as long as the wastes will be a threat to public health and the environment. Typically, the proposed landfill is of minimum (or near-minimum) allowed siting and design in order to reduce the cost of landfilling to those who generate the wastes, thereby imposing the impacts of the landfill on those who live/work/use the area near the landfill.

The US Department of Agriculture (USDA) has recognized the problems with landfills not protecting the interests of the rural community and has developed a Water and Environment Solid Waste Management Grant program that is designed to develop information to

- *"Reduce or eliminate pollution of water resources in rural areas"* by landfills and to
- *"Improve planning and management of solid waste sites in rural areas."*

Information on this program is available at
http://www.usda.gov/rus/water/SWMG.htm#Contact%20Information.

Presented herein is guidance on evaluating the potential impacts of landfills.

Justified NIMBY

While landfill developers and those in urban areas often characterize the opposition to a proposed landfill by the rural communities as "NIMBY" (not in my backyard), a critical review of the current approach for developing new landfills or landfill expansions shows that the current review/permitting process results in a justified NIMBY approach being adopted by those potentially impacted by the landfill. The authors have encountered situations where some urban landfill developers will claim that their proposed landfill will be protective of public health and the environment and that those in rural areas should not oppose the development of the proposed landfill. If the landfill is truly protective of those within the sphere of influence of the landfill it should be possible to locate the landfill within the urban area where the wastes are primarily generated.

It is the authors' experience that there are few individuals who would welcome the siting of a landfill adjacent to their property or areas of activity. Essentially everyone becomes

a "NIMBY" when he/she learns that a landfill is proposed in his/her area. This is justified as landfills typically are adverse to the health, groundwater resources, and interests of those within the sphere of influence of the landfill. That sphere can extend several miles from the landfill.

The adverse impacts of landfills are well-recognized; in response to this situation Lee and Jones-Lee have developed

> "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," Report of G. Fred Lee & Associates, El Macero, CA, December (2004). Updated December 2008). This review is available at http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf.

This Lee and Jones-Lee review provides a discussion of the potential impacts of landfills, in the section of the paper on "Justified NIMBY." This section summarizes the potential adverse impacts of MSW and other types of landfills. These impacts are listed in Table 1.

Table 1
Adverse Impacts of "Dry Tomb" Landfills on Adjacent/Nearby Property Owners/Users

- public health, economic and aesthetic aspects of groundwater and surface water quality
- methane and VOC migration - public health hazards, explosions and toxicity to plants
- illegal roadside dumping and litter near landfill
- truck traffic
- noise
- dust and wind-blown litter
- odors
- vectors, insects, rodents, birds
- condemnation of adjacent property for future land uses
- decrease in property values
- impaired view

From Lee et al. (1994) and Lee and Jones-Lee (2008).

The Lee and Jones-Lee (2008) Flawed Technology review presents information on the characteristics of each of these impacts. Lee and Jones-Lee also discuss how to address/eliminate the justified NIMBY issues by proper landfill siting/location, design, operation, closure and postclosure care for as long as the wastes in the landfill are a threat. While NIMBY issues can be readily addressed, typically the needed changes in landfill development are not implemented due to the increased cost that would occur for urban and other MSW generators. As a result, urban and other MSW generators are able to impose landfills on rural communities and thereby dispose of their garbage initially at cheaper than real cost, where the impacts and real costs are passed on to those within the sphere of influence of the landfill and future generations through adverse impacts on their

health, loss of groundwater resources and ultimately paying the "superfund"-like costs for cleanup of the landfill-polluted groundwaters.

Health Effects of Landfills. MSW landfills release odors, which not only are a nuisance, but can also be adverse to the health of those who live/work near MSW landfills and other hazardous chemical sites. Lee and Jones-Lee reviewed these issues in

> "Association between Hazardous Chemical Sites and Illness," Report of G. Fred Lee & Associates, El Macero, CA, January (2007). This review is available at http://www.gfredlee.com/Landfills/HazChemSites-Illness.pdf.

Other papers and reports on the impacts of landfills and their appropriate development, operation, closure, and postclosure care are available on Drs. G. Fred Lee and Anne Jones-Lee's website, www.gfredlee.com, in the Landfills-Groundwater section, http://www.gfredlee.com/plandfil2.htm.

Groundwater Pollution Issues. Today's minimum design Subtitle D (municipal solid waste) landfills with a single composite liner will eventually pollute groundwaters by landfill leachate (garbage juice) at landfills that are hydraulically connected to underlying groundwaters. This pollution will be caused by the eventual inevitable failure of the single composite liner, which will allow hazardous and otherwise deleterious chemicals to be released from the MSW landfill. In addition, if the polluted groundwaters discharge to surface waters, then the landfill can pollute surface waters as well, rendering them unusable for domestic water supply, as well as adverse to fish and other aquatic life in the surface waters. Further, the groundwater monitoring systems allowed for these types of landfills are highly unreliable in detecting groundwater pollution by landfill leachate before offsite/adjacent properties' groundwater is polluted. In their paper,

> "Improving Public Health and Environmental Protection from Inadequately Developed Landfills,"
> [available at http://www.gfredlee.com/Landfills/ImprovProt-LF.pdf]

Lee and Jones-Lee described a groundwater monitoring program that would improve groundwater quality protection for those who have domestic, farm, and other wells located within several miles of a landfill.

Inadequate Buffer Lands. The active-life (while wastes are still being deposited) releases from landfills that contribute to trespass of odors, hazardous chemicals, dust, noise, view impairment, etc., are largely addressable if the landfill developer is required to acquire adequate buffer lands between areas of waste deposition and adjacent property lines. Often at least one mile, and in some settings two or more miles, of buffer lands are needed to adequately dissipate the odors, etc., so that they are not detectable at adjacent property lines.

Inadequate Postclosure Funding. One of the most significant deficiencies in current landfilling regulations is that the federal (US EPA) and most states' landfilling regulations do not require assured postclosure funding for monitoring, maintenance, and eventual groundwater cleanup from pollution caused by a closed (no longer accepting wastes) "dry tomb"-type landfill for as long as the wastes in the landfill will be a threat to

cause groundwater pollution. Wastes in today's landfills that conform to US EPA Subtitle D minimum regulations, will be a threat to cause groundwater pollution, effectively forever, yet minimum postclosure funding is typically required for only 30 years. The federal (and typically state) landfilling regulations do not require that those whose wastes are placed in a landfill provide the level of funding (through the fees paid for waste disposal) that will be needed to adequately monitor and maintain the landfill containment structure and the groundwater monitoring systems for as long as the wastes in the landfill will be a threat.

Some areas, such as California, have explicit regulations that require postclosure funding for monitoring and maintenance for as long as the wastes in the landfill will be a threat. However, while that requirement has been in the California regulations since the 1970s, there are no funding mechanisms in place to ensure that those whose wastes are placed in the landfill adequately fund the postclosure monitoring and maintenance of the landfill. Basically, this funding is, by default, passed on to future generations, where there is no assurance that the funds will be available when needed.

Drs. G. Fred Lee and Anne Jones-Lee discussed the importance of ensuring that adequate postclosure funding be developed by those who generate the wastes that are placed in a landfill for as long as those wastes represent a threat, in:

> "Comments on the CIWMB Staff Efforts to Gain Assured Postclosure Funding for Landfills for as Long as the Wastes in the Landfill Are a Threat to Public Health and the Environment," Comments Submitted to California Integrated Waste Management Board by G. Fred Lee & Associates, El Macero, CA, January (2007), which is available at http://www.gfredlee.com/Landfills/CIWMBPostCloseFund.pdf,

They pointed out that this is especially important for privately developed landfills, for which the ability and reality of a private company's providing postclosure funding, effectively forever, is appropriately of concern. The potential for a landfill owner to declare bankruptcy or otherwise "walk away" from the landfill while it still poses a threat and shirk its responsibility for postclosure monitoring and maintenance of the landfill for as long as the wastes are a threat, is a very real concern. While public-agency-developed landfills may not face that problem, there are legitimate concerns about whether the public agencies responsible for the landfill will, in fact, support postclosure care of a landfill that was developed and closed many years ago by past residents of the area. It is clear that the consequences of failing to provide adequate postclosure monitoring and maintenance will not be faced by those in the urban areas where the wastes were primarily originally generated. This adds to the justification for NIMBY positions by those who want to protect groundwater resources from the impacts of a landfill in rural areas.

Obtaining Reliable Information on Impacts of Landfills

Rural communities and individuals that are concerned about the potential impacts of a proposed landfill are at a significant disadvantage in participating in the landfill review process of board deliberations, permitting hearings, etc. Typically, landfill developers

are well-financed and able to hire attorneys and consultants who discuss the landfill from the developer's perspective, while failing to adequately discuss the potential impacts of a landfill on those within the sphere of influence of the landfill. In their reports:

> "Practical Environmental Ethics: Is There an Obligation to Tell the Whole Truth?" Published in condensed form, "Environmental Ethics: The Whole Truth," *Civil Engineering*, Forum, 65:6 (1995), http://www.gfredlee.com/ethics.htm

and

> "Selection of an Independent Consultant to Review the Potential Impacts of a Proposed Landfill," Report of G. Fred Lee & Associates, El Macero, CA, December (2006), http://www.gfredlee.com/Landfills/SelectIndepConsult.pdf,

Lee and Jones-Lee discussed the fact that consultants that normally work for landfill developers are advocates for the projects; they cannot be expected to provide disinterested, transparent, reliable information on the adequacy of a proposed landfill's siting, design, operation, closure, and postclosure care, while expecting to be awarded future work from landfill developers. Governmental agencies typically do not have the resources to critically evaluate all aspects of proposed landfills, and may well be facing dilemmas in simply finding a mechanism or location for waste disposal. Therefore, those who stand to be impacted by a landfill must find qualified attorneys, hydrogeologists, and other consultants to provide independent technical review and advocacy on behalf of public health protection, and a means of funding such advisors. Examples of work Lee and Jones-Lee have done in this regard can be found at: http://www.gfredlee.com/plandfil2.htm#examples.

Suggested Approach. We have found that individuals/groups that face evaluating the impacts of a proposed landfill or expansion, and the reliability of a landfill proponents' documentation in support of the landfill's development first need to organize those concerned about the landfill's impacts. Next, the group needs to define the reasons for their concerns. In making such an evaluation, it may be helpful for the members of the group to read the Lee and Jones-Lee "Flawed Technology" review as well as several of the example reports on Drs. Lee and Jones-Lee's website.

The group should then work with their local elected officials and the press to inform them of their concerns about the potential impacts of the proposed landfill. Next the group should assess the amount of funds available to evaluate the potential impacts of the proposed landfill. Some citizens' groups opposed to a landfill have been able to identify a local attorney who will assist the group at no or limited cost to the group. The group needs to acquire the assistance of a local hydrogeologist who is familiar with the hydrogeology of the proposed landfill area. The hydrogeologist should review the landfill application for the accuracy of the hydrogeology information in the application.

The group would also need to acquire the assistance of a landfill expert who can review the landfill's proposed location, design, etc., and prepare a preliminary report on the potential impacts of the landfill. If possible (depending on availability of funding), the

landfill consultant should visit the area and discuss the situation with members of the group. Based on the review of the landfill proposal and the site visit, a course of action should be developed by the group to address their concerns about the potential impacts of the proposed landfill. If possible the consultant should personally present a summary of his/her findings at a landfill review board hearing. If insufficient funds are available from the group to support such a presentation, then their landfill consultant's report should be submitted to the review board with a conference call between the review board and the consultant to discuss aspects of the report.

All of these activities should be conducted in close coordination with the group's attorney, and all work should be conducted so that it can be used in an appeal of a review board/regulatory agency's decision to proceed with the development of a landfill that does not adequately protect the health, groundwater resources, welfare, and interests of those potentially impacted by the landfill. Since review boards' and regulatory agencies' review of a proposed landfill may be limited to whether the landfill meets the current (often inadequate) minimum regulatory requirements, it may be necessary to have the development of the landfill reviewed by the courts, through litigation.

Acquiring the Assistance of Drs. Lee and Jones-Lee

Drs. Lee and Jones-Lee make many of their reports and professional papers available on their website, at no cost, to assist those concerned about evaluating the potential impacts of landfills. They will answer telephone questions about their publications. They can also serve as paid consultants to states, counties, municipalities, environmental groups, citizen groups, and individuals in reviewing the potential impacts of landfills, preparing reports, and testifying in landfill review board hearings, regulatory agency permitting hearings, trials, etc. Information on their qualifications to serve as consultants is available at

http://www.gfredlee.com/landfill.htm,
http://www.gfredlee.com/exp/areawork.htm and
http://www.gfredlee.com/exp/lfbio_exp.htm.

Please contact Dr. G. Fred Lee at gfredlee@aol.com or by phone at (530) 753-9630 for information on obtaining the services of Drs. G. Fred Lee and Anne Jones-Lee in evaluating the impacts of a proposed or existing landfill.

GA Dept. of Natural Resources / Environmental Protection / Solid Waste management

391-3-4-.07 Landfill Design and Operations. Amended.

(1) All landfills must be designed by a professional engineer registered to practice in Georgia and designed in accordance with the following criteria:
(a) Site limitations: the landfill must be designed in such a manner as to comply with the specific site limitations issued by the Division as a part of a site approval.
(b) Buffers: facilities which have submitted a permit application to the Division prior to July 1, 1991 must provide a minimum 100 foot buffer between the property line and the waste disposal boundary. All other facilities must provide a minimum 200 foot buffer between the waste disposal boundary and the property line and a minimum 500 foot buffer between the waste disposal boundary and any occupied dwelling and the dwelling's operational private, domestic water supply well in existence of the date of permit application. The 500-foot buffer may be reduced if the current owner of the dwelling provides a written waiver consenting to the waste disposal boundary being closer than 500 feet. The waste disposal boundary is defined as the limit of all waste disposal areas, appurtenances, and ancillary activities (including but not limited to internal access roads and drainage control devices). No land disturbing activities are to take place in these buffers, except for construction of groundwater monitoring wells and access roads for direct ingress or egress, unless otherwise specified in a facility design and operation plan or corrective action plan approved by the Division.
(c) Site survey control shall be provided to ensure the operation will be on permitted lands. Survey control will be accomplished through use of permanent, accessible benchmarks, survey control stakes, and/or boundary markers which designate and/or delineate all permitted areas. Survey control shall be as indicated on the design and operational plan. Where necessary for construction or operational purposes, vertical as well as horizontal survey control will be established and maintained to delineate fill boundaries, buffers, and property boundaries.
(d) Liners and Leachate Collection Systems: new MSWLF units and lateral expansions shall be constructed with liners and leachate collection systems. The liner and leachate collection system must ensure that the concentration values listed in Table 1 will not be exceeded in the uppermost aquifer at the relevant point of compliance. The liner and leachate collection system must be designed and installed under the supervision of a professional engineer registered to practice in Georgia who shall certify the installation.

TABLE 1

Chemical	MCL (mg/1)
Arsenic	0.05
Barium	1.0
Benzene	0.005
Cadmium	.01
Carbon tetrachloride	0.005
Chromium (hexavalent)	0.05
2, 4-Dichlorophenoxy acetic acid	0.1
1, 4-Dichlorobenzene	0.075
1, 2-Dichloroethane	0.005

1, 1-Dichloroethylene	0.007
Endrin	0.0002
Fluoride	4
Lindane	0.004
Lead	0.05
Mercury	0.002
Methoxychlor	0.1
Nitrate	10
Selenium	0.01
Silver	0.05
Toxaphene	0.005
1, 1, 1-Trichloromethane	0.2
Trichloroethylene	0.005
2, 4, 5-Trichlorophenoxy acetic acid	0.01
Vinyl Chloride	0.002

1. If the MSWLF is located in an area of higher pollution susceptibility, as defined by Hydrologic Atlas #20, A Pollution Susceptibility Map of Georgia, or in a significant ground water recharge area as designated by Hydrologic Atlas #18, the liner and leachate collection system must, at a minimum, be designed with:

a. a composite liner, as defined in paragraph c. of this section and a leachate collection system that is designed and constructed to maintain less than a 30-cm depth of leachate over the liner.

b. at least a five foot separation between the synthetic liner and the seasonal high ground water elevation.

c. For purposes of this section, "composite liner" means a system consisting of two components; the upper component must consist of a minimum 30-mil flexible membrane liner (FML), and the lower component must consist of at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1 × 10(SUP)-7(/SUP) cm/sec. FML components consisting of High Density Polyethylene (HDPE) shall be at least 60-mil thick. The FML component must be installed in direct and uniform contact with the compacted soil component.

2. The relevant point of compliance shall be no more than 150 meters from the waste management unit boundary and shall be located on land owned by the owner of the MSWLF unit. In determining the relevant point of compliance, the Division shall consider at least the following factors:

a. The hydrogeologic characteristics of the facility and surrounding land:

b. The volume and physical and chemical characteristics of the leachate:

c. The quantity, quality, and direction, of flow of ground water;

d. The proximity and withdrawal rate of the ground-water users;

e. The availability of alternative drinking water supplies;

f. The existing quality of the ground water, including other sources of contamination and their cumulative impacts on the ground water and whether groundwater is currently used or reasonably expected to be used for drinking water;

g. Public health, safety, and welfare effects; and

h. Practicable capability of the owner or operator.
3. For MSWLF units not located in significant ground water recharge areas or areas of higher pollution susceptibility, liners and leachate collection systems may meet a design standard other than that specified in paragraph (1)(d) 1. of this Rule, so long as such design ensures that the concentration values listed in Table 1 of this Rule will not be exceeded in the uppermost aquifer at the relevant point of compliance. The factors listed in subparagraph 2. above for determining the relevant point of compliance, shall also be used in determining the suitability of the liner and leachate collection system design.
(e) Erosion and Sedimentation Control: all surface runoff from disturbed areas must be controlled by the use of appropriate erosion and sedimentation control measures or devices. Sediment basins must be designed to handle both the hydraulic loading for the 25 year, 24-hour storm and the sediment loading from the drainage basin for the life of the site. Runoff from the facility must be designed for flow through permanent sediment control impoundments which are designed to assure discharges meeting the requirements of O.C.G.A. 12-7-6(18).
(f) Vegetation: the plan must call for the vegetation of any disturbed area that will remain exposed for more than three (3) months. Vegetation of final cover must take place within two (2) weeks after final cover placement.
(g) Sequence of Filling: the plan must define a sequence of filling showing a detailed progression of filling the entire site that minimizes any problems with drainage and all weather access roads to the working face.
(h) Limited Access: a gate or other barrier shall be maintained at potential vehicular access points to block unauthorized access to the site when an operator is not on duty. A fence or other suitable barrier must be provided around the site, including impoundments, leachate collection and treatment systems and gas venting and processing facilities, sufficient to prevent unauthorized access.
(i) Final Grading: the grade of final slopes shall be designed to:
1. insure permanent slope stability;
2. control erosion due to rapid water velocity and other factors;
3. allow compaction, seeding, and vegetation of cover material placed on the slopes;
4. minimize percolation of precipitation into final cover and provide diversion of surface runoff from disposal area; and
5. meet the final closure requirements of Rule 391-3-4-.11.
6. the grade of the final surface of the facility may not be less than 3 percent nor greater than 33 percent.
(j) Access Roads: access roads shall be designed to provide for the orderly egress and ingress of vehicular traffic when the facility is in operation, including during inclement weather.
(k) Fire Protection: the disposal site must be designed to prevent and minimize the potential for fire or explosion. A minimum supply of one day of cover material must be maintained within 200 feet of the working face for fire fighting purpose, unless other acceptable means have been provided and approved by the Director.
(l) Ground water and Surface water Monitoring Plan: the design must provide for a groundwater monitoring plan in accordance with the requirements for GroundWater Monitoring and Corrective Action as provided in Rule 391-3-4-.14. A surface water

monitoring plan which will determine the impact of the facility on all adjacent surface waters must also be included.
(m) Closure Criteria: the design must provide for proper closure in accordance with Rule 391-3-4-.11.
(n) Post-Closure Care: the design must provide for Post-closure care in accordance with Rule 391-3-4-.12.
(o) Financial Responsibility: the design must provide for financial responsibility in accordance with Rule 391-3-4-.13.
(2) Construction Certification: upon receipt of a final and effective solid waste handling permit, construction may commence in accordance with the approved design and operational plan and permit conditions. Prior to receipt of solid waste, the Division must be provided with written certification by a professional engineer licensed to practice in Georgia, that the facility has been constructed in accordance with the approved permit. Unless notified otherwise by the Division, within 15 days of receipt by the Division of the written certification, the facility owner or operator may commence disposal of solid waste. This process shall be repeated for each subsequent major construction phase, including but not limited to, new cells or trenches, additional monitoring wells, sediment ponds, leachate treatment systems, modifications adding a new solid waste handling process, and application of final cover.
(3) Any person engaged in the operation of landfills shall comply with the following performance requirements:
(a) Air Criteria.
1. Owners or operators of all MSWLFs must ensure that the units not violate any applicable requirements developed under a State Implementation Plan (SIP) approved or promulgated by the U.S. Environmental Protection Agency pursuant to Section 110 of the Clean Air Act, as amended.
2. Open burning of solid waste, except for the infrequent burning of agricultural wastes, silvicultural wastes, landclearing debris, diseased trees, or debris from emergency cleanup operations, is prohibited at all MSWLF units.
(b) Unloading: solid waste unloading shall be restricted to the working face of the operation in such manner that waste may be easily incorporated into the landfill with available equipment.
(c) Procedures for excluding receipt of prohibited wastes:
1. Not later than October 1, 1993, owners or operators of all landfills must implement a program at the facility for detecting and preventing the disposal of regulated quantities of hazardous wastes as defined in the Rules for Hazardous Waste Management, Chapter 391-3-4-11, polychlorinated biphenyls (PCB) wastes as defined in 40 CFR. Part 761, and other wastes prohibited by Rule 391-3-4-.04. or the facility's permit. This program must include, at a minimum:
a. random inspections of incoming loads unless the owner or operator takes other steps to ensure that incoming loads do not contain prohibited wastes:
b. records of any inspections:
c. training of facility personnel to recognize prohibited wastes; and
d. notification of the Director if a prohibited waste is discovered at the facility.
2. The procedures must be made a part of the operating record.

(d) Spreading and Compaction: solid waste shall be spread in uniform layers and compacted to its smallest practical volume before covering with earth.
(e) Daily Cover:
1. Except as provided in paragraph 2. of this section, the owner or operataor of all MSWLF units must cover disposed solid waste with six inches of earthen material at the end of each operating day, or at more frequent intervals if necessary, to control disease vectors, fires, odors, blowing litter, and scavenging.
2. Alternative materials (such as foams or tarps) of an alternative thickness (other than at least six inches of earthen material) may be approved by the Director if the owner or operator demonstrates that the alternative material and thickness control disease vectors, fires, odors, blowing litter, and scavenging without presenting a threat to human health and the environment.
(f) Disease Vector Control.
1. Owners or operators of all MSWLF units must prevent or control on-site populations of disease vectors using techniques appropriate for the protection of human health and environment.
2. For purposes of this Rule, "disease vectors" means any rodents, flies, mosquitoes, or other animals, including insects, capable of transmitting disease to humans.
(g) Intermediate Cover: a uniform compacted layer of clean earth cover not less than one (1) foot in depth shall be placed over each portion of any intermediate lift following completion of that lift.
(h) Explosive Gases Control.
1. Owners or operators of all MSWLF units must ensure that:
a. The concentration of methane gas generated by the facility structures (excluding gas control or recovery system components); and
b. The concentration of methane gas does not exceed the lower explosive limit for methane at the facility property boundary.
2. Owners or operators of all MSWLF units must implement a routine methane monitoring program to ensure that the standards of this section are met.
a. The type and frequency of monitoring must be determined based on the following factors:
(i) Soil conditions:
(ii) The hydrogeologic conditions surrounding the facility;
(iii) The hydraulic conditions surrounding the facility;
(iv) The location of facility structures and property boundaries.
b. The minimum frequency of monitoring must be quarterly.
3. If methane gas levels exceeding the limits specified in this section are detected, the owner or operator must:
a. Immediately take all necessary steps to ensure protection of human health and notify the Director;
b. Within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health; and
c. Within 60 days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the Director that the plan has been implemented. The plan shall describe the nature and extent of the problem

and the proposed remedy.
4. For purposes of this section, lower explosive limit means the lowest percent by volume of a mixture of explosive gases in air that will propagate a flame at 25°C and atmospheric pressure.
(i) Run-on/Run-off Control.
1. Owners or operators of all MSWLF units must design, construct, and maintain:
a. A run-on control system to prevent flow onto the active portion of the landfill during the peak discharge from a 25-year storm;
b. A run-off control system from the active portion of the landfill to collect and control at least the water volume resulting from a 24-hour, 25-year storm.
2. Run-off from the active portion of the landfill unit must be handled in accordance with section (j) of this Rule.
(j) Surface water requirements; MSWLF units shall not:
1. Cause a discharge of pollutants into waters of the state or the United States, including wetlands, that violates any requirements of the Clean Water Act, including, but not limited to, the National Pollutant Discharge Elimination system (NPDES) requirements pursuant to section 402;
2. Cause the discharge of a nonpoint source of pollution to waters of the state or the United States, including wetlands, that violates any requirement of an area-wide or State-wide water quality management plan that has been approved under section 208 or 319 of the Clean Water Act, as amended.
(k) Continuity of Operation: all-weather access roads shall be provided to the working face of the disposal operation and provisions shall be made for prompt equipment repair or replacement when needed.
(l) Environmental Protection: the landfill shall be operated in such manner as to prevent air, land, or water pollution, and public health hazards.
(m) Prohibited Waste: no liquids, except as allowed in Rule .04(9), lead acid batteries, radioactive waste, or regulated quantities of hazardous waste may be accepted. The operator must have a plan for excluding these wastes.
(n) Supervision: the disposal facility shall be under the supervision of an operator who is properly trained in the operation of landfills and the implementation of Design and Operational Plans and who, if the facility is a municipal solid waste disposal facility, is certified in accordance with O.C.G.A. 12-8-24.1 and these Rules.
(o) Limited Access: access to landfills shall be limited to authorized entrances which shall be closed when the site is not in operation. Owners and operators of all landfills must control public access and prevent unauthorized vehicular traffic and illegal dumping of wastes by suing artificial barriers, natural barriers, or both, as appropriate to protect human health and the environment.
(p) Litter Control: scattering of wastes by wind shall be controlled by fencing or other barriers and the entire site shall be inspected daily and all litter removed.
(q) Fire Protection: suitable measures to control fires that may start shall be provided. Stockpiled soil is considered to be the most satisfactory fire fighting material.
(r) Erosion and Sedimentation Control: all erosion and sedimentation control measures or facilities, whether temporary or permanent, shall be continuously maintained by the operator so as to be effective. Runoff from the facility must be directed to permanent

sediment control impoundments which are designed to assure discharges meeting the requirements of O.C.G.A. 12-7-6(18). Erosion and sedimentation control measures and facilities will be employed prior to and concurrent with clearing, grading, overburden removal, access or other land disturbing activities for preparation of the site for landfilling. Immediate measures must be implemented to establish vegetation on disturbed exposed soil which will not be a part of the waste disposal area or which will remain exposed for more than three (3) months.
(s) Information Posted: signs shall be posted at the entrance to landfills indicating the days and hours of operation.
(t) Prohibited Acts: the landfill shall be operated and maintained to prevent open burning, scavenging, and the open dumping of wastes.
(u) Recordkeeping Requirements.
1. Not later than October 1, 1993, the owner or operator of a MSWLF unit must record and retain near the facility in an operating record or in an alternative location approved by the Director the following information as it becomes available:
a. Any location restriction demonstration required under Rule 391-3-4-.05;
b. Inspection records, training procedures, and notification procedures required in section (c) of this Rule;
c. Gas monitoring results from monitoring and any remediation plans required by paragraph (h) of this section;
d. Any MSWLF unit design documentation for placement of leachate or gas condensate in a MSWLF unit as required under paragraph (9) of Rule 391-3-4-.04;
e. Any demonstration, certification, finding, monitoring, testing, or analytical data required by Rule 391-3-4-.14;
f. Closure and post-closure care plans and any monitoring, testing, or analytical data as required by Rule 391-3-4-.11 and Rule 391-3-4-.12; and
g. Any cost estimates and financial assurance documentation required by Rule 391-3-4-.13.
2. The owner/operator must notify the Director when the documents from paragraph 1. of this section have been placed or added to the operating record, and all information contained in the operating record must be furnished on request to the Director or be made available at all reasonable times for inspection by the Director.
3. The Director can set alternative schedules for recordkeeping and notification requirements as specified in paragraphs 1. and 2. of this section, except for the notification requirements in Rule 391-3-4-.05(1) (c), Airport Safety, and Rule 391-3-4-.14 (30) (a) 3., Assessment Monitoring.
(v) Ground and Surface Water Monitoring: all water monitoring points shall be sampled in accordance with the appproved plans or with any directive issues by the Division. Analytical results must be submitted to the Division in accordance with the approved time schedules. It shall be the responsibility of the facility owner or operator to promptly report any exceedance of established standards. All monitoring reports must be accompanied by a statement certifying, for those constituents which have established standards, that established standards have been complied with or certifying noncompliance.
(w) Survey Control: survey control shall be provided by the owner and/or operator as

indicated on the approved design and operational plan. Site survey control shall be provided to ensure the operation will be on permitted lands. Survey control will be accomplished through use of permanent, accessible benchmarks, survey control stakes, and/or boundry markers which designate and/or delineate all permitted areas. Where necessary for construction or operational purposes, vertical as well as horizontal survey control will be established and maintained to delineate fill boundaries, buffers, structural designs. and property boundaries.

(x) Additional Stipulations: notwithstaning the above, additional stipulations for owning or operating a landfill may be imposed by the Director as deemed necessary to carry out the purposes of O.C.G.A. 12-8-20, *et seq.*

(4) Other Disposal Operations.

(a) Industrial Waste Disposal Facilities: industrial waste disposal facilities permitted to receive only a single type industrial waste (monofil) or receive only a single industry's waste may be given a varianace by the Director from installing liners and leachate collection systems, applying daily cover, installing ground water and surface water monitoring systems and monitoring for methane gas if the applicant can demonstrate to the satisfaction of the Director that the waste to be disposed of would not cause odors or be attractive to disease vectors or birds or generate methane gas. Unless a variance is granted, the applicant must demonstrate compliance with all applicable provisions of this Rule. Disposal facilities accepting wastes from more than one industrial source, unless the facility is a monofil, must meet all standards applicable to municipal solid waste landfills in Chapter 391-3-4.

(b) Construction/Demolition Facilities: disposal facilities permitted to receive only construction and demolition wastes, unless such waste includes household waste, may be given a variance by the Director from installing liners and leachate collection systems and applying daily cover if the applicant can demonstrate to the satisfaction of the Director that the waste to be disposed of would not cause odors or be attractive to disease vectors or birds. Unless a variance is granted, the applicant must demonstrate compliance with all applicable provisions of this Rule. All other provisions of Chapter 391-3-4 applicable to municipal solid waste landfills must be met.

(c) Construction and operation of a solid waste handling facility for which specific rules have not been developed is prohibited unless same are consistent with the policies and intent of O.C.G.A. 12-8-20, *et. seq.*, and are permitted by the Director.

Authority Ga. L. 1972, p. 1002, as amended; O.C.G.A. Secs. 12-8-20 et seq., 12-8-23. **History.** Original Rule entitled "Effective Date," was filed as 391-1-1-.07 on November 21, 1972; effective December 12, 1972, an specified by the Agency. **Amended:** Rule renumbered as 391-3-4-.07. Filed September 6, 1973; effective September 26, 1973. **Amended:** Rule repealed and a new Rule entitled "Disposal Operations" adopted. Filed September 19, 1974; effective October 9, 1974. **Amended:** Rule entitled "Disposal Design and Operation" adopted. F. Jun. 9, 1989; eff. Jun. 29, 1989. **Amended:** Rule entitled ::Landfill Design and Operation" adopted. F. Sept. 4, 1991; eff. Sept. 24, 1991. **Amended:** F. Jun. 7, 1993; eff. Jun. 27, 1993. **Amended:** F. Jul. 31, 1997; eff. Aug. 20, 1997.

Numerical modeling of the environment impact of landfill leachate leakage on groundwater quality-A field application

Shao-gang Dong, Zhong-hua Tang, Bai-wei Liu
School of Environmental Studies
China University of Geosciences
Wuhan 430074, China
E-mail: shaogang_dong@163.com

O. D. Orodu
Faculty of Resources
China University of Geosciences
Wuhan 430074, China

***Abstract*—There are more than 372 big uncontrolled landfill areas in China. Waste disposal facilities are mainly responsible for the gradual quality degradation of groundwater. This paper reports an integrated study undertaken to develop an environmental assessment of the uncontrolled sanitary landfill area of the city of Jiaxing, Zhejiang, China. The USGS modular 3D finite difference groundwater flow model (Mod- flow) and Modular 3D Finite Difference Mass Transport Model (MT3D) software were used to simulate groundwater flow and contaminant transport modeling. The results indicated that landfill leachate leakage has significant effect on groundwater quality.**

Keywords-environmental impact ; groundwater ; landfill leachate

I. INTRODUCTION

One of the most common waste disposal methods for solid wastes is by landfilling below or on the land surface. All over the world, about 70% of waste disposal is by landfilling, especially in the underdeveloped and developing countries. The dumping of solid waste in uncontrolled landfills can cause significant impacts on the environment and human health. Some incidences have been reported in the past, where leachate had contaminated the surrounding soil and polluted underlying ground water aquifer or nearby surface water [1][2]. Generally, the landfill leachate pollutes the water resource by three ways: 1. the downward transfer of leachate contaminates groundwater, 2. the outward flow causes leachate springs at the periphery of the landfill that may affect surface water bodies; 3. polluted groundwater seep to surface water (Fig.1). The principal concern is the pollution potential of the migration of leachate generated from the landfill site into groundwater. In the past 10 years, some models have been established for modeling leachate transport in groundwater [3] [4]; [5] [6]. In most studies, Chloride is often used as a simulation element to confirm contaminant plume. And, surface water quality is in turn affected by the seepage of leachate polluted groundwater. Hence, leachate seepage is a long-term phenomenon that must be prevented in order to protect natural water resources

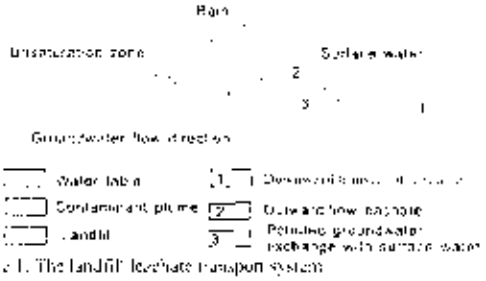


Figure 1. The landfill leachate transport system

In this paper, the potential contamination risk due to leachate leakage to the aquifer beneath a municipal solid waste landfill is examined. The Municipal Landfill of the City of Jiaxing (JXL) in China was selected for field application as a potential contamination of the aquifer beneath the landfill, may have a significant impact on public health and the local economy. The main objectives of this paper are the characterization of the leachate produced at the JXL and the hydrogeological characterization of the area of study, which includes the underlying aquifer. A groundwater flow and leachate mass transport model of the hydrogeological region beneath the municipal landfill was developed in order to examine the impact of leachate seepage from the JXL into groundwater.

