# SITING OF WASTE-TO-ENERGY FACILITIES IN NEW YORK CITY USING GIS TECHNOLOGY


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*Research sponsored by:*
*The Earth Engineering Center and the Henry Krumb School of Mines*

**May 2004**

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## EXECUTIVE SUMMARY

The residential refuse of New York City (NYC) is collected curbside by the New York City Department of Sanitation (DOS) fleet of nearly 1,500 trucks. Most of the Manhattan generated municipal solid waste is transported to a Waste-to-Energy (WTE) facility in New Jersey. The refuse of Brooklyn, Queens and Staten Island is collected by DOS and delivered to private waste transfer stations in the City where it is transferred to 20-ton long haul transport trucks and then transported to landfills in Pennsylvania, Virginia, and Ohio. Some of the Bronx municipal solid waste is delivered to a private transfer station located in Harlem River Yards where it is loaded into containers and transported by rail to disposal facilities in other states.

This study examined the potential of replacing several waste transfer stations (WTS) in Bronx and Brooklyn by implementing two new WTE facilities, one in Bronx and another in Brooklyn, thus reducing the dependence of New York City on other states for landfilling its wastes by about 50%.

The June 2002 New York City Comprehensive Commercial Waste Management Study provided a very comprehensive set of data that was used in this study to create a Geographic Information Systems (GIS) database. For regulatory and management purposes, most of the solid waste generated in the City falls into one of four categories: putrescible, non-putrescible, fill material, and recyclables. The putrescible waste referred to in this study is the black-bag municipal solid waste (MSW) and excludes the recyclables that are set apart by residents and are collected by NYC-DOS separately. Putrescible wastes have the most adverse impact on the communities where the WTS facilities are located. Nine of these WTSs are located in Bronx, ten in Brooklyn and six in Queens.

Two options were examined and are presented in this report: a) Implementation of one WTE facility in Bronx, b) implementation of two WTE facilities, one in Bronx and one in Brooklyn, used in conjunction with two nearby marine transfer stations MTS. The implementation of two WTE facilities would result in reducing truck travel time by approximately 24 million truck miles.

Upon implementation of two WTE facilities, used in conjunction with the retrofitted South Bronx and Greenpoint Marine Transfer Stations, there would be no need for about thirteen existing putrescible WTS in Bronx and Brooklyn. This combination would provide the basis for a socially equitable and environmentally and economically sustainable municipal solid waste management plan for a large part of the New York City MSW. It would also rehabilitate the existing brownfield areas where the new WTEs would be located, along with adjoining parkland and other civic improvements.

For example, the avoided particulate emissions of the long-distance truck used now to transport MSW to out-of-state landfills were estimated to be several times higher than the particulate emissions of the hypothetical WTEs in NYC. Furthermore, when comparing the WTEs to the present alternative of landfilling, the benefits of WTE would include: Reduction of fuel imports to the City, generation of electricity and steam for use by the adjoining community and industry; recovery of ferrous and non-ferrous metals; and elimination of municipal waste transfer stations,

since they would not be needed for intermediate storage of refuse. There would also be sustainable use of land because the two WTE facilities would require a long-term use of about 30 acres, as contrasted to the estimated 30-60 acres that are consigned **annually** to landfilling the two million tons of NYC MSW that would be combusted in the two WTE facilities.

**** Ms. DeAngelo is presently with the Federal Energy Regulatory Commission, Washington, D.C. A pdf file of her thesis is available at www.columbia.edu/cu/wtert.***

**ACKNOWLEDGEMENTS**

First and foremost, I would like to express my gratitude to Professor Themelis for his support and commitment to this research as well as his technical expertise. I would also like to acknowledge the immense support of Professor Yuri Gorokovich, who served as my GIS mentor. There are several other individuals from the environmental and academic community who have provided insight and feedback, which have been of great help to the author during the conduct of this study, including Karsten Millrath, Columbia University Earth Engineering Center; Maria Zannes, Integrated Waste Services Association; Andrew Kasius, New York/New Jersey COAST; Professor Karl Szekielda, Hunter College; Hyo JinAhn, Hunter College (CUNY); Liliana Themelis, Earth Engineering Center; Barbara Algin of the Department of Earth and Environmental Engineering; and Jamie Bradstreet, formerly student administrator of the Department of Earth and EnvironmentalEngineering. The fellowship of the Henry Krumb School of Mines that made possible my studies at Columbia is gratefully appreciated.

I would also like to acknowledge the support of my colleagues and friends, Karena Ostrem, Scott Kaufman, Dionel Albina, and Masato Nakamura, who provided invaluable input to the outcome of this research. Finally, I would like to thank my family for their guidance and encouragement throughout my academic career.

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## PART I

### Introduction

The residential refuse ("black bag" waste or non-recyclables) of New York City (NYC) is collected curbside by the New York Department of Sanitation (DOS) fleet of nearly 1,500 trucks. Except for some DOS-managed waste transferred out of the Bronx by rail, the DOS interim export arrangements depend on truck transport. Most of the residential Manhattan generated waste is transported to a Waste-to-Energy (WTE) facility in New Jersey (Essex Country WTE of American Ref-fuel). Brooklyn, Queens and Staten Island's refuse is collected by DOS and delivered to private waste transfer stations within the five boroughs where it is loaded onto 20 ton long haul transport trucks for transport to landfills in Pennsylvania, Virginia, and Ohio (2). Most of the Bronx municipal solid waste is delivered to a privately operated transfer station located in the Harlem River Yards where it is loaded into containers that are transported by rail to disposal facilities outside of the City (9).

DOS collects the putrescible and non-putrescible waste from residences, institutions, not-for-profit organizations, lot cleaning operations and City agencies. Private waste carting companies collect the putrescible and non-putrescible waste from commercial sources in the City. Both DOS and commercial waste handlers recycle "source separated" materials including paper, cardboard, metal and plastic; and most commercial waste handlers separate and sell the valuable and reusable materials contained in C&D debris and fill material.

The goal of this study was to find a means of eliminating waste transfer stations (and the associated negative impacts) in the New York City region by means of implementing Waste-to-Energy technology and forcibly making New York City maintain its own solid waste rather than relying on exportation. This research utilized the June 2002 New York City Comprehensive Commercial Waste Management Study Preliminary Report, which provided the most comprehensive set of information to create a database for use in Geographic Information Systems (GIS), and therefore provided all of the data and statistics used for this study. In June of 2004 the second study will be produced. An important fact to consider when interpreting this research is that although the data was collected in calendar year 2001, it measures the commercial solid waste stream during calendar year 2000, before Fresh Kills ceased receiving any of the City's residential waste. Part I of this research focused primarily on the flow of waste in and out of the Waste Transfer Stations (WTS) within the NYC region and evaluation of the historic waste management practices. Part II provides recommendations for the future siting of one or two WTE facilities in NYC based on GIS analysis.

### 1. History of NYC Waste Management

In order to properly plan for the future of waste management in NYC, historical means of disposal and waste management practices were evaluated.

#### *1.1. Incinerators (Municipal Waste Combustors)*

Thirty-two Municipal Waste Combustors (MWC) were constructed in NYC at 24 locations between 1908 and 1962. There were eight double incinerator facilities (i.e., two combustion lines per plant) and 16 single incinerator facilities. Approximately 81 million tons of refuse was combusted in municipal waste combustors (MWC) between 1908 and 1993 (17).

Approximately 17,000 multi-dwelling domestic waste combustors (DWC) were installed in NYC apartment buildings between 1910 and 1968, which combusted approximately 33 million tons of refuse between 1910 and 1993. Collectively, these incinerators combusted about 110 million tons of refuse between 1908 and 1993 (71% by MWC) and produced 34 million tons of ash residue (63% by MWC). Since the 1960's, no new waste disposal facilities have been constructed in NYC. There were eleven active incinerators in 1964, seven in 1972, three in 1990, and none in 1994. Figure 1 shows the previous locations of the incinerators in NYC (17).