II. LEACHATE CHARACTERISTICS

Leachate is the main medium for the transport of contaminants from the landfill to groundwater and surface water. Landfill leachate is formed from the infiltration and passage of water through solid waste which results in a combination of physical, chemical and microbial processes that transfers pollutants from waste materials to the water [7][8]. Leachate from municipal landfills contains a complex variety of organic and inorganic compounds. Many factors influence the leachate composition including composition of solid wastes, moisture content, the degree of compaction , hydrology of the site, pH of water , climate, age of the fill and other site-specific conditions including landfill design and type of liners used, if any [9][10].

Under normal conditions, leachate is found at the bottom of the landfill and moves through the underlying strata. Although, some lateral movement may also occur, depending on the characteristics of the surrounding

978-0-7695-3682-8/09 $25.00 © 2009 IEEE
DOI 10.1109/ESIAT.2009.9

material, leachate percolates through the underlying strata and many of its chemical and biological constituents will be removed by filtering and absorptive action of the material composing the strata. In general, the extent of this action depends on the characteristics of the soil. The exact volume of the produced leachate cannot be easily estimated as it depends on groundwater infiltration and waste composition.

The hydrometeorological conditions in the area of the JXL and its surroundings are of high importance as they affect the hydrogeological status of the area, leachate production and subsequently the risk of contamination. The rainfall in the area of the landfill is relatively high (1600-2000 millimeter/year), and, as a result, large quantities of water reach the area of the landfill as rainfall and surface run-off. The seasonal distribution of rainfall and surface run-off is uneven over the year. 60% of rainfall occurs during summer. Due to the uneven distribution of rainfall, leach production is extremely high during summer and practically occurs during the months of June, July and August. Air temperature in combination with moisture also affects leachate production within the landfill. With 10 years of operation, the leachate production of the JAX was 200 -350 meter3/day and the observed values of leachate composition for the JXL are listed in Table 1.

III. OUTLINE OF STUDY AREA

A *Characterization of the landfill*

JXL is located 1.5km east of the City of Jiaxing in the area of Renzhong village (Fig. 2). The landfill is used for the disposal of the municipal solid waste of the City of Jiaxing since 1996 and was active till September, 2007. The JXL is a landfill area of about 45000m^2 with an average of 250-450tons/day disposed (Table 2). Municipal solid wastes include all wastes

Table 1. Leachate composition at JXL

Constituent	MLP (2006) Mean values (mg/l)
COD	306
K^+	1039
Na^+	735
Cl^-	1290
Mg^{2+}	29.2
Fe	1.66
NH_4^+	700
CO_3^{2-}	80.6
SO_4^{2-}	207
NO_3	451
TDS	7364

Table 2. Annual waste disposedin JXL

Year	Waste (tons)
1998	51000
1999	53000
2000	60000
2001	65000
2002	71000
2003	72000
2004	80000
2005	90000
2006	85000

under the control of local authorities or agents acting on their behalf, such as household wastes, street litter, municipal parks, garden wastes and some commercial wastes from shops and smaller trading estates, where local authority waste collection agreements are in place. Based on investigation, the main characteristic of the municipal solid waste is the high percentage of organic matter (29%) that leads to increased production of leachate.

Figure 2. Area of study

B. Characterization of study area

The study area is located in the Yangtze Delta with high rainfall and dense surface water cover, marked by high rate of groundwater and surface water exchange (Fig. 3). JXL is in the vicinity of surface water bodies and the surface water flow velocity is very slow (<300meter/day). The altitude of the landfill area is between 2-4m above mean sea level. The JXL is around and includes the villages of Renzhong and Hexi. The closest inhabited area to the landfill is the village of Renzhong, 200m upstream. The Pinghu Lake traverses the landfill site from west to east. A conceptual geological plan of the study area is shown in Fig. 4. The main geological formations observed in the area of study are summarized as follows:

(1) Alluvial deposits of hydrogeological importance exist all through the study area with thickness of 5-10m.

(2) Distinct interbed sand (aquifer) in the midst of two aquitard (clay layer) (Fig.5)

(3) Hydraulic conductivity of unconfined aquifer varies (k = 0.5~3meter/day), the grain size distribution gradually decreases from east to west, and that of the confined aquifer is uniform (k=3meter/day).

(4) There are two clay sediment layers. The grain size distribution is very uniform, and the permeability of the formation is significantly low (k= 0.01 meter/day).

The basic hydrogeologic characterization of the area of study is summarized in Table 3.

Figure 3. Landfill area for redevelopment into a park (September, 2007)

IV. MATHEMATICAL MODEL

A. Groundwater flow model

The three-dimensional (3D) movement of groundwater of constant density through porous earth can be described by the partial differential equation:

$$\frac{\partial}{\partial x}\left(k_x \frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(k_y \frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(k_z \frac{\partial h}{\partial z}\right)+W=\mu_s \frac{\partial h}{\partial t} \quad (1)$$

$$h(x, y, z, 0)=h_0(x, y, z)$$

$$h_{s_1}=f_1(x, y, z, t)_{s_1}$$

$$k_n \frac{\partial h(x, y, z, t)}{\partial n}\Big|_{s_2}=q_2(x, y, z, t)_{s_2}$$

where k_x, k_y, k_z are hydraulic conductivity along the x, y, and z -axis (LT^{-1}); h is the hydraulic head (L); W is a volumetric flux per unit volume and represents sources and or sinks of water (T^{-1}); μ_s is the specific storage (L^{-1}); and t is time (T); h_0 is initial hydraulic head (L); $f_1(x, y, z, t)_{s_1}$ is the first boundary, $q_2(x, y, z, t)|_{s_2}$ is the second boundary. Equation(1) describes groundwater flow under non-equilibrium conditions in a heterogeneous and anisotropic medium, provided the principal axes of hydraulic conductivity are aligned with the coordinate directions. Analytical solutions of (1) are rarely possible except for very simple systems; therefore numerical methods must be employed to obtain approximate solutions as is the use of the popular finite-difference method based on discretization of points in time and space

B. Groundwater contaminant transport model

Simulation of ground-water flow is performed by the numerical solution of both ground-water flow and solute-transport equations. The partial differential equation describing the 3D transport of dissolved solutes in the groundwater can be written as follows:

$$\frac{\partial(\theta C^k)}{\partial t}=\frac{\partial}{\partial x_i}(\theta D_{ij})\frac{\partial C^k}{\partial x_j}-\frac{\partial}{\partial x_i}(\theta v_i C^k)+q_s C_s^k+\sum R_n \quad (2)$$

Where θ is porosity of the subsurface medium, dimensionless; C^k is the concentration of contaminants dissolved in groundwater of species k, (ML^{-3}); t is time, (T); x_i is distance along the respective Cartesian coordinate axis,(L); Dij is hydrodynamic dispersion coefficient tensor, (L^2T^{-1}); v is seepage or linear pore water velocity, (LT^{-1}); it is related to the specific discharge or Darcy flux through the relationship, $v_i=q_i/\theta$; q_s is volumetric flow rate per unit volume of aquifer representing fluid sources (positive) and sinks (negative), (T^{-1}); C_s^k is concentration of the source or sink flux for species k, (ML^{-3}); $\sum Rn$ is chemical reaction term, ($ML^{-3}T^{-1}$).

In this model, the MT3D, a modular three-dimensional finite-difference groundwater solute transport model based on dispersion approach, coded by [11] was applied to solve the solute-transport equation. The model is based on the assumption that changes in the concentration field do not significantly affect the flow field. This allows the user to construct, calibrate and validate a flow model independently. The calculated hydraulic heads and various flow terms from the current USGS modular 3D finite difference groundwater flow model (MODFLOW) solution are used to set the basis for simulating and predicting the solute transport behaviors of the groundwater system

Figure 4. Conceptual geological plan view of the area of study

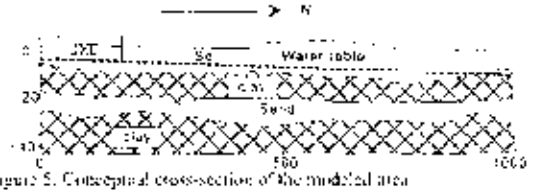


Figure 5. Conceptual cross-section of the modeled area

Table 3. Geological-geotechnical and climatic characteristics

Property	Layer 1	2	3	4
Geologic material	Sand	Clay	Sand	Clay
Hydraulic conductivity (m/d)				
Total porosity	0.32	0.41	0.35	0.39
Effective porosity	0.28	0.21	0.33	0.25
Average thickness(m)	10	10	5	15
Longitudinal dispersivity (m)	0.1	0.03	0.2	0.01
Horizontal dispersivity ratio	0.1	0.01	0.2	0.01
Vertical traverse dispersivity ratio	0.1	0.01	0.2	0.01
Rainfall (mm/year)	1800			
Recharge (mm/year)	600			
Field capacity (m^3/m^3)	0.19			
Storage (1/m)	0.000035			
Bulk density (kg/m^3)	1800			

V. RESULTS AND DISCUSSION

The basic input data for modeling the aquifer parameters includes topography, geometry, elevation, and soil properties of each soil layer in the aquifers. Since the study area is close to a river, the river level was taken as the first boundary. Discharge from the system includes pumping wells and evapotranspiration. A total of 21 village pumping wells located in the study area were taken into consideration. A finite-difference grid was developed to adequately discretize the model domain by minimizing the total number of model cells. For the JXL, the groundwater system of interest is about 1.7 km^2 and is covered with 3D grid cells of D_x=18.28 m, D_y=38.09m consisting of 8,480 cells. Boundary conditions are assigned head boundary to all three sides according to the surface water level. The general head boundary is typically a MODFLOW feature which models the in or outflow to an element through the difference between the head in the element itself and an external fixed head. The Pinglin Lake and Beiliao River in the study area appear to

intersect the groundwater system. The river package was applied to account for this feature. In addition, the drain package is used to take into account the features of drained agricultural areas. The average recharge amount from paddy fields to groundwater was estimated to be 8.5millimeter/day during the planting season of crops from June to September. Water levels along the eastern model boundary were designated as a time varying specified head boundary as water entering or leaving the system depends on the water-level gradient between cells in consideration and adjacent active cells. The initial heads were interpolated based on water level data from near by wells. The final choices for model parameters were achieved through trial and error. During the calibration, the hydraulic characteristics of the modeled layers were adjusted until a satisfactory correspondence between model results and observed field data was obtained. Calibrated hydraulic parameters of material properties of the layered aquifer systems are summarized in Table 3. Fig. 6 shows satisfactory calibration of two wells.

According to the results of the computer program, there will be no contamination in observation wells at Renzhong village for a long time. Fig. 7 shows the model area where Chloride ion (Cl-) (100 mg/l) moves 180m to the north and 30m to the west in the past 10 years in the groundwater. The result of the model indicates that chloride does not reach the observation wells (QR22, QR23) in Renzhong village during this time. But in 30 years, the model results also indicate that Cl- (100 mg/l) can move about 600 m in groundwater to the north, and most of the wells in Hexi village will be affected. Oil and grease has also been applied on the model area, according to this study oil and grease cannot reach the wells in Hexi village since it degrades and is adsorbed by soil particles in 10 years in the future.

Analysis of the groundwater transport model result indicates that leachate move mainly northwards and eastwards. Part of the wells in Hexi village will be contaminated in 5 years suggesting high amount of contaminant transport into the Beijiao River from the landfill, the Pinghu Lake receives minute quantity of the pollutants.

VI. CONCLUSION

The USGS modular 3D finite difference groundwater flow model (MODFLOW) and Modular 3D Finite Difference Mass Transport Model (MT3D) software were used to simulate groundwater flow and contaminant transport modeling. The contaminant source was attributed to leachate from Jiaxing Landfill contaminating groundwater and eventually wells.It was found that groundwater flow is most sensitive to the changes in the hydraulic conductivity and to a lesser extent to changes in infiltration and leachate infiltration flow. The model calibration was performed with field data of the measured chloride plume

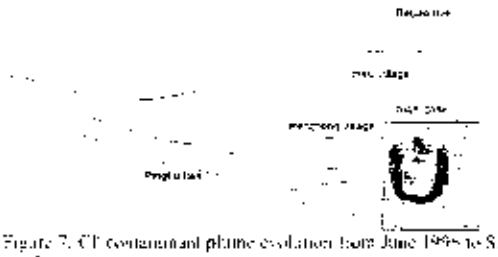


Figure 7. CF contaminant plume evolution from June 1995 to September 2007

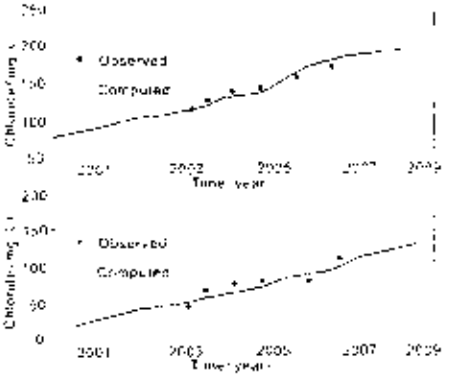


Figure 6. Chloride concentration in wells (QR23 and QR17)

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Draft 2010 Integrated 305(b)/303(d) List

Streams - Supporting Designated Uses

Reach Name/ ID #/ Data Source	Reach Location/ County	River Basin/ Use	Criterion Violated	Potential Causes	Extent		Category	Priority	Notes
Beaverdam Creek R030701011307 59	Headwaters to Big Sandy Creek Morgan County	Oconee Fishing			9	miles	1		
Beaverdam Creek R030701011201 4	Northwest of Smyrna Church Hancock County	Oconee Fishing			2	miles	1		
Beaverdam Creek R030701011203 4	Hancock County Hancock County	Oconee Fishing			4	miles	1		
Big Indian Creek R030701011406 1.36	Little Indian Creek to Little River Morgan/ Putnam County	Oconee Fishing			7	miles	1		
Big Sandy Creek R030701020604 4	Clear Creek to Porter Creek Wilkinson County	Oconee Fishing			6	miles	1		
Black Spring Branch R030701020101 4	Baldwin County Baldwin County	Oconee Fishing			4	miles	1		
Buck Creek R030701020104 4	Tributary to Oconee River Baldwin County	Oconee Fishing			4	miles	1		

GA EPD 303(d)

Description of the 305(b)/303(d) List of Waters

Background

Before the 305(b)/303(d) List of Waters can be described, it is necessary to provide a little background information. Every waterbody in the State of Georgia has one or more designated uses. Examples of designated uses are "fishing", "recreation" and "drinking water". The State has also adopted water quality criteria to protect these uses. For instance, the State has determined that for a water to support its use of fishing, it must have a daily average dissolved oxygen concentration of at least 5.0 mg/l and a minimum of 4.0 mg/l. Some other examples of parameters that have water quality criteria are pH, fecal coliform bacteria, temperature, metals and certain organic pollutants. Georgia's designated uses and water quality criteria can be found in Chapter 391-3-6-.03 of the Rules and Regulations for Water Quality Control.

GA EPD determines whether a waterbody is supporting its designated uses by collecting water quality data and comparing this data against the water quality criteria. It is the goal of the State of Georgia that all of its waters support their designated uses. If it is determined that a water is not supporting its designated use, then GA EPD will typically develop a total maximum daily load (TMDL) as the start of the process of restoring the water. A TMDL determines how much of a particular pollutant a waterbody can contain and still support its designated use. The TMDL will state how much the pollutant load to the water needs to be reduced in order for the water to support its designated use.

What are the 305(b) Report, the 303(d) List and the 305(b)/303(d) List of Waters?

Section 305(b) of the Clean Water Act requires States to assess and describe the quality of its waters every two years in a report called the 305(b) report. Section 303(d) of the Clean Water Act requires States to submit a list of all of the waters that are not meeting their designated uses and that need to have a TMDL(s) written for them. The 303(d) list is also to be submitted every two years. Georgia submits a combined 305(b)/303(d) report. This combined report is called an Integrated Report and has typically been entitled the "Water Quality in Georgia" report. One section of the Integrated Report is the 305(b)/303(d) list of waters. This is a list of all of the waters that the State has assessed. This list of waters is developed as described below.

How does GA EPD Develop the 305(b)/303(d) List of Waters?

Every two years GA EPD gathers data that has been collected across the State. This data comes from a number of sources including GA EPD, other State agencies (such as the Wildlife Resources Division and the Coastal Resources Division), Federal Agencies (such as the US Geological Survey), and local governments and environmental groups. The water quality data are compared to the State's water quality criteria using GA EPD's listing assessment methodology. Based on the comparison of the data to the water quality criteria, GA EPD places each water into one of three broad groups. Waters are assessed as 1) supporting their designated use; 2) not supporting their designated use; or 3) assessment pending.

Description of the Five-Part Categorization System

In addition to the three broad groupings described above, GA EPD adopted a five-part categorization of its waters at the request of U.S. EPA in 2008. Each of the five categories corresponds to one of the three groups (supporting, not supporting, or assessment pending) as described below.

Category 1 – Data indicate that waters are supporting their designated use(s).
Category 2 – A water has more than one designated use and data indicate that at least one designated use is being supported, but there is insufficient evidence to determine that all uses are being supported.
Category 3 – There is insufficient data or other information to make a determination as to whether or not the designated use(s) is being supported.
Category 4a – Data indicate that at least one designated use is not being supported, but TMDL(s) have been completed for the parameter(s) that are causing a water not to meet its use(s).
Category 4b - Data indicate that at least one designated use is not being supported, but there are actions in place (other than a TMDL) that are predicted to lead to compliance with water quality standards.
Category 4c - Data indicate that at least one designated use is not being supported, but the impairment is not caused by a pollutant.
Category 5 - Data indicate that at least one designated use is not being supported and TMDL(s) need to be completed for one or more pollutants. Waters in Category 5 make up the 303(d) list.

In summary, waters supporting their designated use correspond to Category 1. Waters not supporting their designated use correspond to Categories 4a, 4b, 4c and 5. Waters where the assessment for use support is pending correspond to Category 2 and 3. To date, GA EPD has not placed any waters in Category 2 or 4c.

Organization of the 305(b)/303(d) List of Waters

Since waterbodies (such as streams and rivers) are typically many miles long, it is usually not feasible to assess a whole waterbody as a single unit. Therefore each waterbody is typically broken into smaller portions called "reaches". The size of each reach varies. For example, one reach of the Chattahoochee River starts where Utoy Creek enters the Chattahoochee River and ends where Pea Creek enters the River. Each row in the 305(b)/303(d) list of waters represents an assessed "reach".

The 305(b)/303(d) list of waters includes a number of types of information about each assessed reach. While much of the information contained in the list of waters is self explanatory, a table of the different kinds of information included in the list is provided below.

Column Header	**Explanation of Data in Column**
Reach Name	Name of the Waterbody that was assessed
Reach ID #	Unique number assigned to each assessed reach
Data Source	Provides information as to what organization has submitted water quality data. See document "Data Source/Code Key for

	Abbreviations" for an explanation of the codes used.
Reach Location	Narrative describing what portion of a waterbody the assessment applies to
County	Lists the County(s) in which the reach is located
River Basin	Lists the River Basin in which the reach is located
Use	Lists the Designated Use(s) of the waterbody
Criterion Violated	This field is only populated for waters assessed as "Not Supporting" and it shows what criteria are not being met. See document "Data Source/Code Key for Abbreviations" for an explanation of the codes used.
Potential Causes	This field is only populated for waters assessed as "not supporting" and provides potential sources of the violated criterion. See document "Data Source/Code Key for Abbreviations" for an explanation of the codes used.
Extent	Provides the length or area of the assessed reach
Category	Refers to the five-part categorization of waters. Waters in Category 5 make up the 303(d) list
Priority	This field is only populated for reaches in Category 5. It provides the date by which GA EPD plans to draft the TMDL
Notes	Provides additional information such as what TMDLs have been completed or explains why a reach is in Category 3.

Finally, it is helpful to understand how the 305(b)/303(d) list of waters is arranged when reviewing it. As stated above, the 305(b)/303(d) list of waters is a list of all of the waters that have been assessed by the State. The 305(b)/303(d) list is first organized by waterbody type (i.e. streams, lakes, coastal beaches, etc.). Each waterbody type is further arranged by use support (i.e. supporting, not supporting, or assessment pending). Each use support category is further arranged alphabetically by River Basin and then alphabetically by waterbody name.

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Engineering Geology 60 (2001) 3–19

ENGINEERING GEOLOGY

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Containment landfills: the myth of sustainability

A. Allen*

Department of Geology, University College Cork, Cork, Ireland

Accepted for publication 16 April 2000

Abstract

A number of major problems associated with the containment approach to landfill management are highlighted. The fundamental flaw in the strategy is that dry entombment of waste inhibits its degradation, so prolonging the activity of the waste and delaying, possibly for several decades, its stabilisation to an inert state. This, coupled with uncertainties as to the long-term durability of synthetic lining systems, increases the potential for liner failure at some stage in the future whilst the waste is still active, leading to groundwater pollution by landfill leachate. Clay liners also pose problems as the smectite components of bentonite liners are subject to chemical interaction with landfill leachate, leading to a reduction in their swelling capacity and increase in hydraulic conductivity. Thus, their ability to perform a containment role diminishes with time. More critically, if diffusion rather than advection is the dominant contaminant migration mechanism, then no liner will be completely impermeable to pollutants and the containment strategy becomes untenable.

There are other less obvious problems with the containment strategy. One is the tendency to place total reliance on artificial lining systems and pay little attention to local geological/hydrogeological conditions during selection of landfill sites. Based on the attitude that any site can be engineered for landfilling and that complete protection of groundwater can be effected by lining systems, negative geological characteristics of sites are being ignored. Furthermore, excessive costs in construction and operation of containment landfills necessitate that they are large scale operations (superdumps), with associated transfer facilities and transport costs, all of which add to overall waste management costs. Taken together with unpredictable post-closure maintenance and monitoring costs, possibly over several decades, the economics of the containment strategy becomes unsustainable. Such a high-cost, high-technology approach to landfill leachate management is generally beyond the financial and technological resources of the less wealthy nations, and places severe burdens on their economies. For instance, in third world countries with limited water resources, the need to preserve groundwater quality is paramount, so expensive containment strategies are adopted in the belief that they offer greatest protection to groundwater. A final indictment of the containment strategy is that in delaying degradation of waste, the present generations waste problems will be left for future generations to deal with.

More cost-effective landfill management strategies take advantage of the natural hydrogeological characteristics and attenuation properties of the subsurface. The 'dilute and disperse' strategy employs the natural sorption and ion exchange properties of clay minerals, and it has been shown that in appropriate situations it is effective in attenuating landfill leachate and preventing pollution of water resources. Operated at sites with thick clay overburden sequences, using a permeable cap to maximise rainfall infiltration and a leachate collection system to control leachate migration, 'dilute and disperse' is a viable leachate management strategy. Hydraulic traps are relatively common hydrogeological situations where groundwater flow is towards the landfill, so effectively suppressing outwards advective flow of leachate. This approach is also best employed with a clay liner, taking

* Tel.: 353-21-902533; fax: 353-21-271565.
E-mail address: a.allen@ucc.ie (A. Allen).

PII: S0013-7952(00)00084-3

advantage of the attenuation properties of clays to combat diffusive flow of contaminants. These strategies are likely to guarantee greater protection of groundwater in the long term.

Keywords: Sustainability; Landfills; Containment; Liners; Leachate

1. Introduction

The concept of sustainability with respect to landfill management has been frequently propounded recently (e.g. Derham, 1995; Driessen et al., 1995). As with other environmental issues, the attainment of sustainability in the sphere of waste management has become the common aspiration of legislators, regulators, local government and the waste industry at large. Sustainability, however, is a somewhat nebulous term, often used with a less than complete understanding of its full import. In the context of landfills, it is here defined as '*the safe disposal of waste within a landfill, and its subsequent degradation to the inert state in the shortest possible time-span, by the most financially efficient method available, and with minimal damage to the environment*'. The critical clause of the above definition is the reference to degradation of the waste over the shortest possible time-span, as this not only controls the economics of the waste disposal process, but determines the potential for environmental accidents during the period of activity of the waste. Furthermore, from a purely moral standpoint it is important that this generations waste is rendered inactive as precipitously as possible, so that our waste problems are not left for future generations to deal with.

A sustainable waste management philosophy should encompass the following basic principles:

- Reduction in the generation of waste.
- Waste streaming at source.
- Recycling and reuse.
- Pre-treatment of waste to minimise quantity and volume.
- Landfilling of residual waste.
- Aftercare and rehabilitation of landfills after closure.
- Each generation to deal with all of its own generated wastes.

The latter two principles may be the most problematic, since realisation of both is dependent upon the rapid degradation of waste going to landfill. Current EU landfill management policies and legislation, favour the containment strategy of emission control as an environmental protection measure. However, this is an extremely expensive option which, as will be argued below, is likely to create more environmental problems in the long term, than it supposedly resolves in the short term.

Landfill is critical to most waste management strategies, because it is the simplest, cheapest and most cost-effective method of disposing of waste. In 1989, proportions of waste going to landfill, ranged from about 60% in OECD countries (Stanners and Bourdeau, 1995) to 100% in developing countries. Although in the future, waste minimisation and recycling programmes will reduce waste volumes, and other waste treatment options may be developed, at the end of the day landfills will still be required to accommodate residual wastes (Allen et al., 1997). In the developing world, a general lack of education and social and technological infrastructure mitigates against the initiation of waste reduction programmes or the development of alternative waste treatment options, thus ensuring that in these regions, for the foreseeable future, landfills will continue to be the major method of waste disposal (Allen, 1998).

In developing waste management policies, it is incumbent upon the richer nations to take cognisance of the resources of poorer nations so that universal standards can be applied that are within the technological and financial capabilities of the poorer nations. Pollution transcends national boundaries, and given the recent trend of economic groupings such as the EU to develop standard pollution control legislation, it would seem logical to attempt, where possible, to develop standards that, whilst being acceptable to the more developed nations, are relatively simple and inexpensive to implement, thus making them achievable by third world nations.

In the light of the foregoing, the trend of the more developed nations towards the containment strategy of landfill management, which embodies an expensive highly technological approach to the design and operation of landfills, is critically examined. Evidence

and arguments are presented to suggest that this strategy cannot bring about sustainability in landfilling, but on the other hand could lead to serious future environmental degradation of the type that the landfill industry would seek to avoid.

2. The containment strategy

Current EU landfill regulations, now enacted into law by all member states, have made the installation of artificial lining systems and impermeable cappings mandatory for all landfills, except for sites possessing a suitable in situ low permeability ($<10^{-9}$ m s^{-1}) natural liner, which can also ensure complete containment of landfill emissions. Thus containment is now the only permissible landfill management strategy within the EU. Other landfill management strategies, such as hydraulic traps and 'dilute and disperse', which take advantage of the natural characteristics and properties of the subsurface, and which, in appropriate circumstances, could be developed and operated at a fraction of the cost of a containment landfill, will not in future even be considered by planners, since, under current legislation, they will no longer be granted a licence. Thus the EU has favoured, to the exclusion of all other strategies, an expensive purely technological approach to landfill management, at the expense of cheaper natural solutions.

The new EU regulations are based on the premise that artificial lining systems can wholly contain all leachate produced during degradation of landfill waste, and so provide complete protection to all groundwater, i.e. the concentrate and contain method of leachate control (Gray et al., 1974). However, due to unremitting leakage problems, the requirement to contain all leachate within the landfill, has necessitated the design of more and more elaborate liner systems, so that now it is standard to install composite two, three, or four layer multibarrier clay-membrane systems (Tchobanoglous et al., 1993; Cossu, 1994, 1995). These typically consist of sheets of synthetic membrane, most commonly high density polyethylene (HDPE), interlayered with clay mineral material, usually the smectite-rich bentonite or a bentonite-enriched soil (BES). Two layer systems consist of a sheet of HDPE overlying a 1 m thick mineral layer, three layer systems are composed of a 1 m thick mineral layer sandwiched between two sheets of the synthetic membrane, whilst four layer systems are represented by two sheets of membrane alternating with two 1 m thick mineral layers. Leak detection and leachate collection systems are also generally built into the lining designs. Daily covering of the waste with a clay-rich soil, in order to reduce wind-blown litter, odours, birds, vermin, flies and visual intrusion, is a further requirement. On closure of the landfill, an impermeable capping is installed to prevent infiltration of rainwater. The cap commonly consists of a sheet of flexible membrane such as HDPE, or a sufficiently thick layer of clay-rich soil with a permeability of at least 10^{-9} m s^{-1} (Cossu, 1995). A landfill gas collection system is usually installed immediately beneath the capping material, and completed cells are generally landscaped, to ensure that virtually all rainwater runs off the surface.

The effective functioning of such a complex containment system is dependent on the careful design and engineering of each site, strict quality control during installation of the liner system, excessive care during waste disposal operations, and high levels of maintenance throughout the operational life of the landfill. Thus the containment strategy employs a purely engineering solution to leachate management, representing a high cost technological approach, not only involving major expense in construction, but also costly levels of maintenance (Mather, 1995).

3. Flaws in the containment strategy

High levels of confidence have been accorded the containment principle of landfill management. Unfortunately, these may be severely misplaced. There are a number of fundamental flaws in the containment approach, some of which have serious long-term environmental implications, but which have tended to be either ignored or played down. The main problems are discussed below.

3.1. Durability of artificial liner systems

The long-term durability of artificial landfill liners is as yet unproven. Landfill waste degradation is a long-term process, and even under wet conditions,

stabilisation of waste to an inert state ('final storage quality') has not occurred in most landfills 20 years after completion and capping (Belevi and Baccini, 1989). However, landfill liner systems have only been in use for about 30 years, so their long-term performance is uncertain. Thus, apart from the leakage problems, which have plagued them from the outset, and have led to the development of more and more complex lining systems, the uncertain long-term durability of these lining systems is of major concern.

Furthermore, numerous recent studies have drawn attention to some of the deficiencies associated with artificial lining systems, particularly the synthetic membranes. The behaviour of such synthetic materials (e.g. CPE, PVC, EPDM, PP and HDPE) subjected over long time-scales to the corrosive effects of leachate, and to the elevated temperatures generated by the exothermic processes operating within landfills, is extremely uncertain. The polymer membranes (e.g. HDPE) are generally regarded as being more chemically and biologically resistant than other synthetics (Cossu, 1995). However, HDPE membranes have been shown to be prone to stress cracking (Rollin et al., 1991; Thomas and Woods-DeSchepper, 1993) and are also known to crack under cold conditions (Thomas and Kolbasuk, 1995; Thomas et al., 1995). Nonwoven textiles such as PET and PP appear to be highly prone to ageing during exposure to the natural elements, leading to severe embrittlement (Cazzuffi et al., 1995), and PVC is known to degrade when exposed to gasoline products (Surmann, et al., 1995). Bituminous membranes (e.g. SPS) may also be sensitive to stress cracking, and have been shown to be subject to ageing, particularly at elevated temperatures (Duquennoi et al., 1995).

The synthetic membranes are also highly prone to damage (Artieres and Delmas, 1995; Colucci and Lavagnolo, 1995), particularly due to poor dumping practices, or failure of the membranes near welded seams (Surmann et al., 1995). Furthermore, extreme care and favourable weather conditions are essential during installation of these lining systems, because they are susceptible to failure if strict quality controls are not adhered to during installation (Averesch, 1995). Thus, apart from their high costs of purchase and installation, and the need for long-term maintenance, the durability of synthetic liners remains highly suspect.

Mineral layers within the liner system, typically consisting of bentonite clays, which are predominantly composed of expansive smectite group minerals, are usually situated below the synthetic membranes. Thus they are supposedly isolated from the landfill leachate. These layers necessitate emplacement and compaction at optimum moisture contents (Mundell and Bailey, 1985; Daniel, 1987; Majeski and Shackleford, 1997), and even if this is adhered to, they will tend to desiccate under the elevated temperatures generated within landfills. Indeed bentonitic mineral layers have been shown to be susceptible to severe dessication cracking due to inaccessibility of moisture (Meggyes et al., 1995; Holzlöhner and Ziegler, 1995), and elevated temperatures (Holzlöhner, 1994). Furthermore, in the event of failure or leakage of the synthetic membrane, chemical interaction between organic substances and bentonite lead to an increase in permeability (Fernandez and Quigley, 1985; Alther, 1987). Similarly, interaction between inorganic pollutants and smectitic clays in mineral liners can lead to cracking (Wagner, 1988), also increasing the permeability of the clay layers. Also, sorption of heavy metal ions within the intermediate layer of the smectite may result in the loss of swelling potential and plasticity as well as to significant volume changes in the smectite (Wagner, 1994). Joseph and Mather (1995) have further shown that the method of emplacement of the mineral liner in "lifts" can create horizontal migration pathways which can connect with vertical migration pathways of the desiccation type. Thus, in the event of failure of the synthetic membrane, the mineral layers in the lining system may have a significantly reduced potential to inhibit leachate migration.

Ultimately, the key to the containment method of leachate control, i.e. the effectiveness of composite artificial liner systems in preventing leachate migration from the landfill, will be almost solely dependent on the performance of the synthetic membrane member(s). It is unlikely that any synthetic membrane is completely free of defects (Christensen et al., 1994), regardless of quality control and, whilst leakage may be minimal initially, it is the long-term durability of the membrane(s) over periods of tens or possibly even hundreds of years, under conditions that are ultimately unpredictable, that leaves grounds for concern. In the light of the 'precautionary

principle', the wisdom of placing such long-term reliance on an as yet unproven technology is shortsighted, and may ultimately be to our detriment.