**Figure 1. Former NYC incinerator locations**

### *1.2. Landfills*

Over the years, New York City has been home to 89 landfills. All of New York City's landfills were deliberately located on salt marshes in an era when it was believed that marshes were wastelands and a source of disease. The euphemism for a garbage dump, landfill, is derived from this era when filling salt marshes, even with garbage, was considered to be beneficial in that it created useful land (4). These old landfills did not have plastic liners, leachate recovery systems, or monitoring wells, nor the structural integrity required for modern regulated landfills. They are now being retrofitted with leachate recovery systems, monitoring wells and methane recovery systems, which will have to be monitored and managed for decades after closure, at considerable expense (4).

Six landfills, filled to capacity, were closed between 1965 and 1991, leaving the City with only one remaining landfill for the next decade, Fresh Kills on Staten Island. In 1989, when DOS raised the "tipping fee" for commercial waste disposal at Fresh Kills, private waste handlers began exporting the City's commercial waste to out of-City disposal facilities in order to decrease their costs. DOS continued to transport most of the City's residential waste via barge to Fresh Kills. In 1996, the State Legislature mandated the closure of Fresh Kills by January 1, 2002. The following year, DOS began phasing down its use of Fresh Kills and driving its collection trucks to private waste transfer stations within or outside the City, where the waste is transferred to long-haul trucks (some to containers and then on railcars) for transport to out-of-City disposal facilities such as landfills and resource recovery facilities (7). Recycling began in New York City as a voluntary program in 1986. In July 1989, with the passage of Local Law 19, recycling became mandatory (8).

## 2. NYC Waste Management

### *2.1. Background*

New York City (NYC) residents and businesses generate vast amounts of many types of waste materials which must be disposed of: food wastes, yard wastes, animal wastes, furniture and household goods, construction and demolition debris, concrete and asphalt paving, small and large appliances, medical waste, asbestos, paper and cardboard, plastics, scrap metal, dredge spoils, oils, solvents, paints, catch basin grit, grease, sewage sludge, junked vehicles, etc. For regulatory and management purposes, most of the solid waste generated in the City falls into one of four identifiable categories (7) (See Figure 2 for the annual tonnages produced at the time of the study):

- **"putrescible"** waste/**MSW**: organic matter such as food and yard wastes having the tendency to decompose, creating malodorous by-products. For the purposes of this research, putrescible waste is considered to be the equivalent of "black bag" municipal solid waste, i.e., it excludes the recyclable streams (paper, metal and plastics) that are collected separately.

- **"non-putrescible**" waste: primarily construction and demolition (C&D) debris including concrete, plaster, rock, waste timber, tiles, glass, wood, sheetrock, metal, electrical wires and cables, asphalt, shingles, and other non-organic material.

**"clean fill"**: a subset of nonputrescible wastes that includes only excavated dirt, concrete, rock, gravel, sand and stone.

• "**recyclables**": materials that are either "source separated" before collection, such as metal, certain plastics, cardboard, and paper; or reusable materials sorted and separated from C&D debris, such as metals, dirt, aggregate, stone, and asphalt millings.

The materials that do not fit into these four categories, such as liquids, hazardous wastes, medical wastes, sewage sludge, etc., are managed by specialized disposal companies undercontract with the waste generators. In New York City, the volume of these "other" wastes is approximately 41 tons per day or 15,000 tons/year (7).

At waste transfer stations of putrescible materials, waste is transferred to long haul trucks or rail cars for long distance transport to other states. Non-putrescible waste transfer stations and clean fill transfer stations typically engage in sorting, crushing and processing of material; therefore much of the material received at these stations is either recycled or reused (5) and the rest is landfilled.

### *2.2 2000 NYC Waste Statistics*

In 2000, the City's total waste stream was 54,731 tpd, of which 66% was commercial waste, and 34% was residential (DOS-managed) waste. An estimated 30,964 tpd (54%) was exported to final out-of-City destinations (transfer stations, landfills, and resource recovery facilities). Of the exported waste, 15,375 tpd (50%) was MSW, 6,109 tpd (20%) was non-putrescible waste, and 9,480 tpd (30%) was recycling/fill material (7) (Figure 2).