3.2. Problems with clay liners

Clay liners are in common use, particularly in North America, but are employed solely with a containment function, permeability being the critical property, and attenuation properties being of little importance. Various types of clay liner have been experimented with (Farquhar, 1994), including in situ clay deposits; swelling clay (usually bentonite); sand-swelling clay mixtures (ranging up to 15% w/w bentonite); and remoulded and compacted clay. In situ clay deposits may not require remoulding and compaction provided large scale permeability is not adversely affected by weathering, root penetration or continuous inclusions of coarser materials (Williams, 1988; Quigley et al., 1988).

Bentonite or bentonite-bearing mixtures have been predominantly used as clay liners in the past. Bentonites are composed of the highly unstable smectite mineral montmorillonite, which has Na and Ca endmembers, the former having the greater swelling potential and higher activity (Velde, 1992; Cancelli et al., 1994). Replacement of Na in the montmorillonite by Ca, due to reaction with MSW leachate, results in shrinkage of the clay, development of cracks, increased permeability and lower activity (Hoeks et al., 1987; Madsen and Mitchell, 1989)). The extent to which this occurs, depends on the degree of incompatibility between the clay liner and the leachate (Farquhar and Parker, 1989), which will be a function of the leachate composition and the Na:Ca ratio of the montmorillonite. For instance, European bentonites with greater substitution of Ca and Mg as opposed to Na are less susceptible to Na replacement, and thus less prone to shrinkage and increase in permeability (Hoeks et al., 1987; Madsen and Mitchell, 1989). Furthermore, hydraulic conductivities of the same sand-bentonite mixture have been shown to be two orders of magnitude higher for leachate than for water (Hoeks et al., 1987). Thus, bentonite and sand-bentonite liners appear not to perform a containment function well in the longer term.

Compacted clay liners consisting mainly of non-swelling clays do not suffer to a major extent from the problem of reaction with MSW landfill leachate, provided the swelling clay content is kept to a minimum (Gordon, 1987; Farquhar and Parker, 1989). In fact liner permeability often decreases with time due to sealing by precipitate formation, solids accumulation and biomass growth along the upper surface of the liner and into any pre-existing cracks and fissures (Quigley and Rowe, 1986; Daniel, 1987; Farquhar and Parker, 1989). So compacted liners are the most versatile type of clay liner as far as containment is concerned.

However, as indicated earlier, hydraulic conductivity of clay liners is critically dependent on moisture content and degree of compaction. The nature of this dependence is an increased density with compaction effort and also a non-linear dependence of density on moisture content resulting in an optimum moisture content to produce maximum density (Farquhar, 1994). This dependence is specific to the clay mixture being tested, and cannot be applied to other soils, so equivalent data sets must be generated for each liner material being considered. Thus, in order to comply with hydraulic conductivity specifications in landfill design regulations, each liner must be rigorously tested, with placement necessitating optimum weather conditions, standardised compaction effort, strictly controlled moisture content and very careful compaction techniques. Adverse weather conditions, which delay completion of the placement process can have serious ramifications in terms of liner performance. Overall, regardless of whether an in situ or cheap local source of clay is available, the testing and correct installation of clay liners performing a containment function is costly.

Furthermore, field testing of the hydraulic conductivity of clay liners is notoriously difficult to perform, and laboratory test values do not correlate well with field values, often being of the order of one to two orders of magnitude less than field measurements (Daniel, 1987; Williams, 1988). This primarily stems from the high hydraulic gradients of several hundred under which laboratory test are performed, compared with normal field hydraulic gradients of less than 1.0. Such high gradients generate unnatural flow conditions, which adversely affect hydraulic conductivity leading to errors (Quigley et al., 1988). Other problems with laboratory tests are the size of the samples, which are insufficiently large to account

for field heterogeneities such as cracks, or their insufficient duration to account for long term interactions between the liner and the leachate (Farquhar, 1994). The only correct hydraulic conductivity is that exhibited by the liner in place, determined by seepage measurements in the field using large-scale infiltrometers. However, these are expensive and take several months to complete.

Thus, natural clay liners, whilst probably more durable and certainly cheaper and more environmentally friendly than synthetic liners, may not perform a purely containment function as adequately as might be hoped over the longer term, due to problems of chemical interaction with leachate, difficulties in placement and in precise determination of hydraulic conductivity. However, in the event of failure of clay liners, attenuation properties of the clays can mediate, to a greater or lesser extent, groundwater contamination by the leachate.

Furthermore, it has now been recognised that the dominant mechanism of contaminant migration may be diffusion and not advection, (Rowe, 1994b). Consequently, and this applies both to synthetic and natural materials, even if the liner system performs to expectation, and leakage is minimal, migration of contaminants through the liner by diffusive processes, may still occur. Therefore, complete containment of all contaminants emitted by landfill waste may be a fallacy. However, migration of contaminants through natural clay liners may be mitigated by the attenuation properties of the clays.

3.3. Unsuitability of sites

As a consequence of the over-reliance placed in liner technology, frequently little attention is paid to local geological/hydrogeological conditions in the choice of sites for landfills. Indeed, not only are the most suitable sites from a geological/hydrogeological perspective ignored, but often sites are selected regardless of negative geological factors. In fact, misplaced trust in the containment concept is so absolute, that the geological/hydrogeological characteristics of any proposed site are generally seen as no more than the basis for an elaborate engineering plan, based on the attitude that any site can be engineered for landfilling (O'Sullivan, 1995).

For example, landfills are frequently sited in pre-excavated holes such as quarries and gravel pits, chosen because a hole already exists, thus reducing the cost of site development. Rocks forming the floors and sides of quarries are typically highly fractured due to blasting operations, so generally present little barrier to leachate migration. Similarly, gravel provides little natural attenuation to migrating leachate. In such quarry sites, the lining system is often placed almost directly against the bedrock, commonly with only a very minimal thickness layer of gravel or soil beneath it, primarily as protection for the liner. Quarry sites selected may even be filled with water, and thus must be temporarily drained to lower the local water table in order to install the lining system and emplace the refuse.

At one such site in Ireland, bedrock of highly karstified limestone, is first quarried for road metal down to the level of the water table, creating a hole which is then lined and used as a landfill site. The site is coastal, occupying part of a small peninsula, which juts into a tidal lagoon, the mudflats of which are used for oyster farming. The limestone bedrock forms part of a major limestone syncline, representing an important regional aquifer. Not only is there the potential to pollute an ecologically sensitive area, in the event of leakage or liner failure, but widespread contamination of groundwater in this regionally important aquifer is also a serious risk. However, although from a geological/hydrogeological perspective it represents the worst possible scenario, the site is generally regarded as a very satisfactory site on the basis that, because of its seclusion, it has attracted little local opposition apart from the owner of the oyster farm.

The fact that, at this and many other such sites, there is no underlying geological barrier to control leachate migration in order to give secondary protection to the groundwater in the event of liner failure seems to have been of little importance in selecting the site. Indeed at some sites, overburden with a high attenuation potential has been stripped away during site development. Clearly the need for a secondary natural geological barrier to leachate migration is regarded as unnecessary, thus placing total reliance on artificial lining systems. In view of the leakage problems and uncertainties as to the long-term durability of artificial liners outlined above, this represents at best a naïve and somewhat ill-advised trust in such liners.

3.4. Impact on landfill waste degradation rates

Encapsulation of waste inhibits waste degradation and considerably prolongs the activity of the waste. The most critical flaw in the current containment landfill ethos, is the misconception that encapsulation of landfill waste within artificial liner systems will, by minimising leachate and gas production, protect the environment (Joseph and Mather, 1993). In fact the opposite is more likely to be the case. By isolating the waste from the natural agents of degradation, particularly water (i.e. keeping the waste dry), rates of degradation within the waste will be minimised, thereby prolonging the activity of the waste and inhibiting its stabilisation to an inert state. Stabilisation of waste results from degradation processes which, whether they occur over a period of decades or centuries, involve the production of the same amount of leachate and gas (Joseph and Mather, 1995). Permanently isolating the waste, with the resultant long-term threat to the environment, will necessitate an infinite period of monitoring (Carter, 1993; Stegmann, 1995). Furthermore, prevention of rainwater infiltration, designed to minimise the production of leachate, leads to the generation of a highly concentrated, toxic leachate, which in contact with the artificial membrane over a long time-span, may have an extremely corrosive effect on the membrane, leading to its degradation.

It is clear that there is a fundamental flaw in the reasoning that has led to the current landfill legislation. On the one hand, encapsulation of waste in landfills within artificial lining systems reduces the potential for environmental pollution by leachate in the short and medium term. On the other hand, however, minimisation of the production of leachate resulting from the 'dry entombment' of the waste, inhibits its degradation, delaying its stabilisation to an inert state. Given the uncertainty regarding the durability of artificial lining systems over a long time-span, it also increases the potential for environmental pollution in the long term.

Recognition of this paradox has led to the concept of accelerated waste decomposition (AWD) (Harris et al., 1994) by enhancement of microbial degradation processes — the 'bio-reactor landfill' concept (Campbell, 1992; Blakey et al., 1995). Microbial communities are complex and only poorly understood and, given the heterogeneity of waste and the variety of environmental conditions which exist within landfills, it is not surprising that there is much uncertainty regarding microbiological processes and the optimal conditions for their enhancement. It would appear unlikely that control of microbial processes within landfills can be achieved within the foreseeable future, for the 'bio-reactor landfill' concept to become a reality (Blakey et al., 1995).

What has become clear from waste degradation research, is the critical importance of moisture content in promoting microbial activity. In order to increase moisture content, some method of periodic flushing of the waste with water, referred to as 'below cap irrigation', must be accomplished, one solution being recirculation of leachate (Barber and Maris, 1984). This, however, requires installation of sophisticated below cap irrigation systems, and problems of efficiency of recirculation remain. It seems somewhat ludicrous that on the one hand ingress of rainwater to the waste is inhibited by capping, whilst on the other expensive below cap irrigation systems must be built into the landfill design to accomplish what could be achieved naturally.

3.5. Aftercare

Long term post-closure maintenance and monitoring of landfills may be financially unacceptable. The new EU regulations and national legislation of member states holds landfill operators responsible for aftercare and monitoring of landfills after completion and capping, and require the license holders to post bonds to cover financial aspects of the discharge of their responsibilities under the terms of the license. Furthermore, the licensee will not be able to surrender the license until the regulatory agency is satisfied that the facility concerned is not causing, and is unlikely to cause future environmental pollution. This aspect of landfill regulations has major implications for landfill operators, in that the landfill operators, be they local authorities or private contractors, will be responsible for the landfill for as long as the waste is active and has a potential to cause pollution. Thus a scenario of long-term, largely unpredictable, maintenance and monitoring costs following completion and capping of the landfill (after revenue earnings have ceased) looms for landfill operators

(Mather, 1995). It therefore becomes incumbent on landfill operators to ensure that the rate of degradation of waste in landfills is optimised in order to reduce the time-scale of their liability.

The threat of long-term liability also has serious implications both for landfill operators and regulatory agencies. Should the liner system fail before the waste is stabilised to an inert state, leading to leachate or gas migration and environmental pollution, then under the 'polluter pays' principle, the landfill operator will be liable. The economic ramifications of this for landfill operators, given the unpredictability of the costs of mitigation of environmental damage possibly decades into the future, would seem an unacceptable risk, regardless of long-term liability insurance cover. Furthermore, legal difficulties in enforcing such a principle several decades or even centuries into the future, may be daunting, and pose a major problem for regulatory agencies.

3.6. Financial and social costs

The containment strategy employs a costly high technology engineering solution, which puts severe constraints on the economics of the landfill operation. Because of the high cost of preparation of the site and purchase and installation of the lining system, it has become uneconomic to develop small landfills, and the trend is now towards huge superdumps serving large catchment areas. Due to their remoteness from the source of much of the waste arising, these superdumps generate further costs, as waste has to be transported often over great distances, with the inevitable pressure on road networks and the potential for en route traffic accidents and waste spillages. In order to reduce the volumes of waste being transported, construction of a series of transfer stations where waste is compressed and baled, are an essential additional component of the superdump landfill management strategy. All of this adds to the overall costs of the landfilling operation.

Furthermore, local communities typically feel threatened by such superdumps, which generates intense resistance to the siting of such dumps (the NIMBY syndrome), compounded by the fact that little of the waste is of local origin. This invariably gives rise to an adversarial and often acrimonious relationship between advocates and opponents of any given superdump, leading to costly review and licensing procedures, commonly involving court proceedings. The loss of social harmony within communities confronted by the prospect of a superdump in their backyard is a cost that cannot be quantified.

The hugely increased costs associated with the use of artificial lining systems as opposed to in situ natural liners is illustrated by the case of a small landfill in the south-west of Ireland. Ballygyroe in north County Cork is situated upon 21–30 m of very low permeability red lateritic clay (1×10^{-9} m s^{-1}), representing a tropical weathering profile, which overlies Old Red Sandstone bedrock. Opened in 1990, following a court order to close the existing landfill, as a stop gap measure whilst the most suitable site in this administrative district was sought, this landfill was initially operated employing a cellular system using the in situ overburden as a natural clay liner, at a cost of IR£ 100,000 per annum.

Eventually it was concluded that this was the best site available, and a licence was subsequently sought from the Irish EPA which, despite the geological evidence of the suitability of the natural clay overburden as a liner, insisted on the installation of an artificial lining system. A cellular system is still in operation, but the cells have had to be increased in size, and slopes considerably reduced in order to accommodate the lining system, with significant loss of landfilling space. The annual cost of operation of the landfill is now in excess of IR£ 1,000,000, a tenfold increase. Sadly, this landfill, an example of an optimum natural landfill site, and probably the best site in Ireland, is to close due to an injunction obtained by opponents, but it would inevitably have been forced to close anyway, as the operational costs make it uneconomic to run, given that the largely rural area it serves, supports a rather sparse population of only 70,000. A further negative impact of the increased costs of operation of the Ballygyroe landfill, is that high charges of IR£ 300 per truck load of refuse, now levied to private refuse collectors or private individuals delivering waste to the landfill, is likely to have the effect of encouraging illegal dumping.

3.7. Impact on third world economies

A frequently unappreciated ramification of current waste management policies is their impact on third

world economies. The high technology containment strategy embraced by the richer western nations is generally beyond the financial and technological resources of poorer nations. Given the difference in operational costs in installing an artificial liner as opposed to using a natural geological barrier, as illustrated above, the promotion by the EU and other western nations, of a containment strategy based on artificial lining systems, must have a profoundly detrimental impact on the economies of poorer developing countries, placing unnecessary demands on their very limited financial resources.

Groundwater is a critical resource to many third world nations, particularly those with arid climates and thus limited surface water supplies. In addition, poor sanitation infrastructure in many third world countries tends to make surface waters particularly prone to pollution, so groundwater may be the only reliable source of good quality drinking water. The need to preserve the quality of groundwater is a strong motivation to third world nations to follow a landfill management policy which gives greatest protection to groundwater from contamination by landfill leachate. That third world governments are misled into believing that the expensive containment strategy is the safest, most cost-effective approach, is an indictment on western self-interest, since it is the western nations who mainly manufacture and supply the expensive landfill lining systems.

In at least one developing nation, South Africa, opposition to unlined landfills has arisen, due to the mistaken belief that since the richer western nations are pursuing this approach, then it must be the best available technology, i.e. the BATNEEC principle. This is an unfortunate development, because there is a strong likelihood that most third world nations possess numerous sites, which have adequate geological/hydrogeological characteristics to enable the pursuit of landfill management strategies that make use of the natural attributes of the site. In the more overcrowded nations of Western Europe, the shortage of sites with adequate natural geological barriers may, in many instances, make the use of landfill liners an unavoidable necessity. On the other hand, in developing countries with less infrastructure, it is probable that there exist numerous sites with suitable natural liners, both for containment or 'dilute and disperse', or sites with natural hydraulic traps. Identification of such sites will allow developing nations to pursue more cost-effective landfill management strategies, and western technology would perhaps be better channelled into supporting the achievement of such aims.

3.8. Failure of this generation to deal with all its generated waste

The most serious ramification of the current containment policy of landfill management is that the present generations waste problems will be left for the next generation to deal with. A fundamental consequence of encapsulating landfill waste and significantly reducing the degradation rate, is that this generations waste will still be active and posing problems certainly for the next generation, and even perhaps for several future generations. Given that future waste production is unlikely to decrease, and waste management problems are also unlikely to diminish, it seems morally indefensible that, in addition to having to deal with their own waste problems, future generations may have to deal with waste problems created by this generation.

4. Alternative natural landfill management strategies

Natural solutions, which employ the hydrogeological characteristics of the subsurface and the attenuation properties of subsurface materials, are totally ignored in current landfill management strategies. Indeed, as indicated above, no provisions have been made in EU regulations for landfill management strategies other than containment, and in fact the current legislation for most member nations based on these regulations prohibits other strategies. The advantage of using natural in situ geological/hydrogeological barriers is that the natural infiltration and percolation characteristics of the subsurface are not disrupted, and little or no maintenance costs are involved. Such natural barriers do not encapsulate waste and inhibit its degradation, provided the natural characteristics of the barrier are appropriately employed. Two types of natural leachate management solution are available, namely 'dilute and disperse' and hydraulic traps.

4.1. Dilute and disperse

The 'dilute and disperse' principle of leachate management, defined by Gray et al. (1974), has been largely superseded by the containment strategy. It relies both on the natural low permeability and also the attenuation characteristics of geological barriers in the subsurface to control groundwater pollution by landfill leachate. This method of leachate management employs the natural confinement potential of primarily low permeability clay-rich overburden and, to a lesser extent, bedrock to impede the migration of leachate from the landfill, whilst at the same time attenuating and purifying it by processes of filtration, sorption and ion exchange. Such natural processes are in continuous and effective operation in the purification of groundwater, which under normal circumstances requires no treatment for use as household water supply.

The dilute and disperse principle has been militated against by current legislation that requires all leachate emanating from the landfill to be collected and treated (Mather, 1995). These regulations have been introduced despite the fact that field and laboratory studies (e.g. DOE, 1978), have highlighted the effectiveness of natural processes in attenuating leachate concentrations. The conclusion reached was that, in appropriate situations, the dilute and disperse method would be effective enough to prevent the pollution of water resources, and could be used as a leachate management strategy. More recent studies (Warith and Yong, 1991; Batchelder and Mather, 1998; Batchelder et al, 1998) have confirmed the capacity of clay-rich overburden and mudrocks to attenuate leachate. The dilute and disperse principle of leachate control has been unfairly maligned, much of the criticism being that it represents no control whatsoever and relies on, largely unknown, subsurface characteristics at any individual site. However, failure of this approach has stemmed largely from the fact that at numerous landfill sites where the strategy was employed, no adequate geological/hydrogeological investigation was undertaken. Thus, many selected sites were totally inappropriate for this method of leachate management, due to the absence of a suitable geological barrier to attenuate the leachate.

Natural geological barriers, may be defined as low permeability clay-rich geological units (hydraulic conductivity $<10^{-7}$ m s^{-1}), which can perform the function of an attenuating layer, enabling leachate to percolate slowly downwards, simultaneously undergoing attenuation by filtration, sorption and exchange processes with the clays in the unit. Extremely low permeability geological units (hydraulic conductivity $<10^{-9}$ m s^{-1}) cannot fulfil a 'dilute and disperse' function, as they perform in a similar manner to artificial or natural lining systems, providing complete containment of all emissions. Similarly, geological units with higher permeability (hydraulic conductivity $>10^{-7}$ m s^{-1}), do not provide sufficient confinement to leachate, so are also unsuitable for a 'dilute and disperse' role. The optimum permeability for 'dilute and disperse' is of the order of 10^{-7}–10^{-9} m s^{-1}, although in situ geological units just outside that range, could have their hydraulic conductivity modified by addition of fine sand in the case of extremely low permeability natural units, or clay in the case of higher permeability units. In most instances, it would probably be necessary to partially excavate the natural barrier layer in order to remove stones, homogenise it and remould it, and any modification of hydraulic conductivity by addition of sand or clay could be undertaken prior to re-emplacement.

The suitability of any individual barrier layer for 'dilute and disperse' is a function not only of its permeability, but also of its attenuation potential, which is dependent principally on the proportion of clay minerals and iron and manganese oxides present in the deposit, and also the types of clay minerals present, due to the variable sorption and cation exchange capacities (CEC) of the various clay mineral groups. Of the major clay mineral groups, the least activity (sorptive capacity) and also the lowest CEC are possessed by the kandites. The illites have higher activities and CEC, followed by the sepiolite-palygorskites, followed by the vermiculites, whilst the smectites have the highest CEC and sorptive capacities due to their ability both to adsorb ions on to their external surfaces and also to absorb ions between their lattice sheets (Velde, 1992). Interactions between leachate and clay liners include ion exchange, adsorption–desorption, particle size reduction, mineral dissolution and clay mineral disordering and collapse (Batchelder and Mather, 1998; Warith and Yong, 1991). High swelling clays such as the smectites are more prone to mineral transformations and collapse

than mixed clay mineral assemblages and the low swelling illite and kaolinite clay groups (Batchelder and Mather, 1998). Furthermore, clay-rich overburden and mudrock, can buffer acid leachates, leading to precipitation of heavy metals (Batchelder et al, 1998), which displace Na^+, Ca^{2+} and Mg^{2+} on clay mineral surfaces by cation exchange mechanisms (Mohamed et al, 1994).

If improvement of the attenuation characteristics of the barrier layer is necessitated, options may be intermixture with local clay-rich material or enhancement with imported bentonite. However, although the montmorillonite component in bentonite has the highest sorption and CEC of the common clay minerals (Velde, 1992; Cancelli et al., 1994), employment of bentonite-based mineral layers in artificial lining systems is not based on these properties, but rather, as has been pointed out earlier, on its very high swelling capacity.

The minimum thickness requirement of an attenuating layer should be dependent on its hydraulic conductivity, so that provided the attenuation potential of the layer was sufficiently high, the limiting permeability could be related to layer thickness. In order to ensure that a geological barrier would, on its own, give sufficient protection to the environment, stringent geotechnical requirements regarding the nature, thickness, hydraulic conductivity and attenuation potential of the barrier would need to be specified. Furthermore, rigorous site investigation and field and laboratory testing of the permeability and attenuation properties of the geological unit would be a primary requirement of any application for a landfill licence.

Wagner (1994) has introduced the concept of a double mineral base layer (DMBL). This consists of an 'active' layer with a high content of highly active smectite clays (bentonite) and/or carbonate, performing an attenuation function through processes of sorption and ion exchange, above an 'inactive' layer composed predominantly of more stable clay minerals such as kaolinite, which performs a confinement function, but undergoes minimal reaction with the leachate. The presence of the inactive layer beneath the attenuation layer impedes downward movement of leachate maximising the reaction time between the active layer and the leachate. As pointed out by Wagner (1994), this arrangement may represent a better option than a single attenuating layer, as the two functions of confinement and attenuation may be mutually exclusive, since the sorption and ion exchange processes in clays lead to a gradual reduction in swelling capacity and consequent increase in permeability. The two layers could be developed simultaneously from natural in situ clay deposits, by excavation of the natural material, separation of the excavated soil into two piles and treatment of them separately, adding kaolinite to one to create the inactive confining layer, and smectite to the other to form the active attenuation layer. Organic material could also be added to the active layer to enhance its sorption/ion exchange properties and so improve its attenuation potential. Care would be required in placement of the inactive layer to ensure a suitably low hydraulic conductivity, whereas the hydraulic conductivity of the active layer would not be so critical. Such a DMBL liner design could represent a type of 'dilute and disperse' leachate management solution, provided the hydraulic conductivity of the inactive layer was sufficient to allow slow migration through it of the attenuated leachate leaving the active layer.

More rapid stabilisation of waste in such 'dilute and disperse' landfills could be achieved by allowing unrestricted ingress of rainwater into the waste, thus promoting biochemical and microbial degradation processes. In addition a more dilute and therefore less toxic leachate will be produced. Therefore it would be highly advantageous if the capping consisted of a permeable material, whilst pretreatment of the waste by shredding could improve rainwater percolation and access to the waste.

The main danger of uncontrolled rainfall infiltration into the landfill is the build up of leachate head, particularly after periods of heavy rainfall. This would increase the rate of leachate migration through the attenuation clay layer below the landfill, and potentially lead to hydraulic failure of the attenuating layer and resulting groundwater pollution. The solution to this problem is to install an efficient drainage and leachate collection system above the attenuating layer, which could control the leachate head in order to prevent shock loading of the receiving environment. The collected leachate could be stored in leachate ponds and recirculated to the landfill surface during periods when the leachate head is low, so that the leachate collection system would perform the

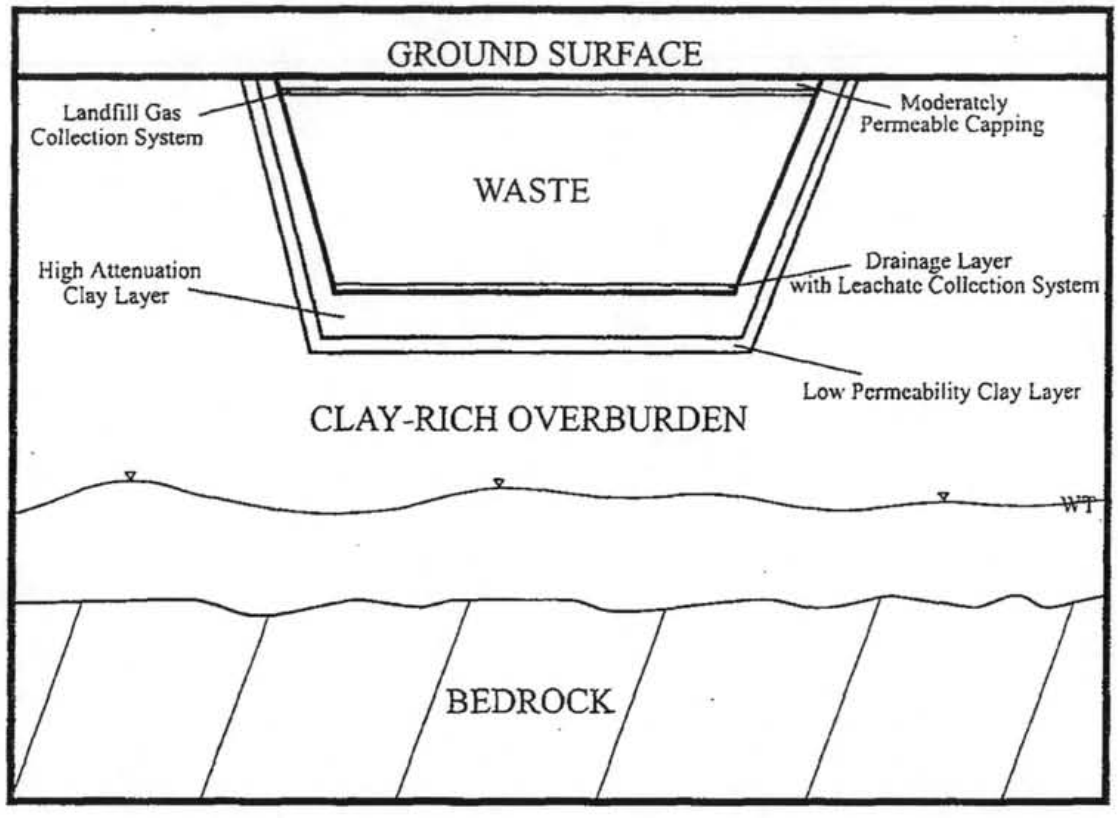

Fig. 1. Attenuation landfill with double mineral base layer (DMBL), consisting of a kaolinite-enriched 'inactive' clay layer overlain by a smectite-enriched 'active' clay layer. A drainage layer with a leachate collection system to control the rate of leachate migration overlies the DMBL, to prevent shock loading of the DMBL. A landfill gas collection layer overlies the waste and the capping consists of moderately permeable soil to allow ingress of rainwater.

function of controlling the rate of leachate migration from the landfill. The final mass release to the sensitive environment should be at a rate which gives rise to no hazard and does not cause unacceptable damage to the environment (Knox, 1989). Fig. 1 depicts a simplified schematic diagram of the elements of an attenuation landfill.

4.2. *Hydraulic traps*

Hydraulic traps, the other type of natural solution, are hydrogeological situations where, instead of leachate migrating outwards from the landfill into the surrounding subsurface, the groundwater surrounding the landfill migrates into the landfill. This reversal of the migration path not only suppresses outwards advective flow of leachate from the landfill, but the addition of ingressing groundwater to the leachate produced within the landfill dilutes it, rendering it less harmful. It is necessary to collect the diluted leachate and dispose of it, otherwise the build-up of leachate plus ingressed groundwater would ultimately overtop the landfill.

Natural hydraulic traps are quite common and usually associated with hollows, often containing lakes or swamps. It is also possible to artificially create a hydraulic trap, by siting the landfill within a pit excavated in the subsurface to a depth below that of the local water table, and controlling the leachate head within the landfill, so as to maintain it at a lower level than that of the water table in the surrounding ground. This creates a negative hydraulic head

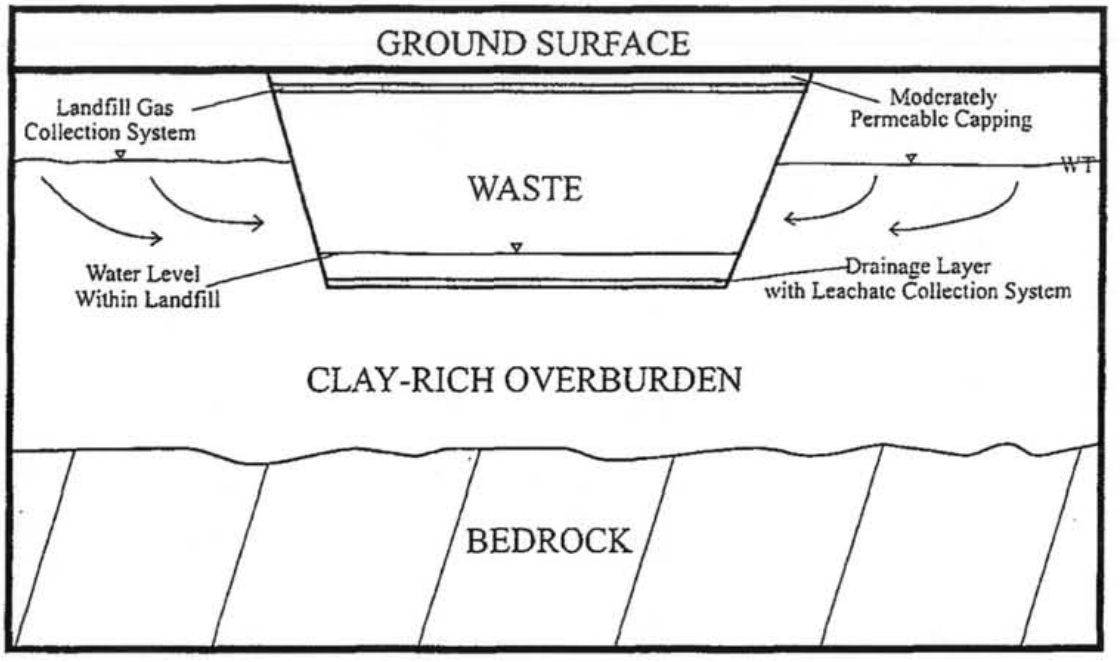

Fig. 2. Hydraulic trap landfill excavated to below the local water table within low permeability clay-rich overburden. Groundwater migrates towards the landfill, and the water level within the waste is maintained at a lower level than the local water table by the leachate collection system. The landfill gas collection system and the capping are similar to that for the attenuation landfill.

towards the landfill, which thus acts as a sump towards which groundwater will migrate, so counteracting leachate migration from the landfill. Water-filled quarries represent examples of holes below groundwater level, but the permeability of the surrounding rocks make this type of hydraulic trap unsatisfactory, since they must be drained to enable waste to be emplaced, temporarily lowering the local water table. During this period, leachate can migrate outwards into the surrounding groundwater.

Most landfills employing hydraulic traps, be they natural or artificially created (Rowe, 1988), are lined with a synthetic lining system, so no cost benefit is derived from the hydraulic trap. Whilst lining may be advantageous to reduce ingress of groundwater from the surroundings during emplacement of the waste, the whole advantage of the hydraulic trap is that leachate cannot migrate outwards regardless of whether the landfill is lined or not, so lining the landfill renders the hydraulic trap superfluous. Clay-rich overburden would behave as a natural barrier to groundwater movement, impeding ingress of groundwater during waste emplacement activities, but still allow operation of the hydraulic trap, both during the operational phase of the landfill, and after waste emplacement has ceased.

Although the negative hydraulic head induced by a hydraulic trap suppresses advective flow of leachate from the landfill, diffusional flow may, in response to a concentration gradient, result in migration of contaminants outwards from the landfill against the hydraulic gradient (Barone et al., 1989). Furthermore, Rowe (1994a) has pointed out that diffusion of contaminant can even take place through synthetic landfill liner membranes. However, the clay layers in the lining system have the potential to attenuate contaminants, provided they are of sufficient thickness. Natural clay-rich overburden will also perform an attenuating role with respect to diffusing contaminants, and will be much more effective in this regard than an artificial lining system. Thus an artificial liner system gives no added protection in a hydraulic trap situation, and is less suitable than a natural clay-rich geological barrier. Fig. 2 illustrates the elements of a hydraulic trap landfill.

5. Conclusions

Flaws in the current containment strategy, outlined above, are:

- leakage problems and major uncertainties as to the long-term durability of synthetic landfill lining systems;
- chemical interaction of many clay liners, particularly bentonite liners, with landfill leachate, leading to an increase in hydraulic conductivity with time.
- the inability of either synthetic or natural liners to suppress diffusive transport of contaminants which, rather than advection, is the dominant contaminant transport mechanism
- the total reliance placed on the lining system, with little account taken of geological/hydrogeological characteristics of sites being selected, and commonly no secondary geological barrier to protect groundwater in the event of liner failure;
- encapsulation of waste in a synthetic lining/capping system, so inhibiting waste degradation and thus prolonging the activity of the waste, possibly for many decades;
- the financial burden of long-term, post-closure maintenance and monitoring of landfills;
- the failure to take advantage of natural hydrogeological solutions to leachate migration, or the natural filtration, sorption and ion exchange properties of clay-rich overburden in order to attenuate leachate;
- excessive costs in development and operation of containment landfills, making the whole strategy uneconomic and financially unsustainable;
- the unsuitability of such a high-technology, high-cost waste management strategy to the financial and technological resources of the less developed third world nations;
- the present generations waste problems being left for future generations to deal with.