Of the remaining waste generated in the City, 4,461 tpd (17%) was MSW, 5,114 tpd (20%) was non-putrescible waste, and 16,623 tpd (63%) was recycling/fill material. In total, 21,737 tpd of non-putrescible waste and recycling/fill material were recycled and reused (7). Figure 2 also shows an estimate of the amount of the annual tonnages, determined by multiplying the daily tonnages by 300 (for 300 operating days per year).

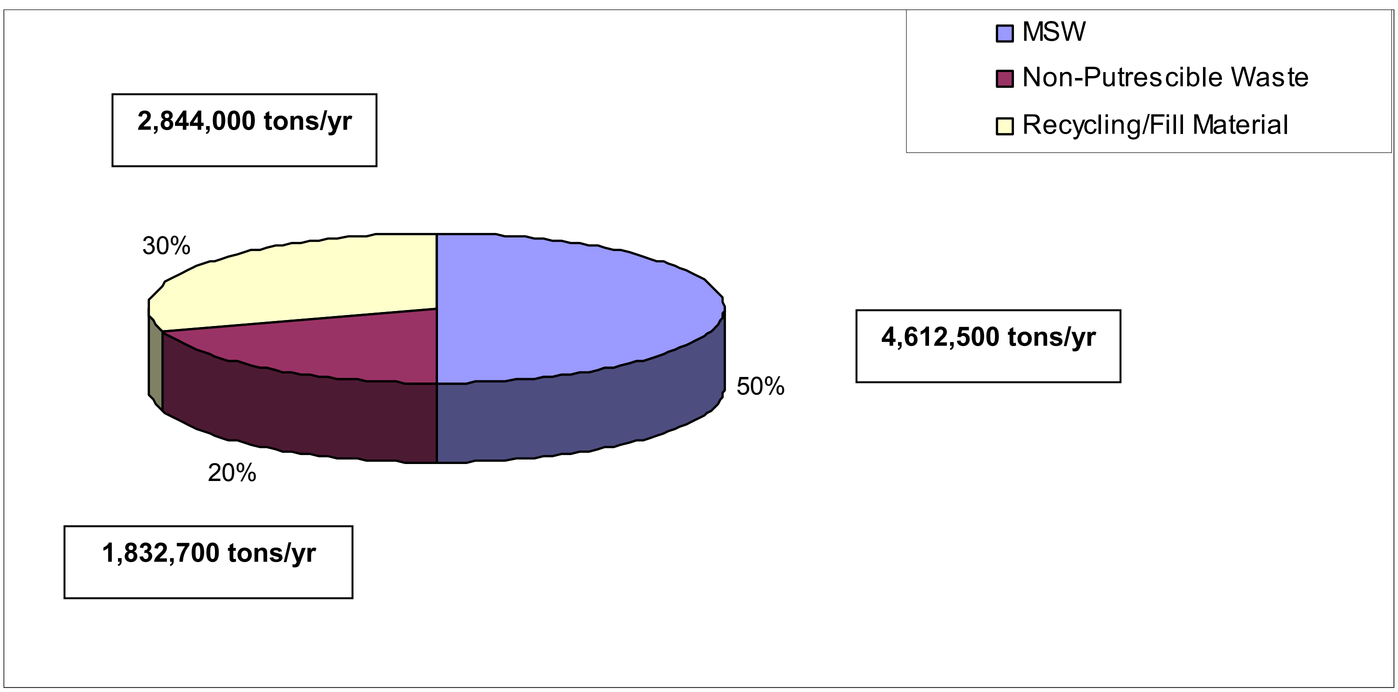


**Figure 2. Waste exported by New York City**

# 3. Waste Management Transport Methods

## *3.1. Waste Transfer Stations*

Waste transfer stations are facilities where waste is unloaded from the collection vehicles

operated by DOS and private carters and briefly held while it is reloaded onto larger long-distance hauling trucks with an average 20 ton capacity for shipment to landfills or other treatment or disposal facilities (15). Combining loads of several individual waste collection trucks into a single shipment saves money on the labor and operating costs of transporting the waste to a distant disposal site and also reduces the total number of vehicular trips traveling to and from the disposal site. Although waste transfer stations help reduce the impacts of trucks traveling to and from the final disposal site, they can cause an increase in traffic in the immediate area where they are located and therefore must be carefully sited so as to create the least amount of impact on the surrounding community.