The alternative landfill strategies can be represented as, on the one hand, high technology solutions offering favourable short-term protection to the environment, but less certainty of long-term protection, possibly resulting in serious environmental pollution in the long-term, as opposed to natural solutions, which offer possibly less guarantee of environmental protection in the short term, but less likelihood of serious long-term environmental pollution. Earth scientists (e.g. Mather, 1995; Allen, 1998) favour the latter approach, whereas the engineering community, in the belief that an engineering solution is superior to a natural approach, have promoted the current policy — which is being followed without due regard to long-term cost or environmental impact.

The containment strategy employs a purely technological approach to the management of leachate, ignoring the potential of natural solutions based on the confinement and attenuation properties of the subsurface. High technology engineering solutions to pollution control are usually expensive and rarely completely successful, and frequently have negative impacts, the tendency being that the more sophisticated the solution, the greater the cost and maintenance that they entail (Mather, 1995). A much more sensible and cost effective approach typically involves some form of enhancement of natural processes by the integration of a cheap, simple technology.

The containment approach has led to increasingly more complex technologies being applied to overcome each succeeding problem. The fundamental flaw in the strategy is that dry entombment of waste inhibits its degradation, so prolonging the activity of the waste and delaying, possibly for several decades, its stabilisation to an inert state. Given the uncertainty regarding the durability of artificial lining systems over long timespans, the potential for environmental pollution in the long term is significant. Furthermore the costs of construction and operation of containment landfills are excessive, and the post-closure maintenance and monitoring costs are ultimately unpredictable. If a universal approach to pollution control is to be adopted, a strategy relying on complex technologies, beyond the financial and technological resources of the less advanced nations, is unlikely to succeed.

Landfill management options are curtailed by the inflexibility of the current EU landfill regulations and national legislation of member states, which not only makes a containment approach mandatory to the exclusion of all other strategies, but militates against the use of natural geological liners in the form of clay-rich overburden. The current legislation reflects the triumph of the engineering solution over the natural solution in landfill management strategies and

represents an extreme approach to the protection of groundwater.

Finally, it should be pointed out that the current regulations render protection of all groundwater as a mandatory requirement, regardless of whether the groundwater being protected constitutes a material resource or not. Not all groundwater can be regarded as a substantive resource, since a real resource only exists where it is readily available and extractable in sufficient quantity at an acceptable cost. Groundwater only constitutes a resource provided the porosity and hydraulic conductivity of the subsurface are sufficient to provide an adequate supply at a sufficient yield for the purpose for which the groundwater is being sought, which at the lowest common denominator could represent the household supply to a single dwelling. Commonly, subsurface characteristics do not fulfil these requirements, so in many areas groundwater cannot be regarded as a resource. If the groundwater does not constitute a resource, then protection of such groundwater becomes a very costly and futile exercise.

In the light of the foregoing, the conclusion that must be reached, is that many of the problems associated with containment are insurmountable, and that the containment strategy and sustainability in landfilling are incompatible. It is therefore hard to conceive of sustainability in landfilling ever being achieved via the containment approach, and conversely it can be argued that if sustainability is to be attained, the containment strategy becomes untenable.

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Mar 10, 2010

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News & Views You Can Use

Jan 20, 2010

Elbert County Considers Controversial Waste-to-Energy Plant

A proposed waste-to-energy incinerator in Elbert county would make electricity by burning trash and wood chips, but opponents say their county commissioners are pushing the project through with too many unanswered questions. Elbert county commissioners have not voted on the proposal yet—or much discussed it at public meetings, although they have certainly been hearing from citizens about it. Opponents have spoken at commission meetings where citizens filled the halls, and the weekly Elberton Star is sending a reporter to Florida to check out incinerator plants there. Commissioners toured a similar plant in Alabama, and have "kicked it around" in work sessions, County Administrator Bob Thomas tells *Flagpole*, but they've been waiting for a recommendation about the proposal from the quasi-governmental Northeast Georgia Regional Commission.

Last week staffers at that that regional think-tank said they had "insufficient information" to evaluate the plant's regional impact (they suggested waiting for the state Environmental Protection Division to review it), and its board voted to delay any recommendation for six months. That puts the ball back in Elbert county's court; commissioners could go ahead and decide in March, Thomas says, but opponents are asking for a cautious delay. "We are asking questions as a public that the commissioners should know the answers to, or know how to find out," says Kevin Lewis, who lives in a home he built about three miles from the proposed incinerator. The facility would be 3 miles southwest of Elberton off Georgia Highway 72; it would burn trash (including tires, which have high heat content), wood waste, and sewage sludge trucked in from a 90-mile radius. It would generate electricity from the heat—enough at least to power 35,000 homes—then landfill the resulting ash on the site. Strict EPD permitting standards for landfills and air pollution sources would have to be met.

Whether this would be an environmentalist's dream or nightmare depends on who you ask (and perhaps how close to it you live). Space for trash is running out in many area landfills; new landfills are expensive, given strict regulations, and neighbors' objections make them hard to site. Many waste-to-energy plants exist already, but there are none in Georgia (one is planned near Vidalia). GreenFirst LLC, the young Canton, Georgia environmental permitting and "real estate investment" company that is spearheading this project, has only one other to its name: a landfill and stream mitigation bank (combined with an industrial park) in Meriwether County. "We manage environmental projects to gain the highest return on investment," GreenFirst's website says. "If we see a good opportunity around projects that we're doing, then we develop them," explains GreenFirst CEO Ernest Kaufmann.

The company's landfill/incinerator/generating plant would take in at least 1500 tons of trash daily—just for comparison, that's five times as much tonnage as the Athens-Clarke landfill handles. Opponents have questioned whether that amount of trash and wood chips is really available in the area, but "we've done extensive studies," GreenFirst project manager Abbey Patterson says. The Elberton area was chosen, she says, because "we looked at a map of Georgia, and there are only a couple of areas where there aren't already paper companies that need pulp... So we're not competing with a paper company" for wood chips, which will be purchased as a fuel source. The plant will be near a rail line, and opponents have speculated that trash could eventually be brought in by rail. Kaufmann denies that, saying it won't be allowed under the operator's contract.

But GreenFirst won't operate the plant; another company, likely Covanta Energy Corporation, will do that, CEO Ernest Kaufmann tells *Flagpole*. Covanta, of New Jersey, runs over 40 similar plants in the US, and claims to turn 5% of America's waste into electricity. Covanta has also paid hundreds of thousands of dollars in environmental fines for past EPA violations, according to *The Herald* newspaper of Rock Hill, SC. But according to the report, an EPA spokeswoman says such violations are "not uncommon." Such plants are required to self-monitor and then report the results; often fines are assessed after corrections have been made.

When EPD sets pollution limits, compliance costs to a company are a factor, EPD officials have told *Flagpole* in the past. Emissions of pollutants like sulfur dioxide and particulate matter are limited by permit and monitored closely, but still measured in tons per year at the biggest local air polluters that include Certainteed Corporation, Power Partners, J.M. Huber, Nakanishi, Oliver Rubber Co., and UGA's physical plant. If it costs a company more than $10,000 per ton to remove a pollutant, EPD will

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not usually require it, EPD Permitting Manager Heather Abrams said at a 2005 hearing on Certainteed's fiberglass plant expansion. Partly because of auto emissions from Atlanta, Athens is "up in the higher cancer risk level for northern Georgia," EPD's Randall Manning said then.

The Elberton waste-to-energy plant would create 50 full-time jobs (and even more support jobs), GreenFirst says, and require 400,000 gallons of water a day (to be supplied by the city of Elberton) for the incineration process. Stormwater runoff from the landfill would not normally be allowed to go into a nearby creek, but would be retained by a settlement pond on the property. The site is 1.3 miles from the Broad River, near the tiny Madison county town of Carlton.

"This is really the first time in the history of Carlton that 100 percent of the population has been in agreement on anything," city councilman Mike Jones tells *Flagpole*. "We're just kind of now on the upswing, and this is kind of the last thing we need," he says. "We're real concerned about the idea that we could have 190 trucks a day coming through." Without discussion, he says, the council voted unanimously to oppose the plant; but the city of Carlton's resolution carries no legal weight. The plant is also opposed by the Broad River Watershed Association and the Sierra Club—and by a local company that wants to open a conventional landfill in Elbert County. That company has gone to court claiming that a November revision to Elbert County's solid waste ordinance favored the waste-to-energy plant over its own proposal.

Larry Winslett of the Georgia Sierra Club believes "incineration is an outdated and completely discredited industry" that effectively concentrates metals and other toxics in ash. Even operating within legal limits, "there is no such thing as an incinerator that doesn't pollute," he says. And "there's not enough wood" in Georgia to feed all the waste-to-energy incinerators that companies like GreenFirst want to build here, he tells *Flagpole*—20 plants throughout Georgia, according to materials filed with EPD and obtained by the Sierra Club through an open records request. "They've gotten it in their heads that they can throw some wood chips in with these things and call them 'biomass,' and *claim that they're green and renewable," Winslett says.*

A better solution, he says, is to recycle more. "We need to move to some serious waste reduction. You can get down to a very low level of waste, if you work at it." But with their voracious appetite for fuel, waste-to-energy plants only encourage cities to ignore recycling efforts in favor of burning more trash and selling electricity, he says.

Athens might beat Elbert county to the draw in generating electricity from trash, ACC solid waste director Jim Corley tells *Flagpole*. Ten companies have responded to an ACC proposal to collect methane (a byproduct of rotting trash) from the Lexington Road landfill and burn it to generate electricity; commissioners could vote on the plan next month. As a contributor to global warming, unburned methane is worse than CO2; burning methane from the dump could pay the county $5 million over 10 years in carbon credits, renewable energy credits, and electricity sales, Corley says. "Green" electricity from the landfill could power 2000 homes, he estimates. At present, most of Georgia's electricity is produced from nuclear and coal-burning plants.

John Hule

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↑ 32.50	↑ 0.45%	
Nasdaq	2358.95	
↑ 18.27	↑ 0.78%	
S&P 500	1145.61	
↑ 5.16	↑ 0.45%	
Russell 2K	674.92	
↑ 5.29	↑ 0.79%	
10Yr Bond	3.72	
↑ 0.019	↑ 0.51%	

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News

Plans announced to build $400 million waste-to-energy incinerator

By Gary Jones

A company is looking at Elbert County as a possible site for a $400 million "biomass facility" in which wood waste products from the timber industry and household solid waste would be used as fuel to produce electricity.

The wood waste and solid waste would be burned to generate steam, and that steam would run through a turbine generator to create electricity.

GreenFirst LLC Chief Executive Officer Ernest Kaufmann made the announcement Tuesday afternoon at the Elberton Rotary Club meeting.

GreenFirst will attempt to initiate the process to acquire state and environmental permits required for the project at next month's Elbert County Board of Commissioners meeting.

At that meeting, the commissioners are expected to sign off on a "needs" assessment for the project, according to GreenFirst's Elbert County Project Manager, Abbey Patterson.

The project would include a landfill in which the company would put ash residue from the facility.

However, the ash would have other practical uses, according to GreenFirst's Mack Reynolds, who is also working on the Elbert County project.

Metals would also be recycled from the facility.

The landfill, which would hold only ashes from the burned wastes, would be a Subtitle D landfill that would meet federal specifications, according to Elbert County Manager Bob Thomas.

Thomas and Elbert County Commissioners Horace Harper, Jerry Hewell and John Hubbard and The Elberton Star toured a Covanta Energy Solid Waste Incinerator in Huntsville, Ala., three weeks ago because the same technologies used to build the Alabama facility would also be used in Elbert County, according to GreenFirst.

That facility converts solid waste into steam for a federal military facility located next to the incinerator in Huntsville.

Patterson said Covanta would be among a few companies who might contract to run a finished facility in Elbert County.

According to Thomas, GreenFirst approached the commissioners earlier this year and asked the county commissioners to consider the project.

Thomas said the facility is proposed for 250 acres of property just off the Athens Highway in southwest Elbert County, but Patterson said that property was one of several properties being considered.

In the past four months, all five Elbert County commissioners (including Frank Eaves and W.D. Albertson) have toured the Covanta incinerator in Alabama, according to Thomas.

Oscar Allen, who is vice president of regional operations at Covanta facilities in Florida, Alabama and Oklahoma, said he estimates the cost of construction on the Elbert County project to be somewhere in the neighborhood of "$420-to-$460 million" by the time the facility is complete.

Allen said the Elberton facility would be Covanta's first facility in Georgia, although the company has considered building facilities in Georgia in the past.

Although Allen said he couldn't be exact, he estimated that the company would hire about 70 employees and that the facility would be a 24-hour-a-day operation like the incinerator in Alabama.

GreenFirst said in a released statement that an estimated 115 permanent jobs would result from the facility, 50 directly in the plant and another 65 in secondary jobs that will be created. In addition, the GreenFirst statement said 2,625 jobs would be created during construction.

Elbert County has economic incentive to host the facility, according to Thomas.

The partnership with GreenFirst would mean Elbert County would no longer spend some $400,000 per year in solid waste disposal expense. Additionally, Thomas said the county would gain some $2 million in tax revenues from the biomass facility.

Patterson, who attended Tuesday's Rotary meeting, said permitting for the project would be a year-long process and Reynolds estimated that if all goes according to proposed plans, construction could begin toward the end of 2010.

2014 in operation

Construction time on the project would be approximately three years, said Reynolds.

GreenFirst and Covanta officials both said the facility proposed for Elbert County would be regulated by state and federal environmental controls and that the technologies used would be the most advanced emissions control equipment to ensure safety in Elbert County.

Part of GreenFirst's mission early in the process will be educating the public on exactly what is being proposed, said Patterson.

"We are here to let everyone know exactly what we are doing," said Patterson.

Florida county plans to vaporize landfill trash

Updated 9/9/2006 10:16 PM ET

Enlarge By Lynne Sladky, AP

St. Lucie County Solid Waste Director Leo Cordeiro, left, and Assistant Director Ron Roberts pose at the St. Lucie County landfill in Fort Pierce, Fla. Atlanta-based Geoplasma plans to build a plant that will use garbage to power homes and production lines.

FORT PIERCE, Fla. (AP) — A Florida county has grand plans to ditch its dump, generate electricity and help build roads — all by vaporizing garbage at temperatures hotter than the sun.

The $425 million facility expected to be built in St. Lucie County will use lightning-like plasma arcs to turn trash into gas and rock-like material. It will be the first such plant in the nation operating on such a massive scale and the largest in the world.

Supporters say the process is cleaner than traditional trash incineration, though skeptics question whether the technology can meet the lofty expectations.

The 100,000-square-foot plant, slated to be operational in two years, is expected to vaporize 3,000 tons of garbage a day. County officials estimate their entire landfill — 4.3 million tons of trash collected since 1978 — will be gone in 18 years.

No byproduct will go unused, according to Geoplasma, the Atlanta-based company building and paying for the plant.

Synthetic, combustible gas produced in the process will be used to run turbines to create about 120 megawatts of electricity that will be sold back to the grid. The facility will operate on about a third of the power it generates, free from outside electricity.

About 80,000 pounds of steam per day will be sold to a neighboring Tropicana Products Inc. facility to power the juice plant's turbines.

Sludge from the county's wastewater treatment plant will be vaporized, and a material created from melted organic matter — up to 600 tons a day — will be hardened into slag, and sold for use in road and construction projects.

"This is sustainability in its truest and finest form," said Hilburn Hillestad, president of Geoplasma, a subsidiary of Jacoby Development Inc.

For years, some waste-management facilities have been converting methane — created by rotting trash in landfills — to power. Others also burn trash to produce electricity.

But experts say population growth will limit space available for future landfills.

"We've only got the size of the planet," said Richard Tedder, program administrator for the Florida Department of Environmental Protection's solid waste division. "Because of all of the pressures of development, people don't want landfills. It's going to be harder and harder to site new landfills, and it's going to be harder for existing landfills to continue to expand."

The plasma-arc gasification facility in St. Lucie County, on central Florida's Atlantic Coast, aims to solve that problem by eliminating the need for a landfill. Only two similar facilities are operating in the world — both in Japan — but are gasifying garbage on a much smaller scale.

Up to eight plasma arc-equipped cupolas will vaporize trash year-round, non-stop. Garbage will be brought in on conveyor belts and dumped into the cylindrical cupolas where it falls into a zone of heat more than 10,000 degrees Fahrenheit.

"We didn't want to do it like everybody else," said Leo Cordeiro, the county's solid waste director. "We knew there were better ways."

No emissions are released during the closed-loop gasification, Geoplasma says. The only emissions will come from the synthetic gas-powered turbines that create electricity. Even that will be cleaner than burning coal or natural gas, experts say.

Few other toxins will be generated, if any at all, Geoplasma says.

But critics disagree.

"We've found projects similar to this being misrepresented all over the country," said Monica Wilson of the Global Alliance for Incinerator Alternatives.

Wilson said there aren't enough studies yet to prove the company's claims that emissions will likely be less than from a standard natural-gas power plant.

She also said other companies have tried to produce such results and failed. She cited two similar facilities run by different companies in Australia and Germany that closed after failing to meet emissions standards.

"I think this is the time for the residents of this county to start asking some tough questions," Wilson said.

Bruce Parker, president and CEO of the Washington, D.C.-based National Solid Wastes Management Association, scoffs at the notion that plasma technology will eliminate the need for landfills.

"We do know that plasma arc is a legitimate technology, but let's see first how this thing works for St. Lucie County," Parker said. "It's too soon for people to make wild claims that we won't need landfills."

Louis Circeo, director of Georgia Tech's plasma research division, said that as energy prices soar and landfill fees increase, plasma-arc technology will become more affordable.

"Municipal solid waste is perhaps the largest renewable energy resource that is available to us," Circeo said, adding that the process "could not only solve the garbage and landfill problems in the United States and elsewhere, but it could significantly alleviate the current energy crisis."

He said that if large plasma facilities were put to use nationwide to vaporize trash, they could theoretically generate electricity equivalent to about 25 nuclear power plants.

Americans generated 236 million tons of garbage in 2003, about 4.5 pounds per person, per day, according to the latest figures from the Environmental Protection Agency. Roughly 130 million tons went to landfills — enough to cover a football field 703 miles high with garbage.

Circeo said criticism of the technology is based on a lack of understanding.

"We are going to put emissions out, but the emissions are much lower than virtually any other process, especially a combustion process in an incinerator," he said.

Circeo said that both plants operating in Japan, where emissions standards are more stringent than in the U.S., are producing far less pollution than regulations require.

"For the amount of energy produced, you get significantly less of certain pollutants like sulfur dioxide and particulate matter," said Rick Brandes, chief of the Environmental Protection Agency's waste minimization division.

Geoplasma expects to recoup its $425 million investment, funded by bonds, within 20 years through the sale of electricity and slag.

"That's the silver lining," said Hillestad, adding that St. Lucie County won't pay a dime. The company has assumed full responsibility for interest on the bonds.

County Commissioner Chris Craft said the plasma process "is bigger than just the disposal of waste for St. Lucie County."

"It addresses two of the world's largest problems — how to deal with solid waste and the energy needs of our communities," Craft said. "This is the end of the rainbow. It will change the world."

Posted 9/9/2006 12:17 PM ET

Updated 9/9/2006 10:16 PM ET

US's First Plasma Gasification Waste-to-Energy Plant Online by 2011

by Matthew McDermott, New York, NY on 11.11.08

photo: D'Arcy Norman

The technology involved in plasma gasification, or perhaps more properly plasma arc waste disposal, has been around for about fifty years, but few facilities exist that utilize it to both dispose of waste and create energy, and none are in the United States. That's about to change.

Geoplasma, part of real estate developer Jacoby Group (same website), has announced that its planned plasma refuse plant in St. Lucie County, Florida is expected to come online by 2011.

Here are the details:

Trash Vaporized at 10,000 Degrees
When trash is put into the plasma converter, the 10,000°F heat vaporizes the solid materials, producing a "syngas" consisting mostly of hydrogen and carbon monoxide. This gas is used to turn an electrical turbine; steam generated in the process can be also utilized to generate electricity.

1500 Tons of Trash = 60 MW
Geoplasma's facility will process some 1,500 tons of garbage a day, and have a net power capacity of 60 MW. In addition to the power generated, the methane emissions from the landfill can be significantly reduced. Geoplasma says that prices for electricity produced from its facility will be on par with natural gas.

via: Scientific American

Plasma Gasification Waste-to-Energy
Zapping Trash With Plasma Produces Clean Energy and Fuel
EST: Making Chemical Waste Disappear into Thin Air?
PlascoEnergy to Build North America's First Waste Gasification Plant

Comments (9)

GEOPLASMA LLC

171 17TH STREET NW, SUITE 1550
ATLANTA GA 30363 USA
T.678.538.4321 F.770.206.9150

January 17, 2007

Mrs. Mary McCauley
3930 Dixie Hwy
Madison GA 30650

Mrs. McCauley:

Thank you for taking the time to come to the school last week. I'm sure the class appreciated the investment of your time to a topic they are interested in. I, too, appreciate others interested in this technology.

The application of plasma can take several different paths; therefore I did not want to discourage the potential project in Morgan County. However, it would be designed a good deal differently due to capacity needs and the financial opportunity with reduced energy rates. There is always a way to make a project work if the parties involved make the commitment to the opportunity.

It was a real treat to present to a "home" audience. In fact after talking to my in-laws, I realized that I actually worked a summer at the nursery in Bostwick.

Thank you again for coming and if you have further interest in plasma, I am at your disposal for further presentations or meetings.

Sincerely,

Mike Ellis
VP Geoplasma

Cc: Mrs. Jane Symmes

CHAPTER 29.3 CRITERIA FOR CONSIDERING ZONING AMENDMENTS

Section 29.3.1 Required Findings for Zoning Map Approval. The following standards governing the exercise of the Board of Commissioners' zoning power are adopted in accordance with O.C.G.A. §36-66-5(b), as amended, to be used by the Director, Planning Commission and the Board of Commissioners in reviewing, recommending, and acting upon applications for map amendments for approval, conditional approval, or disapproval as appropriate so as to balancing the interest of the public health, safety or general welfare against the unrestricted use of property:

(a) **Compatibility with Adjacent Uses and Districts**: Existing uses and use districts of surrounding and nearby properties, whether the proposed use district is suitable in light of such existing uses and use districts of surrounding and nearby properties, and whether the proposal will adversely affect the existing use or usability of adjacent or nearby properties.

(b) **Property Value**: The existing value of the property contained in the petition under the existing use district classification, the extent to which the property value of the subject property is diminished by the existing use district classification, and whether the subject property has a reasonable economic use under the current use district.

(c) **Suitability**: The suitability of the subject property under the existing use district classification, and the suitability of the subject property under the proposed use district classification of the property.

(d) **Vacancy and Marketing:** The length of time the property has been vacant or unused as currently used under the current use district classification; and any efforts taken by the property owner(s) to use the property or sell the property under the existing use district classification.

(e) **Evidence of Need:** The amount of undeveloped land in the general area affected which has the same use district classification as the map change requested. It shall be the duty of the applicant to carry the burden of proof that the proposed application promotes public health, safety, morality or general welfare.

(f) **Public Facilities Impacts:** Whether the proposal will result in a use, which will or could cause an excessive or burdensome use of existing streets, transportation facilities, utilities, schools, parks, or other public facilities and services.

(g) **Consistency with Comprehensive Plan**: Whether the proposal is in conformity with the policy and intent of the locally adopted comprehensive plan.
29-6(h) Other Conditions. Whether there are any other existing or changing conditions affecting the use and development of the property that give supporting grounds for either approval or disapproval of the proposal.

STONE MOUNTAIN INDUSTRIAL PARK, INC.

February 23, 2010

Commissioner Ellen Warren
150 East Washington Street
Madison, GA 30650

Proposed Landfill-Aqua Road

Dear Commissioner Warren:

In 2008, Stone Mountain Industrial Park, Inc., a Pattillo Company, purchased 324 acres on Pierce Dairy Road with the intent of constructing a first class light industrial park. At completion, the development will contain over 2,500,000 s.f. of space at a total investment of approximately $200,000,000, and provide employment for at least 500 people. At the current millage rate, the proposed investment would annually produce $1,600,000 in real and personal property taxes in addition to the ripple effect of the jobs in the community.

The proposed industrial park will be competing with sites across the state and the southeast to attract new industry. Prospects will compare factors such as education, infrastructure, quality of life and long term property values before choosing a final location.

We are concerned that the proposed landfill will negatively influence the perception of the area and discourage prospects from investing in the community. Accordingly, we ask you to consider the long term impact of the proposed landfill on the economic viability of the area as you evaluate the proposal.

We are available to discuss the proposed project at your convenience.

Sincerely,

STONE MOUNTAIN INDUSTRIAL PARK, INC.

Rusty McKellar

5830 East Ponce de Leon Avenue • Stone Mountain, Georgia 30083
Mailing Address: Post Office Box 67 • Tucker, Georgia 30085-0067
Phone: (770) 938-6366 • Fax: (770) 939-4627

Heritage Tourism Calculation
Via Madison-Morgan Chamber of Commerce

It is estimated that Heritage Tourism generates **$5.76 million** annually for Madison and Morgan County.

Assumptions:

- ❑Madison-Morgan Chamber of Commerce estimates 60,000 visitors will visit the Chamber of Commerce office in Madison in 2010.
- ❑Approximately 30,000 more people will visit Madison without going to the Chamber of Commerce office.
- ❑80% of those 90,000 visitors stay for a day.
- ❑20% of those 90,000 visitors stay over night.
- ❑The State of Georgia estimates that visitors staying one day will spend an average of $50/person.
- ❑The State of Georgia estimates that visitors staying over night will spend an average of $120/person.

Calculation:

- ❑80% of 90,000 = 72,000 x $50 = $3,600,000 +
- ❑20% of 90,000 = 18,000 x $120 = $2,160,000 =
- ❑$5,760,000 in revenue from Heritage Tourism in 2010

Owner and Parcel Information

Owner Name:	CITY OF MADISON	**Today's Date:**	3/29/2010
Mailing Address:	P O BOX 32	**Parcel Number:**	046 109 A
	MADISON , GA 30650	**Tax District:**	UNINCORPORATED
Location Address:	0 INDIAN CREEK ROAD	**Neighborhood Code:**	INDDWN
Legal Description:	FR BANKS 12.202 ACRES INDIAN CREEK RD	**Acres:**	12.2
Digest Class:	Exempt	**Homestead Exemption:**	S0
Preferential Use Covenant Year:		**Conservation Use Covenant Year:**	
		Building Sketch:	-- Select Document--
Parcel Map:	MapIt!	**Property Photo:**	N/A

Current Value Information

Previous Value	Current Value	Land Value
$427,300	$524,100	$119,400

Residential Improvement Information

No Improvement Information

Commercial Improvement Information

Total Value	Year Built	Used As	Building Area
$389,335	2007	15Govt Comm Service Bldgs	4,704
$15,494	2007	15Govt Comm Service Bldgs	144

Additional Features (Accessories)

No Additional Features Information

Sales Information

Sale Date	Sale Price	Deed Page
5/13/2005	$183,100	374 115

052005
JODY M. MOSS, CLERK
MORGAN COUNTY SUPERIOR COURT
FILED: May 13, 2005
TIME: 4:20 PM
RECORDED: _____
BOOK _____ PAGE _____
_____ DEPUTY CLERK
R# 159511

Morgan Co., GA, Real Estate Transfer Tax
Paid $183.10 Date: 5/13/05
Susan Wyland, Deputy Clerk
Jody M. Moss, Clerk of Superior Court

WARRANTY DEED

STATE OF GEORGIA
COUNTY OF MORGAN

Lambert & Reitman, LLC
126 East Washington Street
Madison, GA 30650
File #2005COM (12)

THIS INDENTURE, Made the 13th day of **May**, in the year of our Lord Two Thousand and Five; between **JEFFERSON LAMAR BANKS, JR**. of the County of Morgan, State of Georgia, hereinafter whether singular or plural referred to as "Grantor," and **CITY OF MADISON, presently composed of Mayor Bruce E. Gilbert and Barry N. Lurey, Fred Perriman, Rick Blanton, R. D. Crawford and Bonnie B. Binion, Council Members** of the County of Morgan and State of Georgia, hereinafter whether singular or plural referred to as "Grantee," (the words "Grantor" and "Grantee" to include their respective heirs, executors, administrators, successors and assigns where the context requires or permits.)

WITNESSETH: That the Grantor, for and in consideration of the sum of ONE HUNDRED DOLLARS AND OTHER GOOD AND VALUABLE CONSIDERATION, in hand paid at and before the sealing and delivery of these presents, the receipt whereof is hereby acknowledged, has granted, bargained, sold, aliened, conveyed and confirmed, and by these presents, does grant, bargain, sell, alien, convey and confirm unto the said Grantee, all the following tract of land:

All that certain tract or parcel of land, situate, lying and being in Land Lot 321 of the 286th (Mann) GMD, 15th Land District, Morgan County, Georgia, containing Twelve and 202/1000ths (12.202) Acres, more or less, fronting on the Eastern Right of Way of Indian Creek Road (50 ft. prescriptive right of way) and being more particularly described by plat and survey prepared by Whitley Land Surveying, Inc., William E. Whitley, RLS, #2686, dated March 10, 2005, a copy of said plat is recorded in Plat Book 37, Page 4, Clerk's Office, Morgan County Superior Court and reference to said plat and the detail shown thereon is incorporated herein for a more accurate description. Being bounded on the West by the Eastern right of way of Indian Creek Road; bounded on the North, East and South by other lands of J. Lamar Banks, Jr. This being a part of the same property as conveyed by Laura Davis Poole and others to J. Lamar Banks by several deeds, commencing in Deed Book 249, at page 658, Clerk's Office, Morgan County Superior Court.

This property is conveyed subject to the following:

1. All 2005 and subsequent years ad valorem taxes;
2. All easements for utilities and roads;
3. All zoning ordinances for Madison and Morgan County; and
4. All detail as shown on the above referenced plat.

TO HAVE AND TO HOLD the said above tract or parcel of land, with all and singular the rights, members, and appurtenances thereof, to the same being, belonging, or in anywise appertaining, to the only proper use, benefit and behoof of the Grantee forever in Fee Simple, and, the Grantor will warrant

PT-61 (Rev. 11/04)

PT-61 104-2005-00651

SECTION A – SELLER'S INFORMATION (Do not use agent's information)			SECTION C – TAX COMPUTATION	
SELLER'S LAST NAME Banks, Jr.	FIRST NAME Jefferson	MIDDLE Lamar	Exempt Code If no exempt code enter NONE	NONE
MAILING ADDRESS (STREET & NUMBER) 2909 Loch Lomand Drive			1. Actual Value of consideration received by seller Complete Line 1A if actual value unknown	$183,030.00
CITY, STATE / PROVINCE / REGION, ZIP CODE, COUNTRY Conyers, GA 30094 USA	DATE OF SALE 5/12/2005		1A. Estimated fair market value of Real and Personal property	$0.00
SECTION B – BUYER'S INFORMATION (Do not use agent's information)			2. Fair market value of Personal Property only	$0.00
BUYERS'S BUSINESS / ORGANIZATION / OTHER NAME City of Madison			3. Amount of liens and encumbrances not removed by transfer	$0.00
MAILING ADDRESS (Must use buyer's address for tax billing & notice purposes) P. O. B ox 32			4. Net Taxable Value (Line 1 or 1A less Lines 2 and 3)	$183,030.00
CITY, STATE / PROVINCE / REGION, ZIP CODE, COUNTRY Madison, GA 30650 USA	Check Buyers Intended Use ( ) Residential (X) Commercial ( ) Agricultural ( ) Industrial		5. TAX DUE at .10 per $100 or fraction thereof (Minimum $1.00)	$183.10

SECTION D – PROPERTY INFORMATION (Location of Property (Street, Route, Hwy, etc))					
HOUSE NUMBER & EXTENSION (ex 265A)	PRE-DIRECTION, STREET NAME AND TYPE, POST DIRECTION Indian Creek Rd.				SUITE NUMBER
COUNTY MORGAN	CITY (IF APPLICABLE)		MAP & PARCEL NUMBER 046-109		ACCOUNT NUMBER
TAX DISTRICT	GMD 286th	LAND DISTRICT 15th	ACRES 12.202	LAND LOT 321	SUB LOT & BLOCK

SECTION E – RECORDING INFORMATION (Official Use Only)				
DATE	DEED BOOK 374	DEED PAGE 115	PLAT BOOK	PLAT PAGE

ADDITIONAL BUYERS

None

65 b

Owner and Parcel Information

Owner Name:	PARKER ELIZABETH PATTILLO	**Today's Date:**	3/29/2010
Mailing Address:	C/O STONE MOUNTAIN INDUSTRIAL PARK INC 5830 EAST PONCE DE LEON AVENUE	**Parcel Number:**	047 001 A
	STONE MOUNTAIN , GA 30083	**Tax District:**	UNINCORPORATED
Location Address:	0 INDIAN CREEK ROAD	**Neighborhood Code:**	
Legal Description:		**Acres:**	93.84
Digest Class:	*Agricultural*	**Homestead Exemption:**	S0
Preferential Use Covenant Year:		**Conservation Use Covenant Year:**	
		Building Sketch:	N/A
Parcel Map:	MapIt!	**Property Photo:**	N/A

Current Value Information

Previous Value	Current Value	Land Value
$552,648	$535,800	$535,800

Residential Improvement Information

No Improvement Information

Commercial Improvement Information

No Commercial Information

Additional Features (Accessories)

No Additional Features Information

Sales Information

Sale Date	Sale Price	Deed Page
9/30/1998	$1	238 381
7/10/2008	$472,000	451 1006
7/15/2008	$0	451 1010
4/21/2009	$516,100	463 457

DOC# 002453
FILED IN OFFICE
07/15/2008 03:20 PM
BK:451 PG: 1006-1009
JODY M MOSS
CLERK OF SUPERIOR COURT
MORGAN COUNTY
REAL ESTATE TRANSFER TAX
PAID: $472.00

R# 17030

[The space above this line is reserved for the use of the Clerk of the Superior Court]

After recording, return to:

SLUTZKY, WOLFE AND BAILEY, LLP
2255 Cumberland Parkway
Building 1300
Atlanta, Georgia 30339

STATE OF GEORGIA
COUNTY OF MORGAN

LIMITED
WARRANTY DEED

THIS DEED, made as of the 10th day of July, 2008, by and between **J. LAMAR BANKS A/K/A JEFFERSON LAMAR BANKS, JR.**, an individual resident of the State of Georgia, as party of the first part, (hereinafter "Grantor") and **ELIZABETH PATTILLO PARKER**, an individual resident of the State of Georgia, as party of the second part, (hereinafter "Grantee") (the terms Grantor and Grantee to include their respective heirs, successors, and assigns where the context hereof requires or permits).

WITNESSETH:

That Grantor, for and in consideration of the sum of Ten Dollars ($10.00) and other good and valuable consideration, in hand paid at and before the sealing and delivery of these presents, the receipt, adequacy and sufficiency of which is hereby acknowledged, has granted, bargained, sold and conveyed, and by these presents does hereby grant, bargain, sell and convey unto Grantee the following described property, to wit:

> All that tract or parcel of land lying and being in Land Lots 315 and 321 of the 15th Land District of Morgan County, Georgia and being more particularly described on the **Exhibit "A"** attached hereto and by this reference incorporated herein.

TO HAVE AND TO HOLD the above-described tract or parcel of land, with all and singular the rights, members and appurtenances thereof, to the same being, belonging, or in anywise appertaining, to the only proper use, benefit and behoof of Grantee, forever, in FEE SIMPLE.

1/6

67a

PT-61 (Rev. 11/04) To be filed in **MORGAN COUNTY** **PT-61 104-2008-000554**

SECTION A – SELLER'S INFORMATION (Do not use agent's information)			SECTION C – TAX COMPUTATION	
SELLER'S BUSINESS / ORGANIZATION / OTHER NAME J. Lamar Banks aka Jefferson Lamar Banks, Jr.			Exempt Code If no exempt code enter NONE	NONE
MAILING ADDRESS (STREET & NUMBER) 1991 Pierce Dairy Road			1. Actual Value of consideration received by seller Complete Line 1A if actual value unknown	$472,000.00
CITY, STATE / PROVINCE / REGION, ZIP CODE, COUNTRY Madison, GA 30650 USA	DATE OF SALE 7/10/2008		1A. Estimated fair market value of Real and Personal property	$0.00
SECTION B – BUYER'S INFORMATION (Do not use agent's information)			2. Fair market value of Personal Property only	$0.00
BUYER'S LAST NAME Parker	FIRST NAME Elizabeth	MIDDLE Pattillo	3. Amount of liens and encumbrances not removed by transfer	$0.00
MAILING ADDRESS (Must use buyer's address for tax billing & notice purposes) 5830 East Ponce De Leon Avenue			4. Net Taxable Value (Line 1 or 1A less Lines 2 and 3)	$472,000.00
CITY, STATE / PROVINCE / REGION, ZIP CODE, COUNTRY Stone Mountain, GA 30083 USA	Check Buyers Intended Use ( ) Residential ( ) Commercial ( ) Agricultural ( ) Industrial		5. TAX DUE at .10 per $100 or fraction thereof (Minimum $1.00)	$472.00

SECTION D – PROPERTY INFORMATION (Location of Property (Street, Route, Hwy, etc))					
HOUSE NUMBER & EXTENSION (ex 265A)	PRE-DIRECTION, STREET NAME AND TYPE, POST DIRECTION				SUITE NUMBER
COUNTY MORGAN	CITY (IF APPLICABLE)		MAP & PARCEL NUMBER 047 001 A		ACCOUNT NUMBER
TAX DISTRICT	GMD	LAND DISTRICT 15	ACRES 94.275	LAND LOT 315, 321, 322	SUB LOT & BLOCK
SECTION E – RECORDING INFORMATION (Official Use Only)					
DATE	DEED BOOK 451	DEED PAGE 1006	PLAT BOOK		PLAT PAGE

ADDITIONAL BUYERS
None

676

Owner and Parcel Information

Owner Name:	STONE MOUNTAIN INDUSTRIAL PARK INC	**Today's Date:**	3/29/2010
Mailing Address:	5830 EAST PONCE DE LEON AVENUE	**Parcel Number:**	046 109
	STONE MOUNTAIN , GA 300831504	**Tax District:**	UNINCORPORATED
Location Address:	0 PIERCE DAIRY ROAD	**Neighborhood Code:**	INDDWN
Legal Description:		**Acres:**	230.04
Digest Class:	Industrial	**Homestead Exemption:**	S0
Preferential Use Covenant Year:		**Conservation Use Covenant Year:**	
		Building Sketch:	N/A
Parcel Map:	MapIt!	**Property Photo:**	N/A

Current Value Information

Previous Value	Current Value	Land Value
$2,933,010	$3,450,600	$3,450,600

Residential Improvement Information

No Improvement Information

Commercial Improvement Information

No Commercial Information

Additional Features (Accessories)

No Additional Features Information

Sales Information

Sale Date	Sale Price	Deed Page
6/9/1999	$121,000	249 658
7/10/2008	$3,738,202	451 987
7/15/2008	$0	451 991
12/1/2008	$3,950,313	457 476

DOC# 002450
FILED IN OFFICE
07/15/2008 03:20 PM
BK:451 PG:987-990
JODY M MOSS
CLERK OF SUPERIOR COURT
MORGAN COUNTY
REAL ESTATE TRANSFER TAX
PAID: $3738.30

R# M030

[The space above this line is reserved for the use of the Clerk of the Superior Court]

After recording, return to:

SLUTZKY, WOLFE AND BAILEY, LLP
2255 Cumberland Parkway
Building 1300
Atlanta, Georgia 30339

STATE OF GEORGIA
COUNTY OF MORGAN

LIMITED
WARRANTY DEED

THIS DEED, made as of the 10th day of July, 2008, by and between **J. LAMAR BANKS A/K/A JEFFERSON LAMAR BANKS, JR.**, an individual resident of the State of Georgia, as party of the first part, (hereinafter "Grantor") and **REES 667, LLC**, a Georgia limited liability company, as party of the second part, (hereinafter "Grantee") (the terms Grantor and Grantee to include their respective heirs, successors, and assigns where the context hereof requires or permits).

WITNESSETH:

That Grantor, for and in consideration of the sum of Ten Dollars ($10.00) and other good and valuable consideration, in hand paid at and before the sealing and delivery of these presents, the receipt, adequacy and sufficiency of which is herpby acknowledged, has granted, bargained, sold and conveyed, and by these presents does hereby grant, bargain, sell and convey unto Grantee the following described property, to wit:

> All that tract or parcel of land lying and being in Land Lots 320, 321, 328, and 329 of the 15th Land District of Morgan County, Georgia and being more particularly described on the **Exhibit "A"** attached hereto and by this reference incorporated herein.

TO HAVE AND TO HOLD the above-described tract or parcel of land, with all and singular the rights, members and appurtenances thereof, to the same being, belonging, or in anywise appertaining, to the only proper use, benefit and behoof of Grantee, forever, in FEE SIMPLE.

PT-61 (Rev. 11/04) To be filed in **MORGAN COUNTY** **PT-61 104-2008-000556**

SECTION A – SELLER'S INFORMATION (Do not use agent's information)		SECTION C – TAX COMPUTATION	
SELLER'S BUSINESS / ORGANIZATION / OTHER NAME J. Lamar Banks aka Jefferson Lamar Banks, Jr.		Exempt Code If no exempt code enter NONE	NONE
MAILING ADDRESS (STREET & NUMBER) 1991 Pierce Dairy Road		1. Actual Value of consideration received by seller Complete Line 1A if actual value unknown	$3,738,202.00
CITY, STATE / PROVINCE / REGION, ZIP CODE, COUNTRY Madison, GA 30650 USA	DATE OF SALE 7/10/2008	1A. Estimated fair market value of Real and Personal property	$0.00
SECTION B – BUYER'S INFORMATION (Do not use agent's information)		2. Fair market value of Personal Property only	$0.00
BUYERS'S BUSINESS / ORGANIZATION / OTHER NAME REES 667, LLC		3. Amount of liens and encumbrances not removed by transfer	$0.00
MAILING ADDRESS (Must use buyer's address for tax billing & notice purposes) 3535 Roswell Road, Suite 63		4. Net Taxable Value (Line 1 or 1A less Lines 2 and 3)	$3,738,202.00
CITY, STATE / PROVINCE / REGION, ZIP CODE, COUNTRY Marietta, GA 30062 USA	Check Buyers Intended Use ( ) Residential ( ) Commercial ( ) Agricultural ( ) Industrial	5. TAX DUE at .10 per $100 or fraction thereof (Minimum $1.00)	$3,738.30

SECTION D – PROPERTY INFORMATION (Location of Property (Street, Route, Hwy, etc))					
HOUSE NUMBER & EXTENSION (ex 265A)	PRE-DIRECTION, STREET NAME AND TYPE, POST DIRECTION				SUITE NUMBER
COUNTY MORGAN	CITY (IF APPLICABLE)		MAP & PARCEL NUMBER 047 001 A		ACCOUNT NUMBER
TAX DISTRICT	GMD	LAND DISTRICT 15	ACRES 242.237	LAND LOT 320, 321, 328, 329	SUB LOT & BLOCK

SECTION E – RECORDING INFORMATION (Official Use Only)				
DATE	DEED BOOK 451	DEED PAGE 987	PLAT BOOK	PLAT PAGE

ADDITIONAL BUYERS
None

1.96

GRAD Criteria

Georgia Ready for Accelerated Development (GRAD) Site Program Criteria

The **Georgia Ready for Accelerated Development** (GRAD) Site Program has been established by the Georgia Allies to enhance economic development opportunities for the State of Georgia. Many industrial site selection projects are conducted on a rapid schedule. Prospective new industries often decline to consider sites that are not known to be well prepared for development. In response to this need, the Georgia Allies have launched the GRAD Sites pilot program to develop a pool of available industrial sites in the state.

These sites:

• have been submitted by a local community or economic development applicant and selected by the Allies for review;

• have had their applications reviewed by a professional third party, and

• based on that review, have been validated as meeting standards showing that they are at an advanced state of readiness for development and use by prospects.

The Georgia Allies have retained Business Facility Planning Consultants to prepare and implement a program leading to a pool of sites validated to be at a high level of readiness for industrial development.

Below are the elements of the program:

1. **Site Acreage.** To submit a site for consideration, a minimum of 50 acres is required.

2. **Secured Property**. The ability to show that the site is secured by an appropriate organization (community, economic development group, etc.) by either ownership or option; and that if control is by some means other than fee simple ownership, that the purchase price and other key terms are legally established, or at a minimum, that the terms for arriving at a price (i.e., a professional third-party appraisal) have been described.

3. **Zoning.** If the community has zoning, then an industrial zoning designation is an absolute requirement for GRAD application. If the community has no such regulations, then alternative means should be sought to assure that there will be no legal problems developing the site for industrial purposes…possibly a set of protective covenants, or perhaps a binding letter from the appropriate local official assuring that the land may be used for industrial purposes.

4. **Railroad Accessibility.** GRAD applications should include a letter from the railroad company serving the property, setting forth all technical, legal, and financial aspects of having a spur track constructed to the candidate site.

5. **Road Accessibility.** The GRAD Site should describe all aspects of developing a road of appropriate industrial quality into the site. A letter from either a public or qualified private engineer is required, which should reflect all engineering, permitting, and construction issues. Evidence of collaboration with the Georgia Department of Transportation or other appropriate regulatory agency regarding access to a public highway and any requirements (curb cuts, acceleration/deceleration lanes, signalization, etc.) must be provided.

6. **Utilities.** Each GRAD site profile includes a detailed statement of existing and planned utilities and services to the site including water, wastewater, electricity, natural gas, and telecommunications, and includes both local lines and system-wide capacity. The feasibility, cost, and schedule for construction or expansion of utilities is available.

7. **Wetlands and Stream Delineation.** This delineation is required by federal law and is addressed in each GRAD site profile.

8. **Topographic Survey.** This survey is a requirement of the GRAD site program.

9. **Geotechnical Investigations.** Any geotechnical investigations that have been conducted on the property are noted in the site profile.

10. **Environmental Phase 1 Assessment.** This is a critical assessment, and is a definitive requirement of the site program. The site profile also specifies other conditions affecting the site's environmental suitability for industry, including the local attainment status with regard to air quality and any changes that have occurred in the past or are being considered for the future. Proximity to special protected areas such as national parks and forests and any other unique local characteristics is also included in the profile.

11. **Cultural Resources and Endangered Species Investigation.** These assessments are also an absolute requirement for each GRAD site, and are noted in each site profile.

Source: Georgia Allies.

SUMMARY OF FINDINGS

The following statements summarize the findings of this traffic study:

1. The proposed development is a solid waste facility on a 141 acre site served by Indian Creek Road in Morgan County, GA.

2. The owner estimates that ten (10) cars will enter during the AM peak Hour and they will all exit during the PM Peak Hour. The owner estimates that a total of 64 trucks will enter and exit on a daily basis (128 daily two-way trips). The trucks traffic is expected to occur rather uniformly throughout the day. This study assumed that three hours of the traffic estimated by the owner may actually occur during the peak hour. This provides a conservative or worse case analysis.

3. Other development is planned in the area including a 3.1 million square feet industrial park.

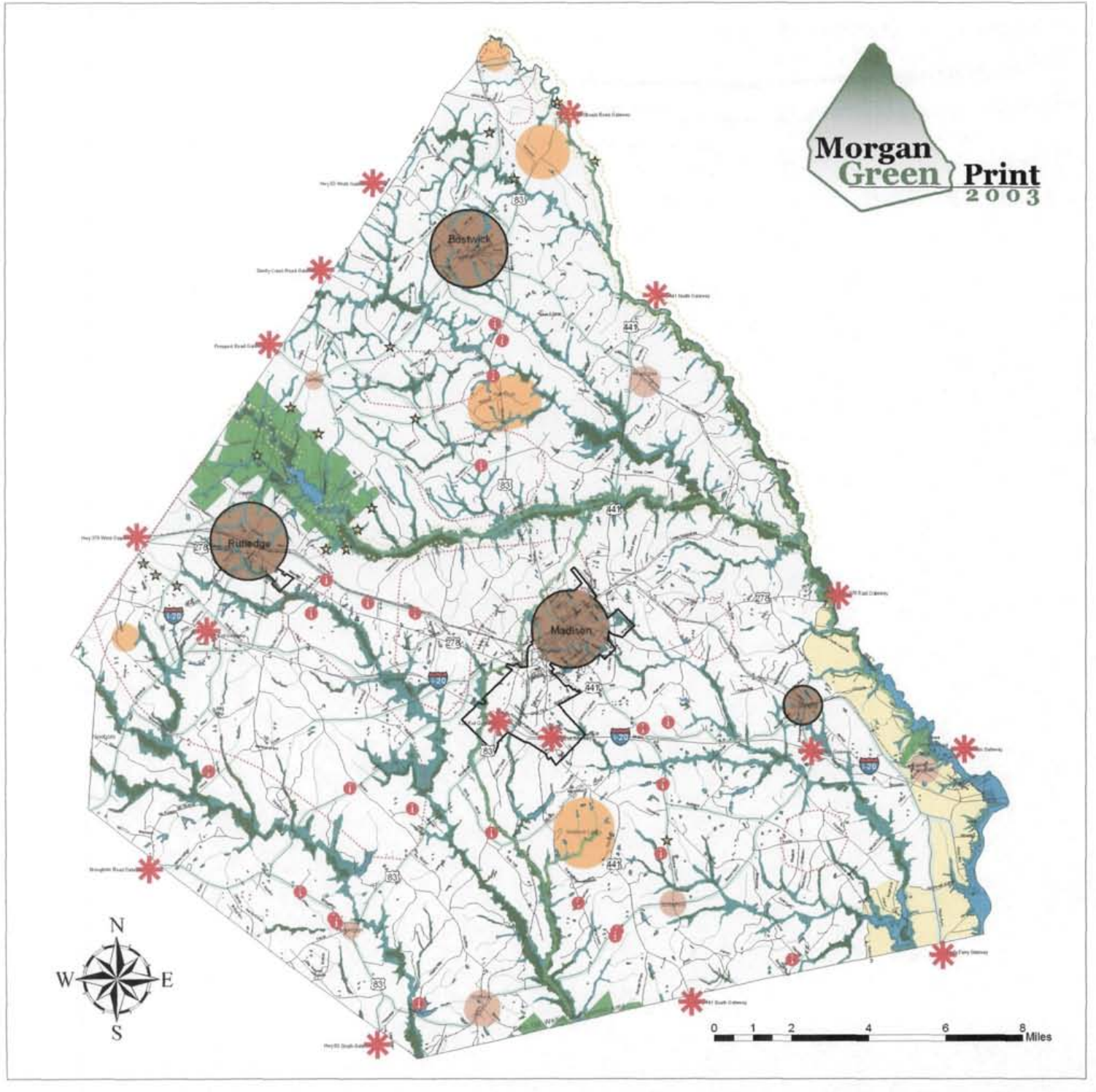
4. When only the traffic from the solid waste facility is accounted for, all intersections in the area will continue to operate at very good levels of service (LOS C or better).

5. When the effects of all planned developements is accounted for (including the solid waste operation, the 3.1 m s.f. industrial park, and other background traffic increases), most intersections continue to operate well. The intersection of SR 24 and Pierce Dairy Road will fail under stop control but would operate at LOS A if traffic signals were installed.

6. The access to the solid waste operation would be via Indian Creek Road which is currently a narrow unpaved road. It is expected that some improvement to this road would need to occur prior to the loading from heavy vehicles going to and from the solid waste operation.

7. Minimum corner turning radii should be provided so in order to accommodate the turning movement of WB 50 vehicles. The radii will need to be increased to 75 feet at SR 24 and Indian Creek Road. At the following intersections, the corner radii should be a minimum of 50 feet:
   - Indian Creek Road and Aqua Road
   - Aqua Road and Pierce Dairy Road

8. Indian Creek Road also has a narrow stream crossing that should be widened to a minimum of 30 feet.



GreenPrint Concept

Map Legend

- Watershed Region
- Farmland Region
- Lake Oconee District
- Town Centers
- City Limits
- Historic Community Node
- Developing Community Node
- Parks
- Lakes and Ponds
- Wetlands
- Floodplains
- Rivers and Streams
- Stream Buffer
- Groundwater Recharge Areas
- Historic or Cultural Resource
- Scenic View
- Gateways
- Potential Trails/Greenways
- Potential Scenic Roads
- Roads
- Railroads

Morgan County
GreenPrint Plan
Draft Copy April 8, 2004

Robert and Company
Engineers, Architects, Planners
96 Poplar Street, N.W.
Atlanta, Georgia 30303
RAC Project 03020.00

FEATURES

Evaluating the Potential Impact of a Proposed Landfill

ABSTRACT

This article is intended as a road map for appraisers who have a landfill consulting assignment. Construction or expansion of a solid-waste landfill typically triggers an extensive permitting process. Real estate appraisers are sometimes called on to present evidence and/or testimony for clients who support or oppose the proposed landfill improvements. This article sets forth information and techniques to assist the appraiser in providing that appraisal service. A literature review is included.

by Shawn E. Wilson, MAI

An article in a Florida newspaper begins, "New York has the Statue of Liberty. St. Louis has its arch. And in coming years, one of Manatee County's most visible landmarks could be a 150-foot-tall mound of construction debris."[1]

This news item was published after a national waste management firm proposed a construction and demolition debris landfill to cover 130 acres of a 300-acre site. Local residents and environmentalists were outraged. On the other hand, a spokesman for the landfill firm was quoted in the same article as saying, "It's near an abandoned phosphate mine, the port, and the jail. If you're going to find a place in Manatee County to put it, that would most likely be it."[2]

The landfill company made a formal application for development approval, and hired experts to formulate a landfill design and prepare all the necessary application paperwork. In government offices, that process of review began. Meanwhile, nearby property owners began to organize in opposition. A "Stop Trash Mountain" Web site appeared. A coalition of developers who own nearby tracts of land hired attorneys, and began planning an organized opposition to the landfill's development applications. A public hearing, which would mark the first major hurdle for the proponents of the landfill, was scheduled. Shortly thereafter, the phone rang at an appraisal office.

The Consulting Assignment

Landfills are a very profitable commercial land use. In areas where growth and new construction are evident, landfill construction and expansion is a logical result.

As with other new commercial uses, landfill construction is subject to the permitting requirements of local government bodies. In addition, the environ-

1. Christopher O'Donnell, "Debris at Planned Landfill Could Form 150-Foot Pile," *Sarasota Herald-Tribune*, August 29, 2007.
2. Ibid.

mental and operational aspects of a landfill may require permitting from local, state, or federal agencies. For instance, landfills in the state of Florida are regulated by the Florida Department of Environmental Protection (FDEP).

During the landfill permitting process, the applicant may be required to present evidence or testimony regarding the suitability of the proposed landfill for a particular location. Individuals or groups who oppose the permit, such as environmental groups or neighboring property owners, also may have the opportunity to present information or testimony regarding compatibility and impact.

In either case, it is not uncommon for the opposing parties to engage the services of a real estate appraiser to evaluate the proposed landfill and provide a written report and/or testimony regarding the potential impacts. These assignments are a form of appraisal consulting.

Identifying Landfill Characteristics

As with all consulting assignments, it is first necessary to establish the scope of work. In this instance, the subject property is defined as the land proposed for improvement with a landfill. All pertinent physical, environmental, and legal aspects of the subject property must be identified, just as in a traditional appraisal assignment. Data must be assembled on the size and shape of the property; zoning and other land use restrictions; floodplain issues; soil type; and other relevant aspects. The development application for the landfill is often a source for this data, but the appraiser should verify this information.

Operational information for the proposed landfill is important to consider. This includes details such as type of permit sought, type of landfill proposed, special physical characteristics (i.e., clays, soils), man-made liners or other barriers proposed, projected useful life, topographical aspects (i.e., above-grade mounded landfill, infill of existing depression), and volume of waste forecast to be received (i.e., tons per week, cubic yards per day). The proposed improvements (specific characteristics of the proposed landfill) must then be identified, including the size and layout of active landfill cells as they relate the overall subject property.

It is also important to identify the operating aspects of the proposed landfill, such as days and hours of operation, location of entrance and exit points, location of front gate, and location of major site improvements (i.e., scale house, fencing, and landscape buffers).

Landfill Cells. Landfill cells are the portions of a landfill site that are used for permanent storage of waste. Other areas of a landfill are used for operations (internal roadways, dirt stockpiles, office, scale house, equipment shed, temporary waste-storage areas for recyclables or land clearing debris). Landfill cells can be active or passive. The working face of an operational landfill is the area where trucks are depositing garbage; Figure 1 is an example of an active construction and demolition (C&D) cell. When landfill cells reach maximum capacity in size and/or height, they are closed. There is a prescribed capping-off process, after which the closed cells are usually planted with sod.

The number and size of landfill cells is dictated by the particular size and shape of an overall site, type of waste accepted, environmental factors, drainage characteristics, and numerous other site-specific criteria. Landfill cells are analogous to the developable pods in a large planned development. The planned development would have roads, drainage ponds, park sites, conservation areas, and other passive uses. The actual areas where development of structures could occur (i.e., Phase I, multifamily building site, shopping center site) would represent the cells.

Landfill Liners. Landfill liners are layers of natural and/or man-made materials that line the bottom of a landfill cell. When working properly, a liner system traps and collects the leachate that drains through the layers of a landfill.[3] The collected leachate is then pumped away for treatment. Monitoring wells are typically required around the perimeter of a landfill to make sure that leachate is not escaping through the liner and polluting the land nearby. When leachate is detected in monitoring wells, it indicates that the liner system is leaking.

Various types of clay and soil are used in landfill liner systems, sometimes in combination with man-made elements. Thick layers of clay are sometimes proposed to form a watertight barrier that can function as a liner. Man-made liner systems are typically engineered from thick plastic sheets, fastened together with seams, to form a waterproof barrier.

3. *Leachate* is defined as "a liquid that has percolated through or drained from hazardous waste; waste that collects contaminants as it trickles through wastes, pesticides, or fertilizers." Appraisal Institute, *The Dictionary of Real Estate Appraisal*, 4th ed. (Chicago: Appraisal Institute, 2002), 161.

Figure 1 C&D Landfill Working Face

A plastic garbage bag placed inside a garbage can is an example of a rudimentary liner system.

The reliability of a liner system depends on many factors, such as materials used, quality of installation, landfill operation policies, climate, and location. The reliability of liner systems is a subject of ongoing debate among stakeholders. For instance, many environmentalists argue that no liner system can be 100% reliable, particularly over decades and centuries of use. On the other hand, those who design and install such systems are adamant about the reliable performance of the landfill liners.

Landfill Categories. Landfills are arranged into major groupings based on the type and amount of waste that they are permitted to receive. Some general classifications for landfills are municipal solid waste (MSW); commercial; land clearing debris; and construction and demolition debris (C&D). Municipal solid waste (MSW) landfills are those that accept general household and commercial garbage, but do not accept hazardous waste. MSW landfills accept waste that produces leachate. Commercial landfills (sometimes referred to as Class III landfills) accept dry materials such as carpet, cardboard, paper, glass, plastic, and furniture, which are not expected to produce leachate. Land clearing debris landfills accept only material of that type, such as branches, stumps, leaves, and other organic material. The construction and demolition (C&D) landfill differs from other landfills because it does not accept general household and commercial waste that is collected from curbsides by garbage trucks. The C&D waste is comprised of materials that are not liquid, and produce little or no leachete. Lumber and drywall are examples of materials that are generally allowed in C&D landfills.

Defining the Appraisal Problem: Case Study Example

While preparing for the landfill public hearing in Manatee County, a land use attorney contacted the real estate appraiser. The attorney explained that, while some old industrial improvements and a low-security jail for women were indeed located near the proposed landfill, the neighborhood was in transition. Over 8,000 housing units in six large-scale, planned developments had been approved already for development nearby, and were waiting for favorable market timing to come out of the ground. She explained that a tall proposed landfill of any type was thought to be a huge threat to these future developments, so the nearby property owners were strongly opposed. Could the appraiser analyze the impact of the proposed landfill on the planned developments and provide testimony at the public hearing?

When investigating a highly controversial situation, it is particularly important for the appraiser to identify the facts regarding the proposed improvements. The controversy and news coverage can quickly spread gossip and incorrect information through the marketplace. As with other appraisal assignments, it is therefore critical to determine the appraisal problem.

In this instance, the development application that had sparked the negative publicity was an invaluable tool for identifying the characteristics of the proposed landfill. Detailed maps, a conceptual site plan, reports on site characteristics, information about operating details, and data on environmental considerations were all required as part of the applicant's submittal package. In this case, a construction and demolition debris landfill was planned, and it would be a mounded type of landfill that would reach a peak of approximately 150 feet in height when its capacity was reached.

The proposed landfill site adjoined US-41, a four-lane, divided highway. The Port of Manatee facility is located nearby, with direct access to Tampa Bay. Proximity to the water was particularly bothersome to environmentalists, who were concerned about potential impacts on nearby aquatic preserves. A portion of the proposed landfill site included wetlands that would be impacted. In addition, environmental concerns were triggered because portions of the site were located in the 100-year FEMA floodplain and in hurricane storm-surge inundation areas.

Possible negative impacts from operation of a landfill in the proposed location also involved compatibility issues. The planned residential developments that had been approved were located approximately one-quarter mile to the east. Proposed improvements near the landfill site included parkland, a school site, and future home sites.

The landfill applicant proposed a Class III landfill, which would have a total site life of approximately twenty to thirty years. Construction plans included landfill cells, storm-water management ponds, a community collection center, a yard-waste processing storage area, and waste drop-off areas. Operating hours were to be Monday through Friday from 7 a.m. to 5 p.m. and Saturday from 7 a.m. to noon. The applicant proposed a liner system for the landfill, which it felt would mitigate any potential environmental problems. A combination of earthen berms and planted landscaping were proposed for the perimeter of the proposed landfill site to buffer the view of the operation.

Once the physical and operational characteristics of the proposed landfill have been identified as in the case study, the appraiser can gather information on the impact that improvements might have in the proposed location. As with any proposed construction, the locational characteristics, highest and best use of the site, and market area must be analyzed in order to evaluate impact.

Hit the Books

Before moving to project-specific research, the appraiser should first gain general background knowledge. In order to identify potential issues and research requirements for a landfill consulting assignment, it is helpful to study published works on the topic of landfill impacts. The Lum Library at the Appraisal Institute is a resource for such study, as are other sources for real estate information. General Internet-based research is also helpful to locate published materials in the state or region where the proposed landfill is located.

Additional research and study is possible using articles that examine the impacts of other types of stigma, sometimes known as NIMBY ("Not In My Back Yard") and LULU ("Locally Undesirable Land Uses"). Examples of such research are listed in the Additional Reading section at the end of this article.

Most appraisal-related publications that discuss landfills include a reference to stigma, or negative influence, which may impact adjoining land. The extent of the impact depends upon many factors, such as the type of landfill, size of landfill, physical

characteristics of the site, types of neighbors, socio-economic characteristics of the neighborhood, etc.

Literature Review

Recent research related to the case study landfill in Florida resulted in twenty articles for analysis. The most pertinent information on the relationship between landfills and adjoining properties was found in eleven of the documents, which are referenced in this article. General information regarding the impact of the proposed landfills upon neighboring properties is summarized herein. Because this research was undertaken for a landfill located in Florida, some general information from Florida sources is included. A summary of the research findings reported in the eleven articles follows. This information is also outlined in Table 1.

In "A Survey Approach for Demonstrating Stigma Effects in Property Value Litigation,"[4] Flynn et al. state, "The values of individual properties are determined to some degree by the reputation of the area where they are located."[5] Buyers and sellers of condominium units, for instance, form immediate conclusions about property that is located on a popular beach. In a similar manner, buyers and sellers of single-family homes near a power plant may draw conclusions about such a property from just this locational reference.

The authors of this study go on to say, "The association of properties with hazardous, noxious, or repugnant conditions, including perceptions of health and environmental risks, can adversely impact values... Property stigma is a socially constructed evaluation of a place; it is a sign or mark created and maintained by processes of social communication."[6] Put another way, if friends and family are impressed by a location, a person will be likely to perceive value in that location (popular beach). If coworkers and cousins express concern or dislike for a location (near a power plant), a person is likely to perceive less value for property in that location.

In "Appraisal of a Class III Landfill," Entreken states, "A Class III landfill is not typical real estate. A landfill is a short-term business enterprise that happens to be conducted on a parcel of land. Most real estate is considered to have a long useful life; this is not the case with a landfill."[7] He also notes, "A landfill generally has very poor public relations. Fills can emit odors and generally during their life they receive a certain amount of neighborhood protest and bad press."[8] Entreken explains that in appraising a Class III landfill, an appraiser must be aware that "there are continuing operations that burden the property for many years after the fill operation is completed and the fill is closed."[9]

In "Neighborhood Stigma Twenty Years Later: Revisiting Superfund Sites in Suburban New Jersey,"[10] Greenberg and Hollander describe several types of environmentally damaged sites in New Jersey. The authors state, "Waste disposal and management sites are among the most stigmatizing land uses."[11] In other words, among the various categories of sites that may create stigma issues for neighboring properties, landfill and other disposal sites are among those that create the greatest market resistance due to stigma.

An article entitled "Evaluating the Impact of Solid-Waste Transfer Stations," by Kimball and Weaver, explains that such facilities are required in urban areas because "governments have extreme difficulty in obtaining voter approval of landfill sites near areas where the waste originates."[12] When considering locations for a landfill, the study found, "Citizens' groups usually favor industrial or commercial locations–away from residential developments."[13]

The Florida Center for Solid and Hazardous Waste Management Research, at the University of Florida, conducted landfill studies. In "Control of Odors from Construction and Demolition Debris Landfills,"[14]

4. James Flynn et al., "A Survey Approach for Demonstrating Stigma Effects in Property Value Litigation," *The Appraisal Journal* (Winter 2004): 35–44.
5. Ibid., 35.
6. Ibid.
7. Henry C. Entreken, "Appraisal of a Class III Landfill," *The Appraisal Journal* (October 1987): 548–557, 548.
8. Ibid., 555.
9. Ibid., 548.
10. Michael Greenberg and Justin Hollander, "Neighborhood Stigma Twenty Years Later: Revisiting Superfund Sites in Suburban New Jersey," *The Appraisal Journal* (Spring 2006): 161–173.
11. *Ibid., 162.*
12. J. R. Kimball and William C. Weaver, "Evaluating the Impact of Solid-Waste Transfer Stations," *The Appraisal Journal* (January 1983): 9–19, 9.
13. Ibid., 9–10.
14. Debra Reinhart and Timothy Townsend, "Control of Odors from Construction and Demolition Debris Landfills" (working paper, Florida Center for Solid and Hazardous Waste Management Research, Gainesville, Florida, August 2003).