Within New York City, two types of transfer stations exist: Marine Transfer Stations (MTS) and privately-owned Commercial Waste Transfer Stations (CWTS), as shown in Figure 3. Since the closure of Fresh Kills Landfill, both the residential and commercial waste streams have been redirected to all the CWTS in the region and the MTS have ceased operation, which formerly transported MSW by barge to Fresh Kills. During the time the data was being collected for the June 2002 Preliminary Report, 4,018 tpd of the City's municipal residential waste was still being sent to Fresh Kills landfill.

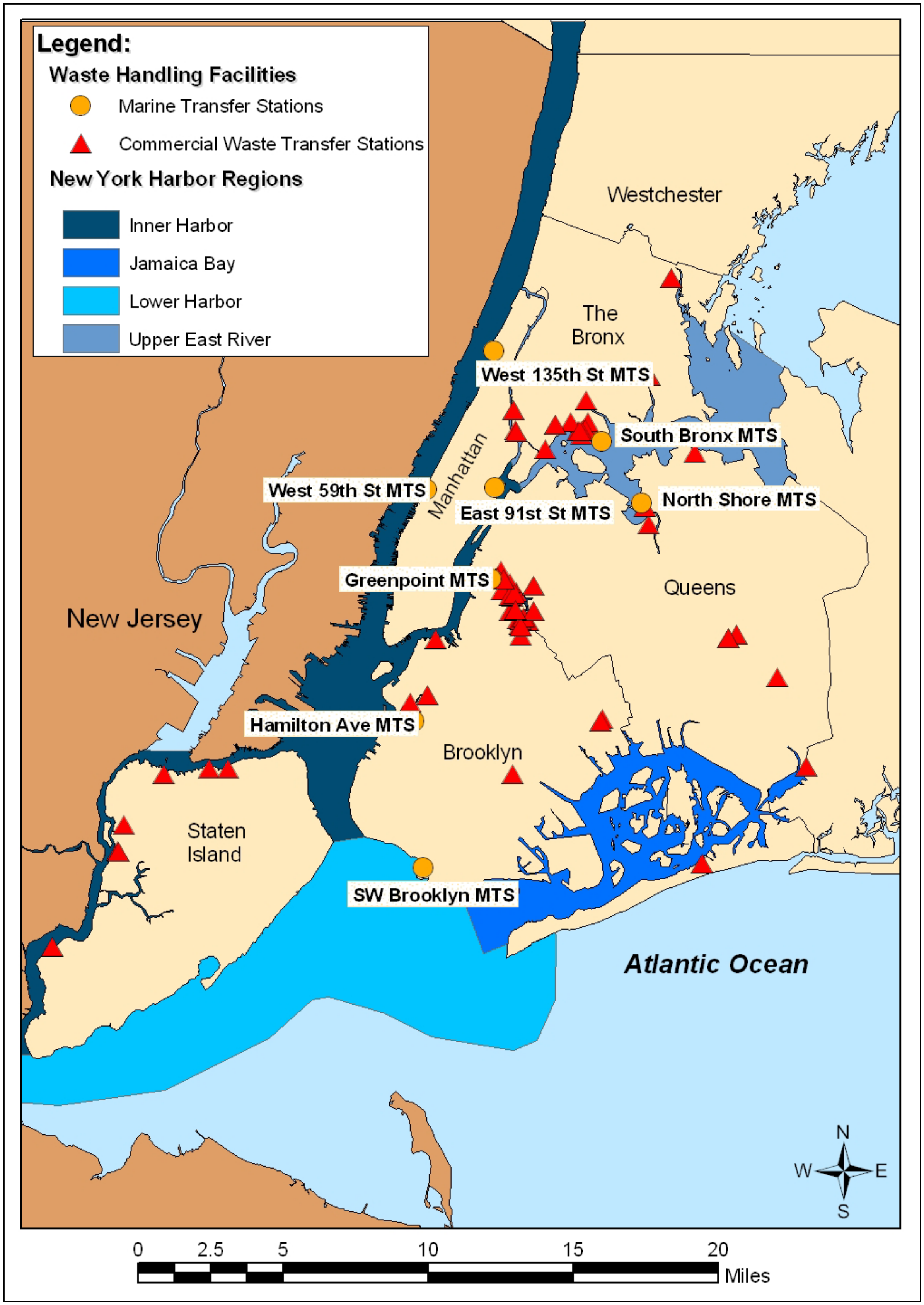


**Figure 3. NYC waste transfer facilities**

### *3.2. Marine Transfer Stations*

On July 31, 2002, Mayor Michael R. Bloomberg, Department of Sanitation (DOS) Commissioner John J. Doherty, City Council Solid Waste Management Chairman Michael E. McMahon and City Council Minority Leader James Oddo announced proposed changes to the City's Solid Waste Management Plan. According to the announcement, this plan intends to utilize and upgrade the City's existing Marine Transfer Station system to include containerization and waste compaction at each site. By implementing these new changes, New York City will not have to rely on out-of-state containerizing facilities to handle the City's waste that DOS collects each day. Containerization at the Marine Transfer Stations is expected to reduce the environmental impact of the City's waste removal process. The City will then be able to use the waterways to safely transport containerized rubbish, drastically reducing road degradation and pollution and expanding transportation alternatives to include barge transport. The marine transfer stations would accept garbage from the collecting trucks, load the trash into covered containers (640 ton capacity per container) (6), and transport the containers via barges to nearby ports or rail facilities, where the trash would then be transported to final disposal facilities by either ship, rail or truck.