Table 1 Summary of Landfill Impact Studies

Authors	Title	Source	Location, Period	Summary of Article
Flynn et al.	"A Survey Approach for Demonstrating Stigma Effects in Property Value Litigation"	*The Appraisal Journal* (Winter 2004): 35–44	Pacific Northwest April 2002	Class action lawsuit against existing MSW landfill. Describes telephone survey of nearby property owners, which indicates stigma effect. Supported paired sales analysis indicates 8%–10% diminution of value.
Entreken	"Appraisal of a Class III Landfill"	*The Appraisal Journal* (October 1987): 548–557	Various	Methodology for appraising a Class III landfill. Includes general information about odor and neighborhood protest.
Greenberg and Hollander	"Neighborhood Stigma Twenty Years Later: Revisiting Superfund Sites in Suburban New Jersey"	*The Appraisal Journal* (Spring 2006): 161–173	New Jersey 1983–2005	Observation of development on and around 6 former landfill sites after Superfund cleanup. General information on stigma.
Kimball and Weaver	"Evaluating the Impact of Solid-Waste Transfer Stations"	*The Appraisal Journal* (January 1983): 9–19	Texas	General information on stigma. Study shows some transfer stations do not negatively impact adjoining property, especially industrial property.
Reinhart and Townsend	"Control of Odors from Construction and Demolition Debris Landfills"	Florida Center for Solid and Hazardous Waste Management Research, (working paper, August 2003)	Florida, New York, Virginia 1991–1998	Synopsis of odor problems and neighbors' complaints at 9 landfills where C&D waste was accepted. Describes a proposed project to measure malodorous emissions and to test various cover soils for effectiveness in mitigating the odor.
Reichert, Small, and Mohanty	"The Impact of Landfills on Residential Property Values"	*Journal of Real Estate Research* (1992): 297–314	Cleveland, Ohio 1980s–1990s	Regression analysis study of 5 landfills indicates diminution of market value to adjoining residential property of 3%–7.3%, depending on quality of home and distance from landfills.
Reinhart	*Urban Infilling Impacts on Florida's Solid Waste Facilities*	Florida Center for Solid and Hazardous Waste Management Research, Report #0632001-07 (January 2007)	Various	Case studies and literature review regarding negative impacts that result from landfill odor and noise.
Bleich, Findlay, and Phillips	"An Evaluation of the Impact of a Well-Designed Landfill on Surrounding Property Values"	*The Appraisal Journal* (April 1991): 247–252	San Fernando Valley, Los Angeles, California 1978–1988	Regression analysis of 1,628 home sales shows no landfill impact. Landfill is separated from the homes by a hill and vacant buffer land, and landfill is not visible from the homes.
Cartee	"A Review of Sanitary Landfill Impacts on Property Values"	*The Real Estate Appraiser & Analyst* (Spring 1989): 43–47	Various	Summarizes 4 case studies that have mixed results. Landfills in remote areas are harder to study, but show no impact. Impact increases in more populated areas and near busier landfills.
Guntermann	"Sanitary Landfills, Stigma, and Industrial Land Values"	*Journal of Real Estate Research* 10, no. 5 (1995): 531–542	Phoenix, Arizona 1984–1994	Vacant industrial land near 12 landfills was studied. Open solid-waste landfills and open or closed refuse landfills have no impact.
Nelson, Genereux, and Genereux	"Price Effects of Landfills on House Values"	*Land Economics* 68, no. 4 (November 1992): 359–365	Suburban Minneapolis, Minnesota 1980s	Reports on study of suburban landfill receiving 500 tons of waste per day. Studied 708 home sales over 10 years. Negative impact up to two miles away and up to 12% diminution in value.

Reinhart and Townsend observe, "Few waste management issues create more public displeasure than the production of odors at landfills, particularly landfills located near residential areas." They state that construction and demolition (C&D) debris landfills "often offer an ideal environment" for the production of hydrogen sulfide gas (H_2S), because gypsum drywall releases the gas when it is exposed to water. This causes a rotten egg odor, and "Consequently C&D landfills can be major sources of H_2S and are frequently the target of complaints from unhappy neighbors."[15]

The Reinhart and Townsend study profiles landfills that have experienced problems with unpleasant odors resulting from construction and demolition debris. In each instance, the landfills were causing odor problems in nearby residential areas. One of these was a C&D landfill in Broward County, which developed a "severe odor problem" shortly after disposal of debris in the aftermath of Hurricane Andrew. Therefore, a hurricane or other disaster could intensify the local impact of a Class III landfill.

Similarly, in "The Impact of Landfills on Residential Property Values," Reichert, Small, and Mohanty report that a survey of homeowners living near landfills found "the most severe nuisances are odor and unattractiveness,"[16] and that "the residents interpreted odor from the landfill as a signal of potential health hazards."[17]

This link between odor and potential health hazards is also discussed by Reinhart and Townsend in their "Control of Odors" paper. Their research findings state that "short exposure at lower concentrations can have long-lasting adverse health effects," and "the gas can lead to immediate fatality at 1000 ppm" concentration.[18]

In another study from the Florida Center for Solid and Hazardous Waste Management Research, *Urban Infilling Impacts on Florida's Solid Waste Facilities*, Reinhart details problems that arise when residential development occurs too close to an existing landfill.[19] This study finds that "sites once considered remote are now located in areas increasingly ripe for development or redevelopment. In order to site solid waste facilities local governments have installed public works infrastructure such as roads and utilities, reducing the costs for owners of adjacent parcels." Therefore, "the potential for nuisance complaints against the existing solid waste facility operations has become an increasing reality in many areas of the nation... public and private owners/operators of solid waste facilities have been forced to close their facilities pre-maturely, resulting in a loss of valuable solid waste capacity and increased cost for solid waste disposal."[20]

In a study entitled, "An Evaluation of the Impact of a Well-Designed Landfill on Surrounding Property Values," Bleich, Findlay, and Phillips describe a landfill in the San Fernando Valley in Los Angeles, California, that has created "no significant difference in either current prices or in appreciation rates (and thus prices over time) over a ten-year period."[21] Various appraisal methods for measuring an impact on property value were employed, including an analysis of over 1,600 sales transactions in three nearby neighborhoods.

Based on the study results, the authors conclude that "a landfill, if well-designed and -managed, can be a good neighbor and have no statistically measurable negative impact on surrounding property values."[22] However, the San Fernando Valley landfill that is the subject of the study is located on the north slope of a hill. The south slope, which abuts the neighboring homes, is undeveloped land owned by the county. Consequently, the actual dumping area is not visible from the neighboring homes.[23]

These findings are in contrast to those of Flynn et al. Their research uses various appraisal research methods to determine if a landfill waste disposal fa-

15. Ibid.

16. A. K. Reichert, M. Small, and S. Mohanty, "The Impact of Landfills on Residential Property Values," *Journal of Real Estate Research* 7, no. 3 (1992): 297–314, 310.

17. Ibid., 299.

18. Reinhart and Townsend, 2.

19. Debra Reinhart, *Urban Infilling Impacts on Florida's Solid Waste Facilities* (Report # 0632001-07, Florida Center for Solid and Hazardous Waste Management Research, Gainesville, Florida, January 2007).

20. Ibid., 1.

21. Donald H. Bleich, M. Chapman Findlay III, and G. Michael Phillips, "An Evaluation of the Impact of a Well-Designed Landfill on Surrounding Property Values," *The Appraisal Journal* (April 1991): 247–252, 247.

22. Ibid., 252.

23. Ibid., 250.

cility is the source of property value losses for nearby property owners. The landfill that is the subject of their study is a publicly owned and operated landfill in the Pacific Northwest. Through paired sales analysis, they find that property values next to the landfill are "lower than in comparable areas more distant from the landfill."[24]

Flynn at al. also interviewed buyers, sellers, and other market participants to understand market attitudes about the location. They find that "sale transactions or projects that did not occur may be as telling as those that did,"[25] meaning that some transactions are not available for analysis because the prospective buyer or developer walked away from the property when they realized the extent of potential impact from the neighboring landfill. At the completion of the research, the authors link "the landfill with a stigma effect of public opinion about the desirability of housing and property"[26] nearby. They estimate the resulting loss in property value to be 8% to 10%.[27]

The Reichert, Small, and Mohanty study, "The Impact of Landfills on Residential Property Values," has been widely referenced in other research. This study of areas near five municipal landfills in Cleveland, Ohio, finds that neighborhoods of more expensive homes experience a greater loss in property values (5.5%–7.3%) than older neighborhoods with less expensive homes (3%–4%). The study results also indicate that the effect of a landfill is "essentially nonexistent for predominantly rural areas."[28]

Reichert, Small, and Mohanty report that "homeowners who own more expensive homes are more sensitive to landfill problems."[29] They also find that "in areas where the population is younger and better educated, very concerned about health issues and child safety, and has a significant housing investment to protect, the potential adverse landfill impact can be significant."[30] They conclude, "Buyers who are aware that a landfill exists in the area and who are concerned about potential nuisance and health problems will either avoid these properties or be induced to purchase them only at a significant discount."[31] In the Ohio market studied, the research indicates that a seller may still receive current market price for a home near a landfill "if potential buyers are not fully aware of the landfill and its associated effects."[32] This is unlikely to happen in most urban and suburban markets however, where laws may require that sellers must disclose all such information to a potential buyer.

In addition to the diminution in selling prices, this study found that "both nuisance and potential health problems are perceived to be related to a reduced level of marketability, lower selling prices, and increased homeowner flight [sellers taking a loss in order to quickly move out of an area]."[33]

In "A Review of Sanitary Landfill Impacts on Property Values," Cartee provides information on four studies of landfill value impacts to nearby residential developments. One of the studies indicates that the amount of waste handled at a particular landfill would influence property impacts. "For landfills handling large volumes of waste (i.e., over 500 tons daily) the rate of new residential construction and sales of residences and lots was much less than those landfills receiving 300 tons or less per day."[34]

Cartee also describes a study that finds development of a sanitary landfill can, in some cases, enhance property values. This generally occurs in remote locations where "the introduction of infrastructure such as new or improved access road, utilities, drainage, etc. [built in conjunction with the landfill] has actually stimulated additional development" with specific cases of "increases in land values and new construction."[35]

In his summary, Cartee states, "property value impacts will depend on several variables such as

24. Flynn et al., 36.
25. Ibid., 37.
26. Ibid., 44.
27. Ibid., 36.
28. Reichert, Small, and Mohanty, 298.
29. Ibid.
30. Ibid., 300.
31. Ibid., 299.
32. Ibid., 300.
33. Ibid., 310.
34. Charles P. Cartee, "A Review of Sanitary Landfill Impacts on Property Values," *The Real Estate Appraiser & Analyst* (Spring 1989): 44.
35. Ibid., 46.

general community perceptions of environmental risks, density of the local population, proximity to population centers, and design features of the landfill, including its physical profile, volume and nature of waste handled, and other site characteristics."[36]

An article by Guntermann, "Sanitary Landfills, Stigma and Industrial Land Values,"[37] reports on a study of the impact of landfills upon vacant industrial land. The study includes twelve landfills in the Phoenix area, with sales transactions studied over the period from 1984 to 1994. Ten of the landfills were MSW landfills, and two were landfills for commercial refuse only. The landfills in the study were a mixture of open and closed facilities. The study results indicate that "land values around open solid waste landfills are reduced relative to the values of other industrial parcels," and Guntermann concludes that the reduction of value "is attributable to solid waste landfills and not to refuse landfills."[38] This study also finds that closed landfills do not adversely affect industrial land value, and that commercial refuse landfills do not have a negative impact on vacant industrial land.

The final article, "Price Effects of Landfills on House Values," by Nelson, Genereux, and Genereux reports on a study of an existing landfill in suburban Minneapolis-St. Paul, Minnesota.[39] Sales of houses over a 10-year period were studied, with distances varying from 0.35 to 1.95 miles from the center of the landfill. The study included 708 sales, and the results indicate a reduction in value between 6% and 12%. The authors state that "given a choice between two sites offered for the same price and identical in every respect, except that one is closer to a landfill, home buyers will choose the site that is farther away."[40]

The study results indicate that the adverse price effect seen in the study was limited to a distance of about two miles, after which there is "little, if any, adverse price effect."[41] The landfill that was the subject of the study began operation in 1967, so the authors caution that it was not "built and operated pursuant to modern standards." Nonetheless, they conclude, "it seems from the analysis reasonable to assume that unless new landfills achieve a state of operations such that the urban housing markets view them as essentially benign, one should expect that landfills will have negative price effects."[42]

Methods Used for Measuring Impact

Many of the articles and case studies summarized here indicate that landfills generally have a negative impact on the property values of neighboring properties. This negative impact is caused by stigma due to the general perception that landfills have problems such as unpleasant odor and unattractive appearance.

The impact of landfills upon the market values of neighboring properties can be measured with both qualitative and quantitative research methods. As with any real estate study, quantitative measurements of market evidence require a relatively large number of real estate transactions from which to draw an adequate data. Proposed projects located in market areas that have landfill(s) of similar type and size relatively close by are the best candidates for this type of research. Techniques such as paired sales analysis and regression analysis can be used when sufficient data is available.

If the proposed landfill under study is quite unusual or atypical for the market area, it may be difficult to locate comparable existing landfills. Absent existing landfills for study, the appraiser cannot abstract sufficient property transactions nearby to illustrate landfill impact or lack thereof. A proposed landfill with more typical operating characteristics also may be difficult to study if the proposed location is of a market type with little transactional data available. For instance, it may be difficult to locate extremely tall landfills to study for transactional impact if the prevalent landfills in an area are either the "infill" type (a depression is filled until it reaches the grade of surrounding property) or relatively low-height landfills.

36. Ibid.

37. Karl L. Guntermann, "Sanitary Landfills, Stigma and Industrial Land Values," *Journal of Real Estate Research* 10, no. 5 (1995): 531–542.

38. Ibid., 538.

39. Arthur C. Nelson, John Genereux, and Michelle Genereux, "Price Effects of Landfills on House Values," *Land Economics* 68, no. 4 (November 1992): 359–365.

40. Ibid., 359.

41. Ibid., 362.

42. Ibid., 365.

Qualitative analysis is appropriate for most types of proposed landfills. This research includes surveys with market participants, research of published newspaper accounts, and observation of occupancy patterns of property adjoining existing facilities. Qualitative research projects should be designed based on the characteristics of the proposed landfill and the characteristics of its location.

Collecting Market Data

Comparable Landfills

Armed with information about the subject property, the proposed landfill, and the general research available through published literature, the appraiser is now ready to gather specific market data. If the appraiser is not familiar with landfills, the best way to acquire market data on typical landfill operations is to inspect several existing facilities.

A listing of similar landfills must first be created. Such an inventory can often be compiled using regulatory information available for a specific geographical area. The specific agency that has this information varies from state to state. For example, the Florida Department of Environmental Protection regulates landfill permitting and operation for all landfills in the state of Florida, while in New York, the Department of Environmental Conservation maintains the listing of active landfills. The appraiser must identify the appropriate permitting authority for the subject property, and investigate the type and extent of landfill inventory available through the applicable regulatory body.

The initial inventory of similar types of landfills should be refined by the appraiser to identify those landfills that are sufficiently comparable to warrant an inspection visit. For example, if the proposed landfill is in a rural area, visits to other landfills in rural locations would be most helpful. If the proposed landfill is relatively large (i.e., over 300 acres) inspection of landfills on sites of similar size would be helpful. Both public and private landfills are good sources of market evidence, and it may be helpful for the appraiser to research both types, regardless of whether the proposed landfill will be publicly or privately owned and operated.

Depending on the extent and reliability of information available from the landfill regulatory body, the appraiser may need to gather additional data from other sources in order to create a meaningful list of comparable landfills for inspection. For instance, if the regulatory body does not publish the land area of the landfills that it regulates, this information could be cross-referenced from property appraiser or assessor records. If the address or locational information available from the regulatory body does not provide useful information as to rural, urban, or suburban locales, use of aerial photography sites (such as Google Earth) can be most helpful in identifying landfills located in neighborhoods similar to the subject property.

After gathering information on comparable landfills, the appraiser then should refine the list to identify a significant sample of landfill operations to visit. The resulting inspections will enable the appraiser to become educated about landfill characteristics and operations, and to gather market evidence regarding the impacts, if any, that the comparable landfills create.

Local Market Evidence

During the inspection of comparable landfills, much important information about landfills and the neighborhoods in which they are located can be observed. The appraiser's time on these inspections can be used most efficiently if road maps and aerial maps are used ahead of time to identify all points north, south, east, and west of the landfill that are accessible by car. Viewing a landfill from as many different angles as possible creates more opportunities for the appraiser to see and hear landfill operations close by. Particularly for landfills situated on very large sites, the active area or working face of the landfill may be distant from the entrance or property boundary on any particular day.

A thorough inspection of every accessible area of the landfill property also provides the appraiser with the opportunity to inspect all neighborhoods that are close enough to the landfill to exhibit evidence of any impact, be it positive or negative. It is also suggested that inspections of the neighborhoods that surround the landfills take place during the facilities' operating hours. In this manner, the appraiser can assess the truck traffic to and from the landfill, and the noise levels associated with trucks and equipment located at the working face of the landfill.

Qualitative evidence of negative impact to nearby residential properties is sometimes found near active landfills. Such market evidence can include yard signs protesting landfill expansions, yard signs complaining about traffic, and evidence of high vacancies or other negative trends (Figure 2).

During the inspection trip, the appraiser can also identify streets and addresses for areas that are in close proximity to the landfills. These areas can be studied for sales activity and market value in a quantitative analysis when the appraiser returns to the office. Field identification of potential study areas is often more meaningful than simply delineating areas on a street map.

Additional market information regarding landfills may be available from an appraiser's client if the client is the applicant seeking the permit. Just as a shopping center client may have access to information about market levels of rent and expense for competing shopping centers, the landfill operator may have industry information available for analysis. Another source of information regarding landfill operations will be the employees of publicly owned and/or operated landfills. For instance, an appraiser who resides in a particular locale might schedule an appointment to tour the local government-owned solid waste operation and interview members of its management team.

Finally, newspaper accounts of landfill operations provide additional market evidence to the appraiser. A well-managed landfill may appear in the news after being the subject of a complimentary article in a trade publication, or after receiving an industry award. Conversely, operational mishaps at problematic landfills (fires, code violations, pollution of neighboring water wells) are often covered by local newspapers and television stations.

Forming Conclusions and Reporting Results

The appraiser is well positioned to form an opinion of possible impacts related to the proposed landfill after he or she has identified the scope of work, researched the subject property, gathered general information about landfill operating characteristics, become educated about existing landfills in the area, assessed the physical and locational aspects of the proposed landfill, and gathered market evidence of impacts from similar landfills. Numerous examples of well-situated landfills exist, and the appraiser may conclude that the proposed improvement falls into that category. Conversely, numerous examples of landfills that cause negative impacts on adjoining neighborhoods exist, and the proposed landfill may share characteristics more similar to that scenario.

Whatever the conclusion may be, it must be reasonable and well supported, and include the necessary steps outlined in the Uniform Standards of Professional Appraisal Practice (USPAP) for a consulting assignment. In reporting the results of the analysis, whether in a written report, verbal testimony, or combination of the two, the appraiser must also be careful to follow the reporting guidelines set forth in USPAP.[43]

Landfill Hearing: Case Study Example

The public hearing on the proposed landfill in Manatee County lasted for approximately seven hours. All 125 seats in the commission chambers were filled, and overflow crowds watched the pro-

Figure 2 Landfill Protest Signs

43. Appraisal Standards Board, *Uniform Standards of Professional Appraisal Practice*, 2008–2009 ed. (Washington, DC: The Appraisal Foundation, 2008), see especially Standards 4 and 5.

ceedings on television monitors from other areas of the building.

The applicant explained plans for using a synthetic landfill liner to help protect the environment. Lawyers and expert witnesses from the landfill company explained various methods to buffer the view of the landfill and mitigate impacts from noise and odor. The applicant also offered a number of incentives, including payment of approximately $19 million in dumping fees over the lifespan of the landfill, an education center, a park, and dedication of land for road improvements.

The coalition of nearby property owners also presented testimony from lawyers and expert witnesses about the potential impacts that could result if the proposed landfill was approved at the hearing. The appraisal component of the presentation at the public hearing included several different types of analysis.

Market evidence from residential neighborhoods near similar landfills in central Florida was presented. Photographs and other descriptive evidence were also provided to illustrate the size, appearance, and operating characteristics of the proposed landfill.

Following the formal presentations and expert testimony, members of the public were able to provide their comments. Many of the comments were related to fears of environmental impact on nearby wetlands and Tampa Bay. A number of comments detailed concerns about diminished property values due to aesthetic problems including view, noise, and odor.

Late in the evening, the applicant requested a short break to prepare rebuttal testimony before the commission's formal vote. After the break, the applicant instead announced that it was withdrawing the application. Newspaper accounts quoted a landfill representative as saying, "We don't want to cram anything down anybody's throat; we value our relationship with Manatee County as a good corporate partner." The article went on to say that the applicant's firm "spent about two years planning and sank a substantial sum into environmental studies" while engineering the proposed landfill project.[44]

One news report stated that the incentives offered by the landfill proponents "were not enough to counter the wave of opposition from an unlikely alliance of residents, environmentalists, and developers from Manatee and Hillsborough counties."[45] Although the newspaper article did not mention it, a real estate appraiser was also involved in the process.

Conclusion

This article presents general information and techniques that an appraiser can use to evaluate the potential impact of a proposed landfill. The specific example in Manatee County, Florida, involved a proposed landfill in a particular place at a particular time. The application for that landfill was ultimately withdrawn by the applicant. This article includes information about both sides of the landfill impact question, because each proposed landfill is unique and must be analyzed in the context of its specific location.

Shawn E. Wilson, MAI, is the owner of Compass Real Estate Consulting, Inc., in Lakeland, Florida. Wilson is a state-certified general real estate appraiser with over twenty-one years of eminent domain and litigation-related appraisal experience. She has provided testimony and analysis relating to several proposed landfills, and has inspected over fifty solid-waste facilities throughout Florida (known in her office as *Landfill Tour 2007* and *Landfill Tour 2008*). Wilson has been an MAI member of the Appraisal Institute since 1993. She is a member of the International Right-of-Way Association and is past president of the Association of Eminent Domain Professionals. She has been qualified as an expert witness in courts throughout Florida as well as in U.S. Bankruptcy Court. Wilson has provided real estate appraisal services in over twenty-eight Florida counties and has authored articles and presentations on various appraisal topics.

Contact: www.ShawnWilsonConsulting.com

44. Susan M. Green, "Developer Trashes Landfill Project," *Tampa Tribune*, September 12, 2007.

45. Christopher O'Donnell, "Hauler Admits Defeat on Landfill, Application Is Withdrawn After County Commissioners Appear Ready to Reject," *Sarasota Herald-Tribune*, September 5, 2007.

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features

A Survey Approach for Demonstrating Stigma Effects in Property Value Litigation

by James Flynn, PhD, Donald G. MacGregor, PhD, Wayne Hunsperger, MAI, SRA, C.K. Mertz, and Stephen M. Johnson, PhD

abstract

There are many reasons why similar properties command different prices. The determination that property value differences exist among comparable properties is a primary task for appraisers. Once a price difference has been determined, identifying the causes for such differences is central to legal claims of stigma. Plaintiffs have the burden of demonstrating a causal connection between the purported source of stigmatization and the responses of buyers. This article presents an approach for designing a survey to address stigma issues and meet the legal requirements for admitting survey data as evidence. The survey does not attempt to quantify dollar losses; it is intended to show a link between negative values in the sales data and negative perceptions of properties in the class area.

The values of individual properties are determined to some degree by the reputation of the area where they are located. The association of properties with hazardous, noxious, or repugnant conditions, including perceptions of health and environmental risks, can adversely impact values.[1] The *Dictionary of Real Estate Appraisal* defines stigma as: "An adverse public perception regarding a property; the identification of a property with some type of opprobrium (environmental contamination, a grisly crime), which exacts a penalty on the marketability of the property and hence its value."[2]

Property stigma is a socially constructed evaluation of a place; it is a sign or mark created and maintained by processes of social communication. The most powerful source of risk and stigma information is the news media, which often reports on dramatic stories involving technological accidents, hazards, and events that have the potential to harm places and people.[3] The two major sources of technological stigma are the nature of the hazard and the responsibility for managing it.[4] The control and regulation of potentially hazardous or noxious conditions are the responsibility of government regulators and the managers of facilities identified as likely sources of public concern. As long as the management meets regulatory standards, including required upgrades, the potential liabilities for stigma effects may be controlled. If managers do not provide conscientious attention to regulations and safe operations, they can be liable for damages to human health, environmental contamination, and the economic costs of lost property values by

1. James A. Chalmers and Thomas O. Jackson, "Risk Factors in the Appraisal of Contaminated Property," *The Appraisal Journal* (January 1996): 44–58.
2. Appraisal Institute, *The Dictionary of Real Estate Appraisal*, 4th ed. (Chicago: Appraisal Institute, 2002), 277.
3. Robin Gregory, James Flynn, and Paul Slovic, "Technological Stigma," *American Scientist* 83 (May/June 1995): 220–223.
4. Roger Kasperson, Nayna Jhaveri, and Jeanne Kasperson, "Stigma and the Social Amplification of Risk: Toward a Framework of Risk Analysis," in Risk, Media and Stigma, ed. J. Flynn, P. Slovic, and H. Kunreuther, 9–27 (London: Earthscan, 2001); R. E. Kasperson et al. "The Social Amplification of Risk: A Conceptual Framework," *Risk Analysis* 8, no. 2 (1988): 177–187; O. Renn et al. "The Social Amplification of Risk: Theoretical Foundations and Empirical Applications," *Journal of Social Issues* 48, no. 4 (1992): 137–160.

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nearby owners. Claims for economic costs can include compensation for direct, physical contamination of properties, or as discussed in this article, the loss of market value due to stigmatization from association with a source of hazardous and noxious conditions.

The determination of economic costs due to stigmatization requires appraisals that demonstrate a loss of value for a property or class of properties in comparison with other like properties, and a demonstrated link between the lost value and stigma responses that are attributed to a specific source by appropriate members of the public. Techniques for measuring damage have been well documented in the appraisal literature by Patchin, Mundy, Roddewig, and others.[5] The quantitative techniques used in the analysis presented here and shown in Table 1 are consistent with those contained in the Appraisal Institute seminar, "Environmental Risk and the Real Estate Appraisal Process"[6] and as set forth by Jackson.[7] Aside from stigma there are numerous conditions that influence property values and produce differences in value from one place to another. The real estate mantra of "location, location, location" refers to property profiles in geographical relationship to transportation, natural and recreational amenities, quality of existing development, and access to work, shopping, schools, and other public services. Similarly, property stigmatization also has a number of possible sources, often related to health, environmental, or investment risks. It may be due to natural hazards and aesthetic disamenities, social conditions such as the crime rate, infrastructure conditions with potentially obnoxious characteristics such as nearby highways, airports, industrial facilities, public institutions (e.g., prisons), or the operations of industrial or waste sites.

The case study presented here involves a landfill waste disposal facility that was charged with being the source of property value losses for a class of nearby property owners. The case study here pays close attention to the conceptual issues of identifying both a loss of property values and the cause of that loss. In working through this problem, the focus was on obtaining responses from buyers familiar with the residential real estate market. This led to the design and implementation of a survey. Because this study was prepared as part of litigation, the survey process was designed to meet litigation standards.

This article focuses on the design of research to identify or exonerate a specific facility as the source of stigma effects and property value losses. For the purposes of this case study, it is specified that a competent, professional appraisal found that properties in the class area had experienced a significant (8-10%) diminution of value. The research task was to show whether or not this value loss, in whole or in part, was due to the operation of the facility in question. Thus, the appraiser measured the property value loss and the survey design and analyses measured the social-stigma role in that loss. In designing this study, it was specified that judgments of the validity and reliability of the study results were expected to be presented in court and within the context of vigorously contested litigation.

The components of a case to support property value loss have been identified by Hunsperger.[8] These components have been slightly modified for the general case and are shown in Table 1. More specifically for this landfill study, paired sales, regression analysis, and case studies were used to quantify the effect on property values. Control areas were selected for both the paired sales analysis and regression model.

Approximately 60 paired sales were conducted. The results indicated generally lower prices for the properties in the area that was the subject of the class action lawsuit (the class area), all other factors being equal. A regression analysis model based on data from control neighborhoods was also used; it too demonstrated lower property values in the class area. While these techniques indicated that property values in the class area were lower than in comparable areas more distant from the landfill, a public opinion survey was commissioned to determine if the loss in value mathematically determined by these techniques was directly attributable to the landfill and its effects. Given Roddewig's summary of court applications for market surveys,[9] particular care was used in designing and implementing the survey that is the subject of this article.

If the studies undertaken include Components 1 through 4 of Table 1 and support the hypothesis

5. Richard J. Roddewig, "Junk Science, Environmental Stigma, Market Surveys, and Proper Appraisal Methodology: Recent Lessons from the Litigation Trenches," *The Appraisal Journal* (October 1999): 447–453; Richard J. Roddewig, ed., *Valuing Contaminated Properties: An Appraisal Institute Anthology* (Chicago: Appraisal Institute, 2002), see Chapter 4, "Understanding, Analyzing, and Estimating Stigma" for articles by Roddewig, Peter Patchin, Bill Mundy, and Wayne Lusvardi.

6. Appraisal Institute, "Environmental Risk and the Real Estate Appraisal Process" (Chicago: Appraisal Institute, 2001).

7. Thomas O. Jackson, "Methods and Techniques for Contaminated Property Valuation," *The Appraisal Journal* (October 2003): 311–320.

8. W. Hunsperger, "The Effects of the Rocky Flats Nuclear Weapons Plant on Neighboring Property Values," in *Risk, Media and Stigma*, ed. J. Flynn, P. Slovic, and H. Kunreuther, 157–171 (London: Earthscan, 2001).

9. Roddewig, "Junk Science, Environmental Stigma, Market Surveys, and Property Appraisal Methodology."

Table 1 Components of Model to Evaluate Property Value Impacts for Cases of Technological Stigma

1. **Real Estate Market Research.** Perceptions in the marketplace directly affect real estate value; thus, it is necessary to interview various market participants in order to understand market attitudes. For example, sale transactions or projects that did not occur may be as telling as those that did. Additionally, if public attitudes about real estate values in the area are negative, implicitly there will be downward pressure on property value. Real estate impact should be measured in the market of well-informed and well-advised buyers, sellers, and users of real estate.
2. **Analogous Case Studies.** Examine other cases of environmental disamenities to (a) understand how real estate markets in other settings react to or perceive risk, (b) study how these reactions translate into overall value, (c) test the reasonableness of other valuation or evaluation techniques, and (d) apply these findings to the subject neighborhood context. Case studies may include academic research, other economic or appraisal studies, and the appraiser's own experiences. After taking into account appropriate differences, a range may be developed within which conclusions are likely to fall. This technique represents a test of reasonableness.
3. **Market Sales Information.** This category relates to the traditional study of actual sales data, including the study of individual sales, as well as descriptive statistics such as trend analysis, sampling, and averaging. For example, individual sales in one area can be compared to otherwise similar properties in a control area to determine if a price differential exists and to what it might be attributed. It is appropriate to consider a statistically valid number of paired data to reflect the value (or lack thereof) of an attribute across an entire area. This technique can then stand alone and/or serve as a field check of results from multiple regression analysis.
4. **Multiple Regression Analysis (MRA).** Multiple regression analysis is a particular statistical technique, similar to correlation analysis, used to analyze data in order to predict the value of one variable (the dependent variable), such as market value, from the known values of other variables (independent variables), such as lot size, number of rooms, and so on.* The application may involve a comparison of sales data in the subject neighborhood to multiple control areas to determine if any variance remains after accounting for all relevant independent variables. If some intangible variables, such as commuting time, cannot be statistically measured, they may be explained in a public opinion survey.
5. **Public Opinion Surveys.** The purpose of survey research is to understand how people relate to technological, environmental, and health risks because such beliefs are expressed in market prices. Formal market surveys are frequently undertaken to demonstrate how market participants might or should behave in a transactional setting.** Additionally, the survey may be used to elicit open-ended responses or explain intangible variables that may not be measured in a regression analysis.

* Appraisal Institute, *The Dictionary of Real Estate Appraisal*, 4th ed. (Chicago: Appraisal Institute, 2002), 190.

** See Albert R. Wilson, "The Need for Standards in the Application of Statistical and Survey Research to Real Estate Valuation Practice," (paper presented at Environmental & Property Damages symposium, cosponsored by The Centre for Advanced Property Economics and the Appraisal Institute, Toronto, April 4–6, 2002).

that an area of residences and business properties are devalued because of a specific noxious or hazardous source, then a public opinion survey can be conducted to determine the causal link between appraisal-derived value losses and the evaluations of informed real estate buyers. The use of survey research to elicit responses from the appropriate populations in a community has a number of advantages.[10] It can provide an efficient, valid, and reliable way to obtain data about potential stigma effects in cases of documented property value losses.

Courts have developed criteria for assessing the validity of surveys and their admissibility in court. These standards are summarized in two authoritative legal references: the *Manual for Complex Litigation*[11] and *McCarthy on Trademarks and Unfair Competition*.[12] There are slight format differences between these two sources but they can be easily combined as shown in Table 2.

These criteria were also compared to the "Reference Guide on Survey Research" (Elements of Importance)[13] and comments prepared by Mathews and Desvousges,[14] both of which appeared in the mate-

10. Marcus T. Allen and Grant W. Austin, "The Role of Formal Survey Research Methods in the Appraisal Body of Knowledge," *The Appraisal Journal* (October 2001): 394–403.

11. Federal Judicial Center, *Manual for Complex Litigation*, 3d ed. (Washington, DC: Federal Judicial Center, 1995); available online, see http://www.fjc.gov.

12. J. Thomas McCarthy, *McCarthy on Trademarks and Unfair Competition*, 4th ed. (Eagan, MN: Thomson/West 2003).

13. Shari Seidman Diamond, "Reference Guide on Survey Research," *Reference Manual on Scientific Evidence*, 2d ed., 229–276 (Washington, DC: Federal Judicial Center, 2000).

14. Kristy E. Mathews and William H. Desvousges, "The Truth, the Partial Truth, and Anything But the Truth: Survey Reliability and Property Valuation," (paper presented at Environmental and Property Damages: Standards, Due Diligence, Valuation, and Strategy symposium, cosponsored by The Centre for Advanced Property Economics and the Appraisal Institute, Toronto, April 4–6, 2002).

Table 2 Property Value Survey Standards: Criteria for Admissibility of a Survey According to the Federal Judicial Center *Manual for Complex Litigation* (MCL) and *McCarthy on Trademarks and Unfair Competition* (McCarthy)

1. The population was properly chosen and defined. (McCarthy)
2. A representative sample of that universe was selected. (MCL)
3. The questions to be asked of interviewees were framed in a clear, precise and non-leading manner. (MCL)
4. Sound interview procedures were followed by competent interviewers who had no knowledge of the litigation or the purpose for which the survey was conducted. (MCL)
5. The data gathered were accurately reported. (MCL)
6. The data were analyzed in accordance with accepted statistical principles. (MCL)
7. The process was conducted so as to ensure objectivity, e.g. the survey was not conducted by persons connected with the parties or counsel and the interviewers were unaware of its purpose in litigation. (McCarthy)

Note: The criteria defined by the *Manual for Complex Litigation* and *McCarthy on Trademarks and Unfair Competition* are very close and often use exact or similar phrases. In this table, to reduce the redundancy we have chosen the more descriptive of the guideline statements for each of the seven criteria.

rials of the 2002 symposium on Environmental and Property Damages.[15]

A Case Study

The specific case reported here involves a publicly owned municipal landfill located in the Pacific Northwest adjacent to Interstate 5 and close to the coastline. A private firm under a contract with the county operated the facility for more than 50 years. A class action suit was filed on behalf of property owners located within 1½ miles of the boundaries of the landfill. The complaint asked for damages and injunctive relief to the property owners due to exposure from the landfill to hazardous substances, odors, gases and fumes. The claim was that these conditions, along with the birds attracted to the landfill, interfered with the use and enjoyment of the owners' property and reduced the value of their property. In addition, the landfill was claimed to have imposed personal costs to the residents and visitors in terms of annoyance, irritation, discomfort, and other physical ailments.