A feasibility study conducted by the City showed that five of the eight existing Marine Transfer Station (MTS) sites should be upgraded and retrofitted at the following locations, also shown in Figure 3 (6):

1. West 135th Street Marine Transfer Station (Manhattan)
2. East 91st Street Marine Transfer Station (Manhattan)
3. West 59th Street Marine Transfer Station (Manhattan)
4. North Shore Marine Transfer Station (Queens)
5. Greenpoint Marine Transfer Station (Brooklyn)

The additional three facilities that will also be utilized are:

6. South Bronx Marine Transfer Station (Bronx)
7. Hamilton Avenue Marine Transfer Station (Brooklyn)
8. Southwest Brooklyn Marine Transfer Station (Brooklyn)

With the proposed retrofit project, Mayor Bloomberg has declared that the commercial waste stream would also be redirected to the MTS, thereby bypassing the land-based transfer stations owned and operated by members of the National Solid Waste Management Association (NSWMA members: Waste Management, Allied, IESI and others). Moreover, these companies' transfer stations would also lose their residential tonnage, forcibly closing them altogether and redirecting commercial volumes to the MTS (10).

### *3.3. Waste Transfer Stations*

As of the 2000 New York City Comprehensive Commercial Waste Management Study, there were 76 operating privately owned WTSs in the New York City Region of which 25 handled MSW, 30 non-putrescible waste (exterior construction and demolition material), and 21 clean fill material. Eleven of the transfer stations were inactive in 2000. All of the transfer stations are located in industrial/manufacturing zones where they are an “as of right” use; 52 are located in heavy industry zones (M-2 and M-3).