A major focus of the suit was the claim that operations of the landfill resulted in damage to the property of the plaintiffs and class members, including permanent and measurable loss of property value.

The case study and survey discussed in this article were contracted by the plaintiffs' attorneys to determine the existence, extent, and value of any adverse economic effects on the class action properties. The following sections explain the process and outcome of the survey research conducted in this case.

The Landfill Survey Design

It is important to understand that traditional housing stock variables (i.e., lot size, building square footage, number of bedrooms and bathrooms, etc.) were used by the appraiser in the regression model and paired sales analyses. The results of the survey were used to help explain the results of these quantitative studies and to define the link between the source of stigma and the diminution of property values.

The survey was designed to interview an appropriate population and to elicit data showing if, and then how, knowledge and regard for real property in the class area were related to the conditions resulting from the operation of the landfill. The variables selected for the survey described marketplace conditions within existing and well-defined markets. Use of a survey presupposes that people active in the market are a suitable source of informed opinion about stigma effects and that a source of stigma prompts social behaviors that have economic effects. Thus, there were clear roles for the appraiser and for the social scientists that designed and analyzed the survey to estimate property losses due to stigma or other effects.

The first step in the survey design was to conduct a thorough review of the legal standards that apply to the use of survey data in litigation. This focused on examination and discussion of the "Survey Evidence and Proper Survey Methods" in *McCarthy*.[16] Subsequently, the survey was designed to meet both the spirit and the letter of these standards and guidelines. For example, respondents were asked to rate three areas on a variety of social, geo-

15. The Centre for Advanced Property Economics and the Appraisal Institute.
16. McCarthy, 32-243–32-330.

graphical, and environmental measures prior to any questions about the landfill. In a similar approach, conditions outlined in the class action suit were elicited by asking for volunteer images of the class area before any identification of the landfill.

The survey consisted of 50 questions. An overview of the survey components is shown in Figure 1.

In the survey, Questions 1 through 8 qualified respondents; Questions 9 through 27 identified three housing areas and elicited ratings on seven attributes. These areas were selected by the appraiser based on similarities of housing stock, relative location, and demographic variables. Two comparison areas were used to validate the results. The housing areas were described by a unique set of geographical descriptors. For example, the class area was identified in relation to Interstate 5 and a major interchange. Comparison area 1 was described in relation to a major state highway, a lake, and a golf course. Comparison area 2 was described relative to the local airport, Interstate 5, and a major river. Each of the areas was rated on seven characteristics: (1) access to place of work, (2) general traffic conditions, (3) access to shopping, (4) overall visual appearance, (5) air quality, (6) overall environmental quality, and (7) future value of homes. These characteristics were chosen because buyers commonly consider them when looking for housing and this short list can be rated quickly for the three areas. The results allow for a comparative overview of survey responses and facilitate analyses of other data, especially those provided by responses to open-ended questions. The scale and responses to these characteristics are shown in Table 3. All respondents (N = 400) rated the class area and one of the comparison areas, with one-half of respondents (n = 200) rating comparison area 1 and one-half of respondents rating comparison area 2.

Questions 28 and 29 asked respondents who rated the class area as below average (n = 68) or much below average (n = 5) why these ratings were given. The verbatim responses were recorded.

Question 30 identified for the first time the landfill in the middle of the class area by name and location and asked if the respondent had heard anything about the landfill over the past few years. Questions 31 through 43 asked a series of questions about the landfill and its effect on adjacent properties.

Questions 44 and 45 asked about the recently completed improvements to the Interstate 5 interchange located in the class area. Questions 46 through 50 collected basic demographic information.

Survey Results

The survey results supported the class action suit. Table 3 provides the response data for of three comparison areas. Comparative distributions of the average scores for each of the tested attributes are shown in Figure 2.

The average scores for access to place of work, general traffic conditions, and access to shopping were similar with only slight variations across the comparison areas. Comparison area 2 showed somewhat higher ratings for traffic conditions. In terms of overall visual appearance, air quality, environmental quality, and future value of homes, the class area was rated lower than the other two areas. Most noticeable were the ratings of much below average for the class area for each of these questions. Air quality for the class area was identified as much below average by 7.3% of the respondents, but no respondents provided that rating for the other two areas. For overall environmental quality, for the class area over 30% of the respondents said this characteristic was much below or below average compared to 6.7% below average for comparison area 1 and 5.4% below average for comparison area 2. A similar dis-

Figure 1 Components of Survey Protocol

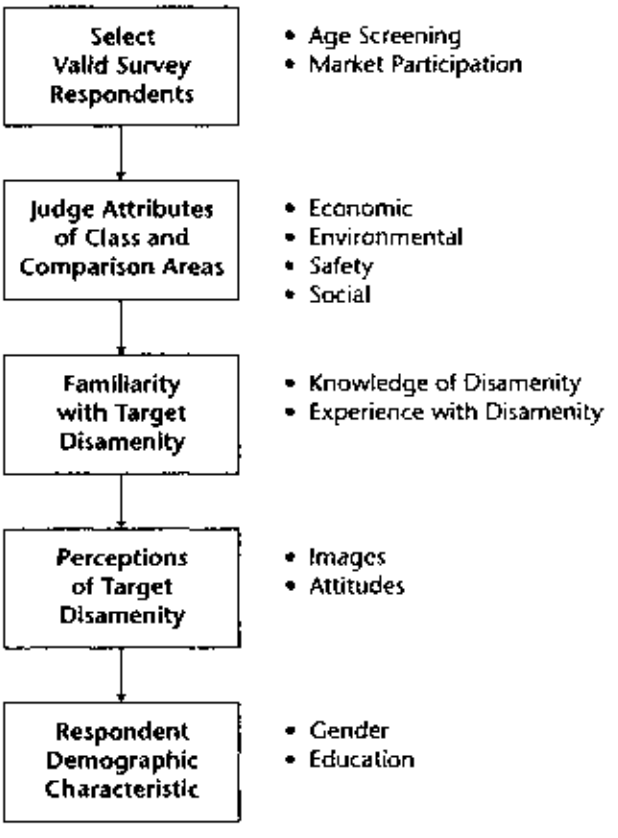

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Table 3 Ratings of Characteristics for Three Areas by Attributes with Mean Scores and Difference Scores

	Much Below Average %	Below Average %	Average %	Above Average %	Much Above Average %	Mean	N	Difference Scores
Access to your place of work								
Class area	3.8	21.4	39.3	28.9	6.6	3.13	346	
Comparison area #1	3.4	27.6	51.7	13.2	4.0	2.87	174	0.31**
Comparison area #2	3.0	25.4	43.2	21.9	6.5	3.04	169	0.06
General traffic conditions								
Class area	9.3	39.1	39.4	11.4	0.8	2.55	386	
Comparison area #1	8.8	36.6	41.8	12.4	0.5	2.59	194	0.04
Comparison area #2	1.5	21.4	53.1	23.0	1.0	3.01	196	-0.48****
Access to shopping								
Class area	1.8	24.7	50.0	21.1	2.3	2.97	384	
Comparison area #1	1.5	16.8	59.2	20.9	1.5	3.04	196	-0.08
Comparison area #2	1.5	24.2	41.9	31.8	0.5	3.06	198	-0.05
Overall visual appearance								
Class area	3.3	41.5	41.2	12.7	1.3	2.67	393	
Comparison area #1	0.0	16.2	48.5	34.3	1.0	3.20	198	-0.48****
Comparison area #2	1.0	21.6	50.3	27.1	0.0	3.04	199	-0.42****
Air quality								
Class area	7.3	35.5	43.4	13.6	0.3	2.64	369	
Comparison area #1	0.0	4.7	54.7	37.9	2.6	3.38	190	-0.74****
Comparison area #2	0.0	3.2	60.8	33.9	2.2	3.35	186	-0.73****
Overall environmental quality								
Class area	2.7	27.8	56.5	12.2	0.8	2.81	370	
Comparison area #1	0.0	6.7	58.8	32.5	2.1	3.30	194	-0.52****
Comparison area #2	0.0	5.4	58.9	34.6	1.1	3.31	185	-0.52****
Future value of homes								
Class area	1.1	23.5	39.2	33.1	3.1	3.13	357	
Comparison area #1	0.0	8.4	39.5	48.4	3.7	3.47	190	-0.34****
Comparison area #2	0.0	10.2	49.2	39.5	1.1	3.32	177	-0.19*

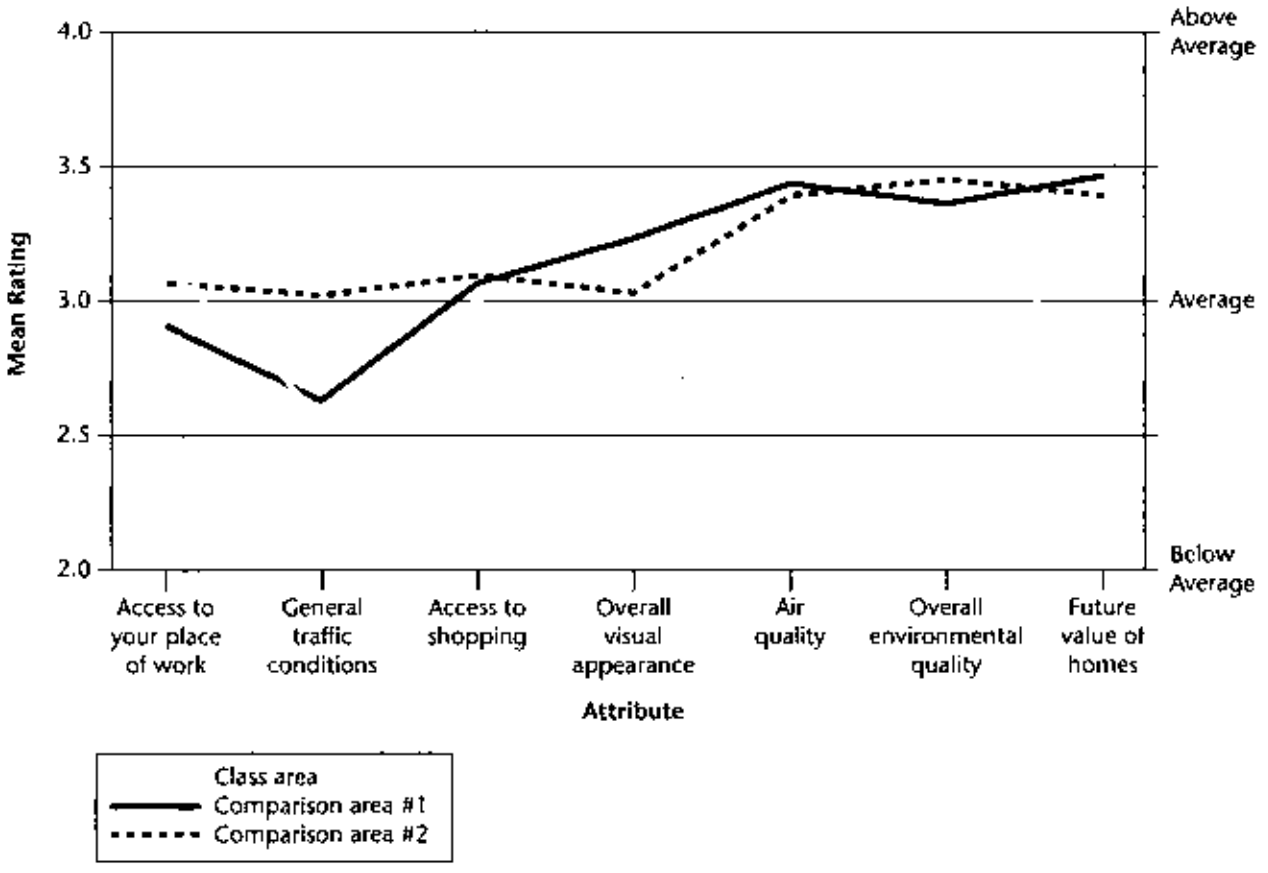
Coding used for calculating means: Much below average = 1, below average = 2, average = 3, above average = 4, much above average = 5.
Difference scores: Positive score mean class area has higher score, negative score meant class area has lower score
* p <= .05; ** p < .001; *** p < .0001

tinction was made for future value of homes, with almost a quarter of the class area evaluations at much below average and below average compared to 8.4% below average for comparison area 1 and 10.2% below average for comparison area 2. The perceived disadvantages of housing in the class area were for visual appearance, air quality, environmental quality, and future home values.

The open-ended questions asked of respondents who rated the class area as below average (n = 104) or much below average (n = 10) produced a number of direct references to the landfill. These were voluntary references since at this point in the interview no mention had been made of the landfill on the part of the interviewers. The 110 respondents that said this area was below average included 56 who identified the landfill as a reason for the poor rating, 22 said odors in the area were connected to the landfill, and 9 said there were environmental problems from the landfill. Of the 10 respondents who rated the area much below average, 7 cited the landfill and 4 of those 7 identified the landfill with odors.

Questions 30 through 43 identified for the first time the landfill in the center of the class area and asked a series of questions about the landfill and its effects on respondent evaluations. When asked if they had heard anything about the landfill in the past few years, 253 respondents (63.3% of the 400 respondents) said they had. These respondents were then asked, "When you think about the landfill, what comes to mind?" The exact responses were recorded and each respondent was asked to say if this memory was positive or negative. More than half these responses (53.0%) were negative; 40.3% were positive,

Figure 2 Mean Scores on Seven Attributes by Survey Area



and almost 7% said they did not know or had no answer to the positive versus negative question. Negative responses referred to adverse effects of the class area environment, appearance, and neighbors while positive responses focused on the community service provided by a solid waste disposal facility.

This same subset of the sample answered the follow-up questions in this way: 95.7% reported they had a some time driven by the landfill, 84.2% said they had visited the landfill, 59.3% said that "odor" strongly or moderately came to mind in reference to the landfill, while 26.1% associated garbage trucks with the landfill. When asked about birds and the landfill, 71.5% said this was a strong or moderate association, with 51.0% recording a strong association. Almost all respondents, 92.1% agreed that the landfill was a health risk. Respondents were asked about the effect of the landfill on their evaluation when they were in the housing market, i.e., did proximity to the landfill make houses much more, somewhat more, somewhat less, much less desirable, or did it not make a difference? One person responded that houses were much more desirable and two people said somewhat more desirable. About one-fifth of the respondents (19.4%) said proximity made houses somewhat less desirable and about one-third (32.0%) said proximity made houses much less desirable. Almost one-half (47.0%) said the landfill made no difference.

The 130 respondents who said the landfill made nearby property somewhat less or much less desirable were asked if price reductions would compensate for the adverse desirability. Four people (3.1%) said no price reduction would be necessary, 23 (17.7%) said a slight price reduction, 42 (32.3%) said a moderate price reduction, and 28 (21.5%) said a large price reduction would be necessary. A fifth category, "no amount of reduction would compensate" was selected by 29 (22.3%) of the respondents. Respondents were not asked to quantify their responses in terms of money values because the appropriate quantification was measured with the professional analyses of the sales data. The qualitative responses were elicited to determine the validity of the mathematical techniques.

In the lawsuit at issue, a substantial part was initiated and pursued by a large commercial prop-

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erty holder whose business operations were especially damaged by the operation of the landfill. We suggest that there are a number of cases of adverse environmental impacts on neighboring properties due to the operations of landfills and other industrial sites. However, many cases are not formally addressed because the property owners have neither the resources nor the knowledge to seek redress. Understanding the sources of property-value impacts should provide appraisers with a more informed context for their valuations, whether they are involved in complex litigation or not.

Summary of the Survey In Relation to the Criteria for Evidence in the Class Action Case

This section is a modified version of the declaration prepared for the class action lawsuit. It describes the approach, methods, and techniques applied to the property value survey conducted in April 2002, and its admissibility as a legal document according to the criteria outlined by the *Manual for Complex Litigation*[17] and *McCarthy*.[18] These criteria are very similar for both sources, although the specific language is not exactly the same. The criteria descriptions presented here in modified form are those shown in Table 1 and accurately represent the two sources. Two of the survey designers and article authors are members of the American Association for Public Opinion Research (AAPOR). The survey methodology follows the AAPOR's most recent guidelines for survey implementation and outcome reporting.[19]

Criteria 1: The population was properly chosen and defined.

The population chosen for the survey was defined as residents living near the class area, active in the residential real estate market, and who actually moved their residence (but did not necessarily buy their new residence) at some time during the period 1995 through 2000. This definition of the survey population provides actual and potential buyers that are informed about property values and the relative attractions of the key residential areas. The geographical area included three zip codes. These three zip code areas covered the general area from the airport on the western boundary to the rural areas to the eastern boundary of the metropolitan area. The class area was not part of these zip code areas.

Individual respondents were screened to meet the following criteria: they had to have (1) lived in the metropolitan area for more than two years, (2) be familiar with the class area, and (3) have been in the real estate market at some time during the period 1995 to 2000. It was not necessary that the respondents had actually purchased real estate but only that they had been looking actively at residential real estate in the market area.

Criteria 2: A representative sample of that universe was selected.

QwestDex[20] maintains a record of telephone connections and moves by zip code. Telephone numbers for this survey were purchased from QwestDex. These numbers included all listed new telephone numbers for new residents and for households that had moved from one residence to another in the target zip codes during the period 1995–2000. The total count of these telephone numbers was 6,240, from which 2,700 were randomly selected and used to complete the survey. The selection and qualification of the respondents provided subjects that fully met the specifications of Criteria 1.

Criteria 3: The questions asked of interviewees were framed in a clear, precise, and non-leading manner.

The survey instrument consisted of 50 questions of which 43 questions were answered by selection from a response scale, 5 questions were about social-demographic characteristics (e.g., age, gender), and 2 questions were open ended with the verbatim responses being recorded. The interviews took 10–12 minutes on average. Only after the ratings of the comparison residential areas were completed were respondents introduced to the evaluations of the subject landfill. The survey was designed and pretested under the supervision of three PhD social scientists. These colleagues reviewed the survey criteria described in *McCarthy* and the *Manual of Complex Litigation* prior to beginning their work and incorporated these guidelines into the survey design.

17. Federal Judicial Center.

18. McCarthy.

19. American Association for Public Opinion Research, *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys* (Ann Arbor, MI: AAPOR, 2000).

20. QwestDex Direct (Englewood, CO: Qwest Dex, Inc., 2002).

Criteria 4: Competent interviewers, who had no knowledge of the litigation or the purpose for which the survey was conducted, followed sound interview procedures.

All interviewers were experienced and extensively trained personnel employed by a professional survey research and data services firm. Specific training for this survey instrument was conducted by the director of the survey research firm (a PhD sociologist) with the project director (a PhD social scientist) in attendance. Continuous supervision and monitoring was provided during the data collection period by supervisors. Data were collected during the period April 10 through April 24, 2002.

Interviewers and respondents were told the survey was being conducted on behalf of real estate appraisers, with the name and contact information for the survey research firm that was conducting the survey, and that the subject was "things that affect the quality of life in local residential areas." Neither the interviewers nor the respondents were told that the survey would be used in litigation.

Criteria 5: The data gathered were accurately reported.

All data collected from this survey are provided with the exact questions and answers recorded by the interviewers and complied by the survey research firm. The responses are listed according to the scales or parameters allowed for respondent answers.

Telephone Protocol. The 2700 randomly selected telephone numbers were called seven days a week starting as early as 10 a.m. and continuing until 9 p.m. A single telephone number was attempted up to 11 times, with subsequent dial attempts moved around a seven-day schedule that guaranteed that each number would be called on different days and at different times of the day. Partial interviews were completed on an appointment basis with appointment times determined by the respondent's schedule.

Response Rate. A response rate of 34% was achieved for this study, with a refusal rate of 9%.[21] At the end of the survey, 837 telephone numbers had been determined to be ineligible either because the respondent failed to qualify, or because the number did not lead to a residential telephone. In addition, 1,217 telephone numbers still had an unknown status (primarily because all calls to them had resulted in an answering machine). Four hundred interviews were completed and there were 23 final refusals.

Margin of Error. This survey has a margin of error of +4.7% when generalized back to the entire universe of 6,240 telephone numbers supplied by QwestDex. This margin of error is based on a worst-case scenario of a 50/50 proportional split and is at the 95% confidence level. Since there is every reason to believe that this QwestDex sample is representative of a larger population of area residents who may have been in the real estate market, it is worth noting that a sample of 400 produces a margin of error of no worse then +4.9% for a population of up to one million. For the split sample portion of the survey, where 200 subjects were asked about either comparison area 1 or comparison area 2, the margin of error, when generalized back to the entire QwestDex universe of 6,240 telephone numbers, is +6.8%, also at the 95% confidence level.

Criteria 6: The data were analyzed in accordance with accepted statistical principles.

Since the survey instrument was very concise and clear, most results are reported with simple descriptive statistics. These include distributions for question scales, mean scores and differences for selected questions, recording and categorization of open-ended response, and some basic cross-tabulations for bivariate analysis.

Criteria 7: The process was conducted so as to ensure objectivity.

The purpose of the survey was not communicated directly to the interviewers or the respondents. It was known to the designers of the survey. The objectivity of the residential area ratings was assured by eliciting the ratings and responses prior to any mention of the landfill and then presenting the questions and recording the responses to landfill questions at the back-end of the survey (but prior to the factual questions on social-demographic items).

Summary

This survey provided a design approach, question preparation, and implementation methodology to meet the criteria for the admissibility of surveys as prescribed in *McCarthy* and the *Manual for Complex Litigation*. The survey conclusion was that the nega-

21. Response and refusal rates are reported as recommended in Frankel and other sources; see Lester R. Frankel, "The Report of the CASRO Task Force on Response Rates," in *Improving Data Quality in a Sample Survey*, ed. Fredrick Wiseman (Cambridge, MA: Marketing Science Institute, 1983). The response rate is defined as "the number of complete interviews with reporting units divided by the number of eligible reporting units in the sample." Also see, American Association for Public Opinion Research, 35–40.

tive property values shown in the plaintiffs' case (developed by paired sales, regression analysis, and case studies) were due to the public perceptions of the landfill and its stigma characteristics as evaluated by potential real estate buyers in the larger community. The survey did not attempt to quantify in dollar terms the lost value of property in the class area since this was established with standard appraisal methods including the use of case studies, paired sales analyses, and multiple regression analyses. Even though these techniques did show loss in value, there may be a question as to the causal link between an environmental disamenity and the loss in value. What the survey did was link the landfill with a stigma effect on public opinion about the desirability of housing and property in the class area. This allowed the appraiser to account for the negative values identified in the sales data and to understand the causal link between public responses to the stigmatized neighborhood and the diminution this caused in property values. In other lawsuits of this type, defendants might show alternative sources of property loss or challenge the survey design, methods, analyses, and conclusions. In terms of the subject class action lawsuit, the outcome was a settlement of the case shortly before it was scheduled for trial.

James Flynn, PhD, is a senior research associate at Decision Research in Eugene, Oregon, and a senior fellow at the Pacific World History Institute in Stockton, California. He graduated from Eastern Washington State University and completed his graduate degrees at the University of Washington. He has published more than 50 articles on public perceptions and responses to technological and environmental risks. In 2001, he published *Risk, Media and Stigma*, with Paul Slovic and Howard Kunreuther. Contact: jflynn@decisionresearch.org

Donald G. MacGregor, PhD, is president of MacGregor-Bates, Inc., and a senior research associate at Decision Research, both in Eugene, Oregon. He graduated from California State University, Sacramento, and completed his graduate education at the University of Oregon. He has published extensively on judgment, decision making, and the perception of risk. Contact: donaldm@epud.net

Wayne Hunsperger, MAI, SRA, is a principal with the appraisal firm of Hunsperger and Weston, LLC, in Greenwood Village, Colorado. The firm is a full service real estate appraisal company with special capabilities in the valuation of open space, eminent domain takings, and properties impacted by disamenities or contamination, including entire residential neighborhoods and special properties of various kinds. He often works with multidisciplinary teams including engineers, economists, statisticians, and social scientists. He is a graduate of the University of Texas, with a degree in business. Contact: wayne@hwltd.net

C. K. Mertz, MRCP, is a research associate at Decision Research, in Eugene, Oregon. She graduated from Oklahoma State University and received her master's degree in regional and community planning from Kansas State University with additional graduate studies in statistics at the University of Oregon. She has coauthored more than 40 articles in journals such as *Human and Ecological Risk Assessment, Risk Analysis,* and *Health, Risk & Society*. Contact: ckmertz@decisionresearch.org

Stephen M. Johnson, PhD, is president of Northwest Survey & Data Services, in Eugene, Oregon and is a research associate at Decision Research. His undergraduate and doctorate degrees are from the University of Oregon. He has published more than 40 articles and book chapters on a wide variety of subjects in social science and science journals, including *The Journal of Psychology and Financial Markets, Journal of Behavioral Decision Making, Journal of Risk and Uncertainty, American Scientist,* and *Journal of Geophysical Research*. Contact: stevej@nsdssurvey.org

Journal of Real Estate Finance and Economics, 22:2/3, 185–202, 2001
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Property-Value Impacts of an Environmental Disamenity: The Case of Landfills

DIANE HITE
Department of Agricultural Economics, Mississippi State University, Mississippi State, MS
Email: hite@agecon.msstate.edu

WEN CHERN
Department of Agricultural, Environmental, and Development Economics, Ohio State University

FRED HITZHUSEN
Department of Agricultural, Environmental, and Development Economics, Ohio State University

ALAN RANDALL
Department of Agricultural, Environmental, and Development Economics, Ohio State University

Abstract

The purpose of this article is to quantify the property-value impacts of a change in environmental quality by using the hedonic price model. In particular, we focus on the impact of the presence of landfills on nearby residential real estate prices. We combine elements of an urban location choice and hedonic pricing model to estimate the effects of the presence of multiple environmental disamenities on residential real estate prices. We explicitly account for temporal effects by including housing transactions in areas with both open and closed landfills and control for information effects. In addition, we treat property taxes and prices as being simultaneously determined. Our analysis suggests that closing landfills will not necessarily mitigate property-value impacts.

Key Words: hedonic price model, property values, externalities, environment, urban, rural, and regional economics

1. Introduction

The objective of this article is to conduct an empirical investigation into the impact of landfills on the property values of houses located nearby. The fact that organized markets for environmental quality do not exist requires the application of a nonmarket valuation technique in order to measure economic impacts. We use Rosen's (1974) well-known hedonic pricing model (HPM) in which an explicit goods market (the real estate market) is analyzed to estimate the implicit price associated with proximity to a landfill, thus enabling estimation of marginal willingness to pay at various distances from a landfill. A number of authors, such as Lunneman (1981), Parsons (1986), and Quigley (1984), have used the HPM to estimate willingness to pay for housing characteristics. There has also been a growing literature that uses the HPM to measure welfare changes in implicit markets for environmental quality, for example, Driscoll et al. (1994), Mendelsohn (1984),

Nelson (1992), and Palmquist (1988). Other authors, such as Kohlhase (1991) and Nelson et al. (1992) have specifically used the HPM to examine landfill impacts.

In contrast to previous studies of landfills that employ the hedonic method, the current research focuses on the locational factors inherent in the real estate market by combining spatial aspects of the standard urban-amenities models with the hedonic model. We combine a model that accounts for locational effects such as those in the urban literature (Henderson, 1985; Fujita, 1989) with a standard model for implicit goods.

In addition to spatial effects of disamenities, we consider landfill life expectancy to be a factor that may have nontrivial bearing on measures of social welfare. We thus investigate the possibility that the disamenity effect of a landfill may decrease with life expectancy and negative impacts on real estate values may linger after the landfill has closed. We demonstrate the welfare impacts by estimating a fully specified HPM that accounts for change in distance to a landfill, as well as changes in landfill life expectancy.

A number of authors have pointed out the importance of information in the hedonic price model (Bite, 1998; Kiel and McClain, 1995; Kask and Maani, 1992; Kohlhase, 1991). We thus recognize that information about local real estate markets—and in particular, about the existence of disamenities such as landfills—may influence buyers' bargaining power and hence hedonic prices. We thus include a proxy variable for information to test the validity of this hypothesis.

To implement the model, well-defined study areas around each of four landfills in Franklin County, Ohio, were chosen for the analysis. A full year of 1990 real estate transaction data from Franklin County were collected and augmented with data from other sources. First, 1990 census block group micro data were used to obtain demographic variables and to create a proxy for buyer information about local disamenities. Second, variables from maps were created and combined with data from other sources to account for environmental and neighborhood characteristics. The full data set captures the marginal price effects of structural housing and environmental characteristics, as well as neighborhood and locational impacts. In addition to the fully specified data set we use, the inclusion of landfills from a single urban area with both positive and negative life expectancies sets this research apart from previous studies of landfill impacts. Finally, we posit that property taxes and housing prices are endogenously determined and thus estimate a simultaneous equation system that includes both annual property taxes and rents.

2. Analytical framework

We set up our model in a single-period, static framework as follows. Households are assumed to purchase a home according to tastes for property characteristics, environmental amenities, and disamenities Z (see Diamond and Tolley, 1982, for a thorough treatment of the theory of disamenities). The model assumes that each household chooses from a set of amenities and disamenities, each of which is described by a set of distance measures, such as distance from central business district (CBD) and landfills. Households then maximize utility, which is a function of property

characteristics, as well as amenities, and a numeraire (composite) good, X. Households are constrained in their choice of amenities, housing characteristics, and location by per period income, Y. Income is allocated over purchase of a per period housing rent, which is described by the hedonic price function (HPF), $P(Z)$, property taxes, $T(Z)$, and a composite good, X. Note that $P(Z)$ is assumed to be a function of property characteristics and neighborhood amenities and disamenities, while $T(Z)$ is determined by property characteristics and local public goods, especially schools. Amenities and disamenities, local public goods, and property characteristics all emerge as important determinants of household location choice.

Each household solves the maximization problem (subscripts suppressed)

$$\max_{Z,X} U(Z, X)$$
$$\text{s.t. } Y - P(Z) - T(Z) - X = 0, \tag{1}$$

From the first-order conditions, we obtain the result that $MRS_{Z,X} = \frac{\partial P}{\partial Z} + \frac{\partial T}{\partial Z}$, implying that the marginal willingness to pay for individual characteristics of a property and its neighborhood is governed by both the marginal price and the marginal contribution of the characteristic to property taxes. This implies an equilibrium relationship different from other similar studies in that a marginal property-tax component emerges as part of marginal willingness to pay (MRP). The tax component helps to measure the WTP for local public goods, an important determinant of location choice. It should also be noted that, in general, a number of home buyers are forced to pay taxes and insurance as part of their mortgage payment, implying that taxes are an integral component of house rents. Furthermore, property-value assessments are generally based on structural characteristics of a house and other physical factors, such as lot size. Urban economists (e.g., Brasington, 1999; Haurin and Brasington, 1996) frequently specify tax millage rates as an exogenous variable in the right-hand side of the hedonic function. We take a different approach in this article, specifying a simultaneous equations model in which prices and taxes are jointly determined.

3. Sample design and data development

The data used in this article were collected in such a way as to represent the extended hedonic model as completely as possible. To investigate the full social impact of landfills, we consider information about the disamenity, its spatial dimension, and its life expectancy to be important factors. With respect to information impacts, we would expect individuals with less information about local real estate markets to pay higher prices for homes close to disamenities than would those with more information, ceteris paribus. Spatial effects enter the model in such a way that we would expect to observe lower real estate values close to a landfill site. In regard to landfill life expectancy, we would expect to see increases in real estate values, as well as possible increases in nearby population densities, after a landfill has been reclaimed. There may also be speculation in the real

estate market, which would increase property prices as landfill life expectancy decreases. In addition, different types of landfills may impact property values more than others, such as when comparing hazardous waste sites or demolition landfills to sanitary landfills. The foregoing considerations were taken into account when designing the overall sample used in this article.

3.1 The study areas

In an effort to capture both the effects of distance to a landfill as well as life expectancy, four study sites were selected for the current analysis, described by circles within 3.25 mile radii of four different landfill areas in Franklin County, Ohio. The landfills have different life expectancies and are located in areas with differing urban characteristics. The 3.25 mile radius was chosen because previous studies have found positive distance effects for up to 1.5 miles from landfills (Nelson et al., 1992). Increasing the size of a study area to a 3.25 mile radius has a number of advantages. Most important, we can fully investigate distance relationships and make comparisons between impacted and relatively nonimpacted populations. In addition, larger study areas increase variability of neighborhood and housing characteristics, which helps to mitigate problems associated with multicollinearity.

Two of the areas, Alum Creek and Obetz, were affected by demolition dumps (landfills that accepted only building materials and that had a relatively limited life span). In 1990, these two sites had been closed for six and 11 years, respectively. The first of these sites, Alum Creek, is comprised of four demolition landfills that operated on contiguous properties for 10 years between 1969 and 1979, with the maximum operation of any given landfill lasting about five years. In the Obetz area, two adjacent demolition landfills operated from 1980 to 1985. The other two areas chosen were impacted by sanitary landfills (landfills that accept municipal solid waste or household waste as opposed to toxic substances or demolition debris). In 1990, one had a life expectancy of two years and another had a life expectancy of at least 20 years. Of these, the Galbanna landfill opened in 1968, and the Grove City landfill opened in 1984. Life expectancy is determined by landfill operators based on remaining cubic yards of airspace available at a given site and is reported to the Ohio Environmental Protection Agency (OEPA) annually.

It is notable that the operating life expectancy of the sanitary landfills is over 20 years, while the life expectancy of demolition dumps is about five years. Furthermore, OEPA records show that while sanitary landfills have been relatively well run in Franklin County, the demolition dumps in the sample were frequently not in regulatory compliance. The demolition sites were repeatedly cited for accepting sanitary and, in some instances, hazardous waste.

Figure 1 illustrates the geographic areas in Franklin County that are included in the study. It should be noted that the Obetz and Alum Creek areas overlap significantly, with the outer diameter of the Alum Creek site coming to within 1.5 miles of the Obetz landfill.