DOS and the New York State Department of Environmental Conservation (DEC) permit and regulate the transfer stations located within the City. The DEC has authority to permit and regulate solid waste transfer stations pursuant to its “Part 360" regulations, while DOS has authority to permit and regulate transfer stations pursuant to title 16, sections 130-133, of the New York City Administrative Code (Ad Code) and title 16, chapter 4, of the Rules of the City of New York (RCNY). Since 1992, DEC and DOS have conducted coordinated environmental impact reviews of all proposed new transfer stations in the City. Their combined regulatory efforts have contributed to the closure of 26 transfer stations since 1996. Local Law 40 requires operators of dumps and private transfer stations within the City to maintain and submit quarterly reports to DOS on their commercial solid waste inflow and outflow. These transfer stations provide quarterly reports that enable DOS to roughly monitor the flow of commercial waste. Since the closure of Fresh Kills, private transfer stations were also forced to manage the residential as well as the commercial waste until a new Solid Waste Management Plan provides for alternatives. This information accurately accounts for all the solid waste in the City and can be used to plan for future alternatives (7).

In 1998, DOS adopted a stringent rule governing the siting of transfer stations even in the industrial/manufacturing zones where presently they are an “as of right” use (18). This ruleestablishes mandatory buffer zones between transfer stations and “sensitive receptors” such as residential zoning district boundaries, schools, and parks. Pursuant to a court order in the case of Organization of Waterfront Neighborhoods (OWN) vs. Carpinello (19), DOS is redrafting the siting rule to address the clustering of transfer stations (7).

In addition to the transfer stations located within the five boroughs, the surrounding counties in New York and New Jersey have many transfer stations within reasonable driving distance of the City. Both DOS and private carters deliver New York City waste to these transfer stations.

**4. Analysis**

The analysis conducted for this study included a mass balance of flow into and out of the WTS in the New York City region (based upon the June 2002 New York City Comprehensive Commercial Waste Management Study Preliminary Report), in order to determine the largest area of impact by solid waste management practices on the surrounding community. Waste does not flow immediately from collection to transfer station to disposal site. Therefore, the holding time for waste at the transfer station can result in significant impacts to the surrounding area. MSW transfer stations may sort and separate out recyclable material, which they transfer to recycling facilities or specific material handlers and processors.

Non-putrescible waste and fill material transfer stations sort, sift, process, and transform construction and demolition (C&D) debris and fill material into useable construction products such as sand, rock, and aggregate. They store the building materials on site, or transfer them to other C&D or fill material transfer stations for storage or sale, or to construction and excavation sites for storage or immediate reuse. Other materials, such as metals, are transferred to scrap metal yards or metal processors.

Facilities that handle recyclables separate putrescible and non-putrescible waste from the recyclable material, and either transfer it to appropriate transfer stations or export it to other states or countries for disposal. Due to its composition, the MSW stream has the most significant impact on the surrounding area and the impacts (odors, pestilence) increase withholding time. It is for this reason that this analysis primarily focuses on the MSW WTS and their associated impacts.

In order to carry out the analysis, a database was compiled for use in a Geographic Information System (GIS) of the 76 WTS in the New York region (7). Components of this database include: facility name; facility type ( putrescible, non-putrescible, fill material); facility address; county; city; state; zip code; permitted capacity (tons); operating capacity (tons); capacity dedicated to recycling (tons); material received (days/week); material processed (days/week); scale on site (yes/no); certified (yes/no); input weighed (yes/no); output weighed (yes/no); 2000 MSW (tons/year); 2000 construction and demolition (C&D) material (tons/year); 2000 SSR (tons/year); residue (tons/year); and 2000 Total throughput (tons/year). The database is searchable by any of these fields and can be displayed graphically in GIS through a geo-referencing process. Most of the maps created in this thesis as well as the subsequent analysis, referenced the data in this database which can be found in the Appendix. As a first step, the MSW transfer stations were separated via GIS analysis from the rest of the WTS and identified by their 2000 total capacity in tons/year, as indicated by the different proportional-size symbols in Figure 4.