Except for the Alum Creek area, which is located within a mostly urban area, the landfills under investigation are located in the suburbs of Franklin County. The town of

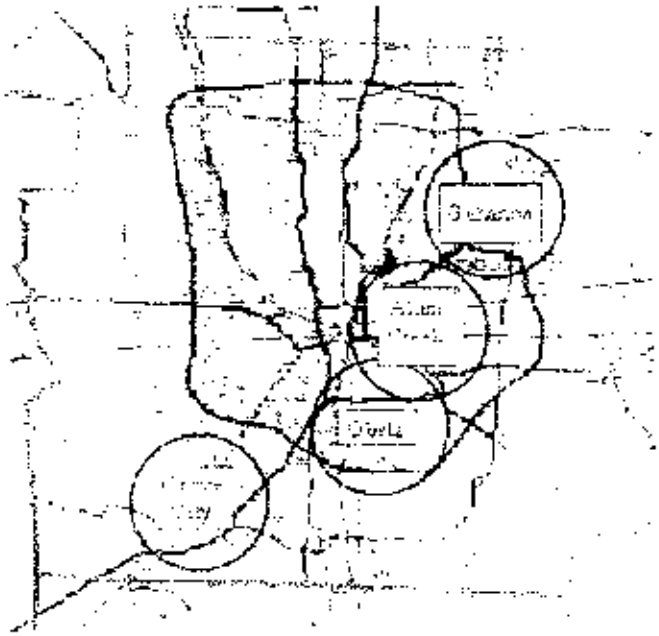

Figure 1 Map of study areas.

Obetz had a population of 3,167 in 1990, while Grove City's 1990 population was 19,661 and Gahanna's was 27,791. Furthermore, Grove City and Gahanna are high-growth areas where the population increased almost 225 percent over the 20-year period from 1970 to 1990, while the Obetz population increased about 140 percent (Vonada, 1992). In comparison, Franklin County's overall population increased only about 14 percent in this time period, demonstrating an increasing trend toward suburbanization. Table 1 briefly describes these four areas. Note that the reference year for landfill life expectancy is 1990. Nine different school districts are represented within the study areas, as are 279 unique census block groups.

Other environmental disamenities are present in the study areas chosen. First, the different study areas have varying amounts of noise pollution resulting from rail and air traffic, with additional noise and air pollution from nearby freeways. A trash burning power plant affecting mainly the Obetz and Alum Creek sites was also in operation during the time period in which the analysis takes place. The power plant came under scrutiny in 1993 by the United States EPA for emitting unsafe levels of dioxins and was closed by the end of 1994. In 1990, however, it was largely unknown to the public that a dioxin danger was present, and, aside from potential for unpleasant odors, the plant may not have been a major factor in individuals' location decisions.

Table 1. Characteristics of study areas.

Study Area	Landfill Type[a]	Life Expectancy[b]	Urban Characteristics	School Districts
Grove City	Sanitary	20 years	Mostly rural	Groveport-Madison, South-Western City
Gahanna	Sanitary	7 years	Mixed rural and suburban	City of Columbus, Gahanna-Jefferson, Whitehall, Reynoldsburg, Licking Heights
Obetz	Demolition	−6 Years	Mostly suburban	City of Columbus, Groveport-Madison, Hamilton
Alum Creek	Demolition	−11 Years	Mixed established suburban established urban	Bexley, City of Columbus, Whitehall, Hamilton

Source: Ohio EPA.

Notes: [a]The difference between demolition landfills and sanitary landfills is strictly in the type of solid waste accepted. Demolition landfills accept solid waste with no organic matter but have the potential to contain more dangerous substances such as asbestos and lead. The distinctions between demolition dumps and solid waste landfill disamenity effects may be blurred due to the fact that there is evidence of a high degree of illegal solid waste disposal at the two demolition dumps in the study. Source: Personal interviews with Ohio EPA staff engineer, Jim Rah

[b]Negative life expectancies represent number of years closed

3.2. The data

Our intent is to include transactions in the study that are expected to represent owner-occupied housing units. The reason for this is simple: hedonic pricing theory states that individuals' utility maximization leads to demands for characteristics and that persons purchasing housing units to become landlords will not necessarily be consumers of the characteristics of a property.

Within the study areas defined, actual sales prices of 2,891 transactions on single-family homes and condominiums along with 22 repeat sales transactions were obtained from one full year (1990) of county auditor's records. The final data set consists of a sample of 2,913 observations.

Each property transaction record includes information used to create variables for the structural characteristics vector. These include age of structure, number of rooms, bedrooms, baths, half baths, porches and stories, square footage of structure, garage and lot, and dummy variables for condominiums, central air conditioning, fireplace, and masonry construction. In addition, information about month of transaction, school districts, and the individuals who participated in transactions was obtained from these records.

Because the names of the grantors and grantees of the properties were available, it was possible to identify many transactions that could be considered as out of market. These transactions were included because they help to explain purchasers' tastes as well as site-specific property characteristics. We also include them in the tax equation as they may capture unobserved attributes of the neighborhood in which they occur. Dummy variables were thus created for the following transaction types: (1) intrafamily transactions as identified by surnames of grantors and grantees, (2) corporate transactions in which realtors or limited partnerships participated, (3) transactions in which financial institutions were involved, and (4) transactions wherein properties were purchased from an estate. Also, transactions in which prices appeared artificially high or low for a given neighborhood were assigned dummy variables to help account for unobservable quality differentials in the housing.

By locating the transacted properties on a street map of Franklin County, variables for neighborhood characteristics (such as proximity to the airport and to railroads, freeways, parks, and country clubs) were created. Map locations were also used to establish the distance from each property to each of the landfills, the Columbus municipal trash burning power plant, and the CBD. Locations were also used to match properties with indices of neighborhood crime rates and competitiveness of local school districts.

In the case of distance to the CBD, the landfills and the trash-burning power plant, linear measures were used to create distance variables. To create a variable for proximity to Port Columbus Airport, an area 1.5 miles from its outer perimeter was described on a map, and all properties falling within that area were assigned a dummy variable. Likewise, properties within one-half mile of railroads and freeways were given dummy variables, and dummy variables were also created for properties adjacent to parks and country clubs.

Franklin County neighborhood crime rate indices were created from Federal Bureau of Investigation Uniform Crime Statistics and represent total occurrences of both violent and nonviolent crimes per 1,000 population. In the study areas used in this article, the crime index ranges from a low of 29 in one neighborhood in the Gahanna area to a high of 211 in a neighborhood within the Alum Creek area. These represent the lowest and highest crime rates in Franklin County.

School-district quality was measured by a school competitiveness index that was constructed from proprietary data obtained from the Ohio State University Admissions Office. Fourteen high schools in the study areas were assigned an index that ranges from 0 to 100, with both the highest- and lowest-ranked high schools located within the Alum Creek area. In addition, yearly property taxes for each household were included.

Table 3 contains some of the key descriptive statistics from the primary data set that help to characterize the four areas analyzed. In the overall sample, the 1990 yearly rental equivalent is $7,540.91, with the lowest rent in Obetz ($5,092.62) and the highest in Gahanna ($9,678.69). Likewise, 1990 property taxes range from a low of $496.34 per year in Obetz to $864.64 in Gahanna, and the average square footage of homes was smallest in Obetz and largest in Gahanna. However, lot sizes, as predicted by the standard model of urban density, are a monotonically increasing function of distance to the central business district. Crime rates also follow this pattern inversely, with area average rates ranging from 112.75 to 41.00 as average distance from the CBD increases. Out-of market transactions

Table 2. Selected descriptive statistics: primary data

Variable	All Areas (N = 2,913)	Alum Creek (N = 1,599)	Obetz (N = 396)	Gahanna (N = 855)	Grove City (N = 263)
Yearly rent equivalent	$7,542.91	$6,569.62	$5,092.56	$9,678.69	$8,280.63
Yearly property tax	$729.56	$717.37	$496.34	$864.64	$646.50
Square footage of structure	1,443.78	1,394.24	1,173.55	1,595.68	1,433.33
Square footage of lot	13,898.48	7,798.72	11,316.61	21,732.92	27,629.26
Age of structure (years)	37.44	45.17	27.97	23.44	25.62
Percent out-of-market transactions	19.94	24.06	16.92	15.57	12.46
Percent 1.5 miles from airport	14.28	2.00	0.00	43.94	0.00
Percent 0.5 miles from freeway	25.82	28.83	43.94	14.76	29.20
Percent 0.5 miles from railway	17.78	22.84	43.43	4.27	24.00
Percent moved from out of state	5.73	5.88	4.66	9.61	4.25
Crime rate	86.25	102.75	72.55	53.90	41.06
School index	44.40	33.00	28.05	65.96	59.15
Miles to Alum Creek landfill	4.10	2.16	5.41	6.21	9.97
Miles to Obetz landfill	6.34	5.11	1.85	10.02	8.13
Miles to Gahanna landfill	6.13	6.50	8.43	2.27	15.15
Miles to Grove City landfill	11.72	10.96	9.45	10.69	2.67
Miles to trash-burning plant	6.44	4.96	3.44	10.49	4.84
Miles to CBD	5.09	3.32	8.14	11.87	12.14

behave similarly, with the highest percentage occurring closest to the center city. This is expected, since more homes that are foreclosed on or sold by estates would be located in poorer and older neighborhoods.

In terms of neighborhood disamenities, the highest proportion of homes sold near freeways and railroads occurred in Obetz, and of houses sold in the Gahanna area, 43.94 percent were within 1.5 miles of Port Columbus airport. Transactions in the Obetz area are also the closest, on average, to the trash-burning power plant (an average of 3.44 miles) and are also closest of any area to any landfill. On average, housing transactions in Obetz were within 1.85 miles of the Obetz landfill while Grove City transactions were farthest, at an average of 2.67 miles from the Grove City landfill. Thus, the average distance to landfill of transactions in areas with closed landfills is closer than the comparable measure for areas with open landfills. To account for differences in buyer information about neighborhood characteristics, we include a variable from the census block group data. The variable represents the total percentage of households in a block group that moved to their current location within the five years previous to 1990 from locations outside the state or from outside the country. We would expect that individuals moving from outside of the area would have less reliable information regarding local disamenities.[1]

4. Estimation of the hedonic price function

The HPF represents the locus of equilibria of all the individual buyers and sellers in the real estate market, and as such, economic theory suggests no a priori assumptions on the

form that it takes. We deal with two issues associated with estimation here, functional form and market segmentation.

Initial efforts to use the Box Cox model as a tool to find the best functional form for the HPF led to unstable results. Investigation into the causes of instability uncovered the fact that standard errors of both the price variable and the lot size variable were such that subtracting one standard deviation from the mean resulted in negative values. The implication here is that, since no negative price or lot-size variables existed in the data, the assumption of normality of these data would have to be rejected. Olsen (1977) has pointed out that, in applying the Box-Cox model in cases such as encountered here, the Jacobian of transformation for the likelihood function will incorrectly assign positive probability to negative values of the dependent variable, leading to an inappropriate application of the model.

From the analysis of the standard errors above, log transformations of the price and lot variables resulted in more nearly normally distributed variables. As a result, we use a mixed log-linear function based on the notion that distance to CBD, price, and lot size are log linearly distributed while other variables may follow a normal distribution. Distance to landfill variables are estimated with second-degree polynomials.[2]

We assume that, if housing-market segmentation exists,[3] different implicit prices in different areas for a given characteristic would be observed. Real estate market segments could be thought to exist among the four different landfill sites, since they are in distinctly different parts of Franklin County. Although the Obetz and Alum Creek areas have some overlap, there are freeways intersecting these areas that act as physical barriers. Thus, the part of the Alum Creek area that overlaps the Obetz area is expected to be more affected by proximity to the Obetz landfill than the Alum Creek landfill.

A number of segmentation schemes were introduced and sequentially tested with F-statistics, based on annual rents. First, an analysis was done in which there were three segments, one of each of the Grove City and Gahanna areas and one that pooled observations from the Alum Creek and Obetz areas. This specification was tested against one in which four market segments, one for each of the landfills, were assumed. Segmentation was achieved by including dummy variable interaction terms corresponding to all of the neighborhood, environmental, and property characteristics, as in equation (2) below

$$\ln(Rent) = DV_i(Intercept + \alpha h \ln(lot\ size) - \delta_1 D + \delta_2 D^2 + \nu' N + \gamma' E + \beta' H - \varepsilon)$$
$$i = (1, \ldots, 4), \tag{2}$$

where N represents a vector of local goods including the school index and crime rate index, as well as dummy variables for housing transactions that could be considered as out of market. Environmental goods are represented as the vector E and include proximity to railroads and Port Columbus airport, as well as distance from landfills. The variable DV represents a dummy variable, one for each of the four study areas. The H vector represents housing characteristics, including square footage of building and garage, number of stories, number of rooms and bedrooms, number of baths and full baths, and age of

structure. In addition, dummy variables for type of construction (masonry versus frame), presence of central air conditioning and fireplaces, and whether the structure is a condominium are included. $\alpha, \delta_1, \delta_2, \ldots, \gamma$, and β represent parameters.

By testing parameter restrictions on the dummy variables, the model with four versus three market segments was favored. We proceeded to test segmentation by applying more specific restrictions.[4] The econometric model that resulted is one in which housing characteristics, park proximity, and freeway access are segmented over the four study areas, while all other neighborhood characteristics and environmental goods are pooled. Freeway access could be viewed as an amenity to individuals living in suburban areas but as noise pollution to individuals living in urban areas. Likewise, in some neighborhoods, parks may be viewed as disamenities that attract noise and crime, while in others they may represent an amenity because of the green space they provide.

The final hedonic model is a mixed log-linear specification that incorporates a certain degree of market segmentation. In addition, after the market segments were determined, the model was reformulated as a simultaneous equations model, under our assumption that taxes and prices are jointly determined. Thus we include annual property taxes as a right-hand-side variable in the rent equations and include rent as a right-hand-side variable in a hedonic tax equation. For the sake of brevity, only the final model for rent is shown below in equation (3):

$$
\begin{aligned}
\ln(Rent) = {} & \alpha_{AC} - \alpha_1(\textit{Distance to Alum Creek}) \\
& - \alpha_2(\textit{Distance to Alum Creek})^2 \\
& - \alpha_{OB} + \alpha_3(\textit{Distance to Obetz}) - \alpha_4(\textit{Distance to Obetz})^2 \\
& - \alpha_{GH} - \alpha_5(\textit{Distance to Gahanna}) \\
& + \alpha_6(\textit{Distance to Gahanna})^2 \\
& + \alpha_{GC} + \alpha_7(\textit{Distance to Grove City}) \\
& + \alpha_8(\textit{Distance to Grove City})^2 \\
& - \alpha_9 \ln(\textit{Distance to CBD}) + \alpha_{10}(\textit{Proximity to Airport}) \\
& - \alpha_{11}(\textit{Proximity to Railroad}) \\
& + \alpha_{12}(\textit{Crime Rate}) + \alpha_{13}(\textit{School Index}) \\
& - \alpha_{14}(\%\ \textit{CBG Out of State}) + \alpha_{15}(\textit{Property Tax}) \\
& + \alpha_{16}(\textit{Transaction in 2nd Half of 1990})
\end{aligned}
$$

$$
\begin{aligned}
DV = \Bigg[& \alpha_1(Near\ Freeway) + \alpha_2(Near\ Park) \\
& + \alpha_4(Near\ Country\ Club) \\
& + \alpha_{20}(Intrafamily\ Transaction) \\
& + \alpha_{21}(Bank\ Transaction) \\
& + \alpha_{22}(Corporate\ Transaction) \\
& + \alpha_{23}(Estate\ Transaction) \\
& + \alpha_{24}(Other\ Transaction) \\
& + \alpha_{25}\ln(Lot\ Size) + \alpha_{26}\left(\frac{Sq.\ Footage\ Structure}{100}\right) \\
& + \alpha_{27}\left(\frac{Sq.\ Footage\ Garage}{100}\right) + \alpha_{28}(Number\ of\ Rooms) \\
& + \alpha_{29}(\#Bedrooms) + \alpha_{30}(\#Full\ Baths) \\
& + \alpha_{31}(\#Half\ Baths) \\
& + \alpha_{32}(Structure\ Age) + \alpha_{33}(Central\ Air) \\
& + \alpha_{34}(Fireplace) + \alpha_{35}(Brick/Masonry) + \varepsilon \Bigg]
\end{aligned}
\tag{3}
$$

The same variables are used in both the rent and tax equation because factors that determine house prices are also taken into consideration in the tax-assessment process for individual properties. Neighborhood factors will likewise enter into tax assessments in that assessors consider recent market-transaction prices in their valuation, which are affected by local characteristics. Finally, school quality affects property taxes directly.

The model was estimated using nonlinear three-Stage least squares. The estimated parameters of the HPF and HTF represented by the specification in equation (3) are reported in Tables 3 and 4. The significance levels of resulting t-statistics are given at the 10 (*), 5 (**), and 1 percent (***) levels.

The estimated coefficients of the variables that represent neighborhood characteristics (such as school quality, crime rate, and proximity to the airport) generally follow the theoretically correct signs, and most are significant at the 5 percent level. Among the segmented variables, it is interesting that proximity to a park is significantly positive in the most urban study area, Alum Creek, but is significantly negative in the most suburban area, Gahanna; this is true in both the rent and tax equations. Thus parks represent amenities in urban areas but disamenities in suburban areas. Furthermore, as hypothesized, the presence of a nearby freeway has a positive though insignificant influence on housing prices in suburban areas but has a negative impact in urban areas in the rent equation. In the tax equation, the only difference is that proximity to a freeway is significantly positive in the

Table 5. Estimated hedonic price function (nonlinear 3SLS).

Common Variables	Parameter Estimate	Standard Error
Alum Creek intercept	−1.0027	0.1470
Obetz intercept	1.2140	0.3936***
Gahanna intercept	−1.0045	1.1594
Grove City intercept	1.3949	0.4028***
Distance to Alum Creek	0.2235	0.0235***
(Distance to Alum Creek)²	−0.0094	0.0031***
Distance to Obetz	0.1140	0.0345***
(Distance to Obetz)²	−0.0057	0.0021***
Distance to Gahanna	0.1292	0.0217***
(Distance to Gahanna)²	0.0008	0.1879
Distance to Grove City	0.1241	0.0341***
(Distance to Grove City)²	0.0169	0.0021***
Ln(Distance to CBD)	−0.1452	0.0528
Crime rate	−0.0012	0.0003***
≤ 1.5 miles to airport	0.0235	0.0337
≤ 0.5 miles to railroad	−0.0162	0.0265
School index	0.0922	0.0026***
CBG percent moved from out of state	0.7079	0.2070***
Property tax	0.1003	0.0460***
Transaction and half of year (0,1)	0.1560	0.0158***

Market Segment	Alum Creek		Obetz		Gahanna		Grove City	
Segmented Variables	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
≤ 0.5 mile to freeway	−0.0296	0.0293	−0.1325	0.0499***	0.0278	0.0440	0.1516	0.0939
Adjacent to park	0.2602	0.0560***	0.0319	0.0797	−0.1214	0.0552**	0.0354	0.1096
Adjacent to country club	N/A	N/A	N/A	N/A	0.0288	0.0539	−0.0213	0.1147
Relative/family sale	−0.3592	0.0640***	−0.1550	0.1392***	−0.3719	0.0488***	−0.2370	0.1529**
Bank sale	−0.4571	0.0482***	0.3555	0.1756**	0.1532	0.0977	−0.4499	0.2216
Corporate sale	−0.3479	0.0250***	−0.1563	0.0567*	−0.2188	0.0355***	0.0695	0.2092
Estate sale	−0.0959	0.0437***	−0.0221	0.1090	−0.0389	0.0527	−0.2864	0.1249**
Other	0.9174	0.0756***	−1.4024	0.2401***	−0.6418	0.1202***	0.5224	0.2442**
Lake frontage	0.2072	0.0156***	0.0407	0.0259**	0.2175	0.0167***	0.0490	0.0412
Sq. ft. house (00s)	0.0052	0.0038**	−0.0067	0.0119	0.0221	0.0062***	0.0249	0.0104**
Sq. ft. garage (00s)	0.0342	0.0056***	0.0358	0.0084***	0.1306	0.0064***	0.0246	0.0150***
Number of rooms	0.0405	0.0169**	0.0219	0.0470	0.0399	0.0286	0.0371	0.0426
Number of bedrooms	0.0130	0.0249	0.0245	0.0646	−0.0754	0.0393*	0.1056	0.0610*
Number of full bath	−0.0839	0.0405***	0.1571	0.0818*	0.0489	0.1476	−0.0515	0.0857
Number of half bath	0.1209	0.0277***	0.0275	0.0351	0.1097	0.0393***	0.0065	0.0825
Age of house	−0.0052	0.0005***	0.0068	0.0016***	0.0074	0.0015***	−0.0086	0.0021***
Central air (0,1)	0.1644	0.0272***	0.0154	0.0197	−0.1715	0.0370**	0.0016	0.0651
Fireplace (0,1)	0.2374	0.0279***	0.0205	0.0760	0.1159	0.0409***	0.1113	0.0754
Brick/masonry exterior (0,1)	0.0614	0.0165***	0.1403	0.0649***	0.0102	0.0127	[illegible]	0.0751
Adjusted R² = 0.8656				F = 1,394.78***				

most suburban area, Grove City. The coefficient for percentage moving from out of state is positive and significant and is larger in magnitude and significance in the rent equation than in the tax equation. This coefficient can be interpreted as meaning that as the

Table 4. Estimated hedonic tax function (nonlinear 3SLS).

Common Variables	Parameter Estimate	Standard Error
Alum Creek intercept	−0.1214	0.0438**
Obetz intercept	0.9234	0.3676**
Gahanna intercept	−0.0229	0.0833
Grove City intercept	0.5632	0.4313
Distance to Alum Creek	0.1565	0.0210***
(Distance to Alum Creek)²	0.0052	0.0019***
Distance to Obetz	0.7321	0.0522***
(Distance to Obetz)²	−0.0051	0.0022***
Distance to Gahanna	0.1477	0.0502**
(Distance to Gahanna)²	0.0021	0.0015
Distance to Grove City	[illegible]	0.0565***
(Distance to Grove City)²	0.0068	0.0039**
Ln(Distance to CBD)	−0.7308	0.0482***
Crime rate	0.0013	0.0005***
≤ 1.5 miles to airport	−0.1157	0.0314***
≤ 0.5 mile to railroad	−0.0214	[illegible]
School index	0.0073	0.0005***
CBG percent moved from out of state	0.3646	0.2939*
Annual land equivalent	1.5E-5	1.3E-6***
Transaction date (of 1–4 years = 1)	0.0305	0.0147**

Market Segment	Alum Creek		Obetz		Gahanna		Grove City	
Segmented Variables	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
≤ 0.5 mile to freeway	−0.0121	0.0273	−0.1724	0.0465***	0.0240	0.0410	0.1480	0.0876*
Adjacent to park	0.2513	0.0522***	0.0103	0.0744	−0.2439	0.0521***	−0.0056	0.1022
Adjacent to country club	N/A	N/A	N/A	N/A	0.0006	0.0503	0.0882	0.1065
Institutional sale	−0.5729	0.0597***	−0.4369	0.1257***	−0.3458	0.1014***	−0.3200	0.1425**
Bank sale	−0.2795	0.0637***	−0.251	0.1005**	−0.3137	0.0873**	−0.1082	0.2065
Corporate sale	0.2436	0.0354***	0.1778	0.0840**	−0.2136	0.0520***	0.0570	0.1955
Estate sale	−0.0994	0.0417**	−0.0162	0.1015	−0.0552	0.0780	−0.2166	0.1164*
Outlier	−0.9551	0.0704***	−1.0834	0.2234***	−0.6245	0.1120***	−0.3906	0.2275*
Lot size	0.1599	0.0146***	0.0591	0.0361**	0.1702	0.0156***	0.0795	0.0384
Sq ft. house (00s)	0.0050	0.0026**	−0.0063	0.0111	0.0192	0.0056***	0.1274	0.0097**
Sq ft. garage (00s)	0.0270	0.0052***	0.0109	0.0092***	0.0295	0.0080***	0.0581	0.0150***
Number of rooms	0.0590	0.0157***	0.0365	0.0440	0.0796	0.0267	0.0227	0.0397
Number of bedrooms	0.0175	0.0232	0.0051	0.0602	−0.0443	0.0360	0.1129	0.0574**
Number of full bath	0.0625	0.0263**	0.1398	0.0762**	0.0165	0.0505	−0.0560	0.0800
Number of half bath	0.1289	0.0256***	0.0300	0.0155	0.1034	0.0566***	−0.1009	0.0769
Age of house	−0.0052	0.0006***	−0.0078	0.0015***	−0.0066	0.001***	−0.0075	0.0020***
Central air (0, 1)	0.1365	0.0253***	0.0150	0.0455	0.1510	0.0298	0.0675	0.0602
Fireplace (0, 1)	0.2179	0.0250***	0.0241	0.0708	0.1074	0.0353***	0.1052	0.0705
Brick/masonry structure (0, 1)	0.0938	0.0247***	0.1255	0.0642*	−0.0076	0.0351	0.0171	0.0681
Adjusted R^2 = 0.6908				F = 12.21***				

percentage of households that moved into a neighborhood from out of state increases, the price of a house will likewise increase. This helps to support the notion that information plays an important role in determining market prices, since those moving from outside of the area will have less knowledge about local amenities and disamenities than do those

who have been long-time residents of the area. Other factors may be at work here as well. For instance, out-of-state movers may have time constraints if a move is a result of a change of employment, and they may also be more likely to use the services of realtors who act as sellers' agents.[5]

The variables of primary interest in this paper are those for distance to landfill. The estimated coefficients indicate that the HPFs are increasing at all four landfill areas, suggesting that property values are negatively impacted by the proximity of both open and closed landfills, ceteris paribus. From the estimated coefficients, the slope of the HPFs in each area is seen to increase at a rate that is positively related to landfill life expectancy. In addition, with the exception of the Gahanna area, the slopes increase at a decreasing rate. However, in the tax equation, the HTFs are not monotonically related to landfill life expectancy and the parameter estimates are significant as well.

5. Discussion

By inspecting the predicted price of homes at various distances, we can estimate the impact of the four landfills on housing prices within 3.25 miles. Table 5 presents predicted rents and taxes as follows. First, predicted rent values for all households in the sample are estimated, the means of which give rents at the average distance of transactions from the landfill in each sample (2.10, 1.85, 2.27, and 2.67 miles from Alum Creek, Obetz, Gahanna, and Grove City, respectively) (see Table 2). Next, we simulate predicted rent and tax values for houses in the sample as if all houses were located 3.25 miles from the nearest landfill.

We assume that a move from any distance less than 3.25 miles from a landfill to a distance of 3.25 miles will constitute an increase in welfare, as evidenced by higher property values that reflect increased levels of environmental quality attained by living farther from a landfill. The term *welfare* is used loosely in this context. The analysis is a simplification of true welfare measures because the measure used here is simply the difference in predicted rent values for a home under two levels of environmental quality holding all other characteristics constant. A true welfare measure would be

Table 5. Estimated price differentials at 0.5 and 3.25 miles from landfill.

		Predicted Rent		Predicted Tax		
	N	Mean Miles from Nearest Landfill	3.25 Miles from Landfill	Mean Miles from Nearest Landfill	3.25 Miles from Landfill	Mean, Predicted Rent, Full Information
Alum Creek	1,410	$7,349.54	$8,661.05	$852.08	$953.18	$7,208.69
Obetz	396	$5,007.72	$5,963.31	$457.48	$501.32	$4,836.42
Gahanna	868	$8,508.92	$11,345.66	$848.86	$948.67	$8,802.39
Grove City	250	$3,989.30	$9,583.96	$623.80	$675.91	$7,341.11

obtained by integrating under the demand curve for environmental quality that would necessarily be obtained from a second-stage hedonic estimation.[7] In addition the timing of home purchase, as well as sensitivity to environmental factors, will impact individuals differently. For instance, persons buying a home while the landfill is in operation and then selling after the landfill closes will experience a different welfare change than those who purchased a home before a landfill was sited and sold while the landfill is in operation. Nonetheless, we expect these differences to average out over the sample.

From Table 5, it can be seen that the average annual welfare increase for household in the Alum Creek area would be $1,311.51 ($8,661.05 – $7,349.54) annually as a result of a move to 3.25 miles from a landfill; this represents a 17.84 percent increase. Likewise, the estimated gains for average households in Obetz, Gahanna, and Grove City are $955.59, $1,836.74, and $1,590.66, respectively, which translates into percentage terms of 19.08, 19.31, and 19.90 percent. Thus, the percentage gains in welfare as measured by property-value increases are seen to be positively related to landfill life expectancy. Furthermore, significant property-value impacts remain even when a landfill has been closed for a number of years. In terms of annual mortgage rates, the differences in property values translate into mortgage payment increases of up to $337 per month at the 8 percent mortgage rates that prevailed in the early 1990s.

In light of the relationship between landfill life expectancy and property value gains, it is curious that the model predicts that property taxes at Alum Creek, Obetz, Gahanna, and Grove City would increase by 11.86, 2.84, 11.76, and 8.21 percent if all households in the areas surrounding the landfills were located 3.25 miles from the landfill's center. Thus there is no clear trend in tax differences based on landfill life expectancy, as was observed with predicted rents. Also, the magnitudes of the distance to landfill coefficients are mostly lower in the tax equation than in the rent equation. Therefore, tax differences appear to be more related to local public goods, while property values are more sensitive to disamenities. A further investigation of the magnitude of coefficients for crime rate, school quality, and proximity to CBD and railroads in the tax and rent equations tends to support this idea. However, the coefficients for proximity to freeways and parks are not consistent with this notion, possibly because park and freeway proximity may be either amenities or disamenities depending on the degree of urbanization of a study area, following the logic presented in the previous section of this article.

Finally, in Table 5 we report the full-information mean rent for the four study areas—that is, the annual rent that would be paid if no out of state movers existed. Comparing the full-information rent to the mean predicted rent, we estimate that information has a fairly significant impact on property values.[7] For instance, in the area with the highest percentage of out-of-state movers, Gahanna, property values are such that the estimated difference between predicted rent and full-information rent is $706.33 per year. Using the results reported in Table 2, this implies that the value of the average property in Gahanna increases $73.49 for every 1 percent increase in out-of-state movers. In contrast, the rent difference is only $140.85 per year for the Alum Creek area, which has the lowest percentage of out-of-state movers of the four study areas; this translates into a $36.30 increase per 1 percent increase in out-of-state movers.

6. Conclusion

We have demonstrated that welfare losses that result from decreased property values near landfills can be of a significant magnitude. Declining landfill capacity means that more landfills will be located near population centers in the future, making this analysis relevant to policies for siting new landfills. Our results provide the foundation for developing compensation schemes for populations close to landfills. For instance, higher landfill per ton tipping fees could be collected from all households and businesses that use a landfill, which would then be used to compensate those households living nearby. The fact that damages vary with both population and landfill characteristics suggests that these factors should be accounted for when compensating households. We also show that when considering the optimal location for new landfills, property-value impacts that remain after the landfill closes should be taken into consideration. Proper compensation measures would be developed from the sum of the net present value of welfare losses, discounted not only by real interest rates but also by the rate of decay of costs associated with landfill life expectancy. In addition, there are questions about individual households' willingness to trade environmental quality and other property characteristics. Such sorting clouds the definition of social loss.

We have also shown that property taxes are relatively less sensitive to the presence and life expectancy of landfills than are property values. Thus our results imply that local governments will be less affected by the presence of certain environmental factors than are homeowners in the short run; that is, the external costs of certain disamenities are internalized more by individual property owners than by local taxes. On the other hand, we demonstrate the interrelationship of property values and property taxes. The presence of a public bad in a community may therefore undermine the tax base in the long run by lowering property values. These results present a number of policy implications for local governments. First, provision of public goods such as schools and law enforcement may eventually be negatively impacted by the presence of a disamenity. It would therefore be necessary to raise taxes if a comparable level of public goods is to be provided. Thus, housing density in affected areas may be expected to increase. Second, lowering of the tax base via property value impacts of a disamenity may cause outmigration from the afflicted area, contributing to urban sprawl. Finally, because the external cost of landfills is reflected more markedly in housing prices than in property taxes, disadvantaged socioeconomic groups may tend to migrate into these areas to take advantage of lower housing prices, ceteris paribus. This would exacerbate the problem of unequal distribution of environmental quality, a focus of the environmental justice literature.

Acknowledgments

The authors thank David Brasington for insightful discussions regarding local taxation and public goods and are grateful to Kathleen Segerson and two anonymous referees, whose comments helped to improve the manuscript. Any errors or omissions are strictly the authors' own.

Notes

1. Theoretically, real estate agents would inform new buyers of local conditions, but we have anecdotal information that suggests that the agents are not always aware of disamenities such as landfills.
2. We acknowledge the assistance of G.S. Maddala and Randy Olsen in determining the functional form used here.
3. We cannot assume that there is true market segmentation because Franklin County represents a single employment market.
4. For instance, a test was performed in which the parameters of all neighborhood and environmental characteristics were the same versus that all were different. Various other combinations of segmentation of neighborhood and environmental variables were also investigated.
5. The Gahanna area, among all the study areas, had by far the largest percentage of people moving in from out of state—9.6 versus 3.9, 4.7, and 4.2 percent in Alum Creek, Obetz, and Grove City areas, respectively.
6. The data used in this analysis are from a single employment market. Thus, such a modeling strategy would be inappropriate here because of the identification problem (Brown and Rosen, 1982).
7. This interpretation should be tempered by recognizing that out-of-state movers may have constraints, such as timing of move and less search time, that would restrict their ability to bargain over property prices.

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CHAPTER 1.1 OBJECTIVES

This ordinance is for the purpose of setting forth standards and permissible uses designed to conserve and protect the natural, economic and scenic resources of Morgan County, the County's health, aesthetics, morals, convenience, order, prosperity and general welfare; to provide adequate light and air; to protect natural resources; to prevent the overcrowding of land; to promote desirable living conditions and stability of neighborhoods; to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other public requirements by dividing the unincorporated areas of Morgan County into districts of such size and shapes as may be best suited to carry out the purposes of the legislative act and of this ordinance.

CHAPTER 1.2 LEGISLATIVE AUTHORITY

The Board of Commissioners of Morgan County, Georgia under the authority of Article IX, Section 2, Paragraph 4 of the Constitution of the State of Georgia and Chapter 66, Title 36 of the Official Code of Georgia Annotated, and for the purpose of promoting the health, safety, morals, convenience, order, prosperity, and the general welfare of the county and designed to lessen congestion in the streets; to secure safety from fire, panic, and other dangers; to promote health and overcrowding of land, to avoid undue concentration of population; to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other requirements, ordains and enacts into law the Official Zoning Ordinance for unincorporated Morgan County for planning, zoning and subdivision control purposes.