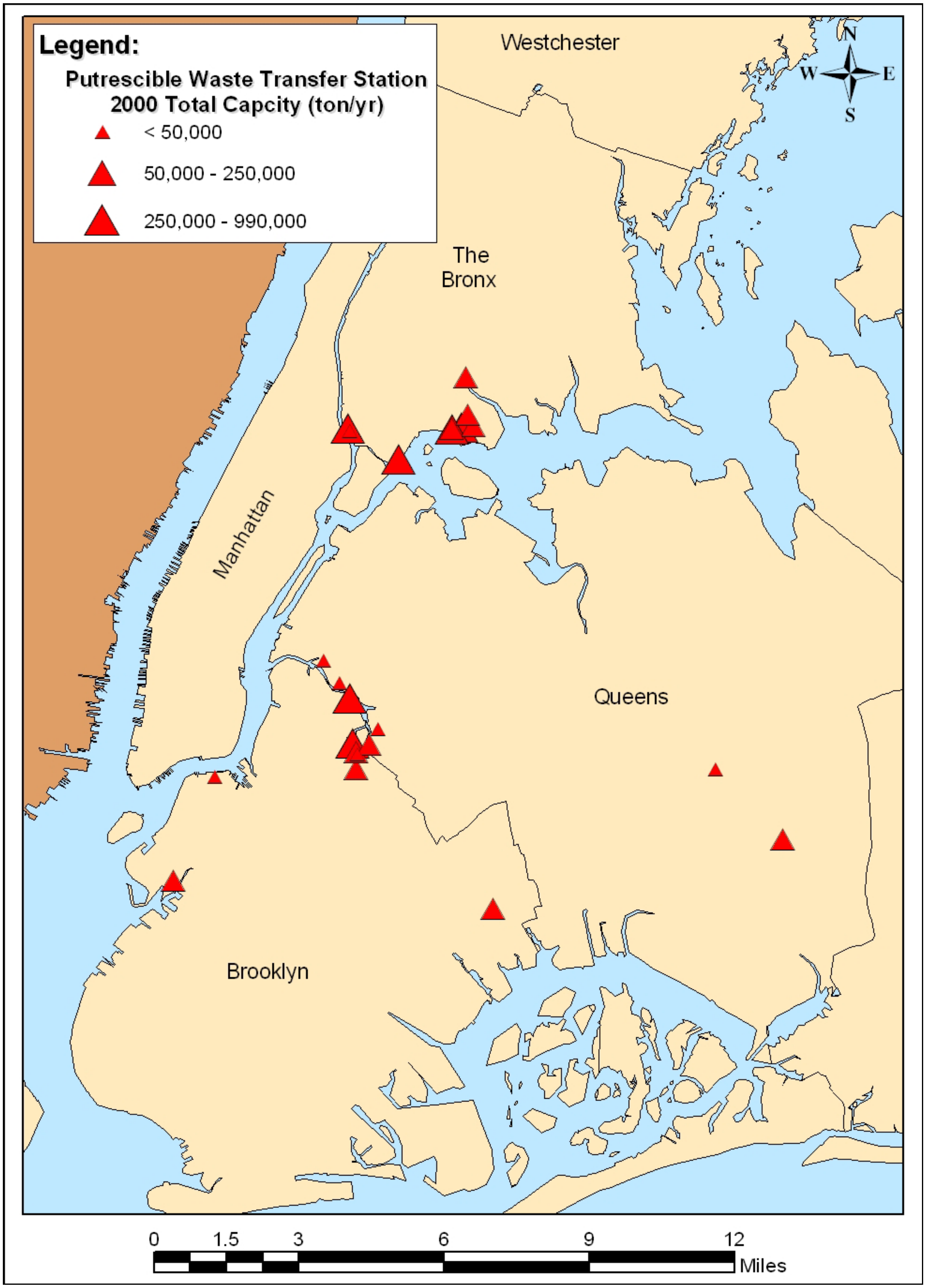


**Figure 4. MSW transfer facilities**

Then, by examining the past and present solid waste management practices of DOS, the areas of extreme stress on the surrounding areas were identified, as shown in Figure 5. The two circular areas indicate the two regions that have been over-utilized by DOS solid waste management operations both now and in the past. Historic uses of land used for solid waste purposes are potential indicators of current brownfields in need of restoration.

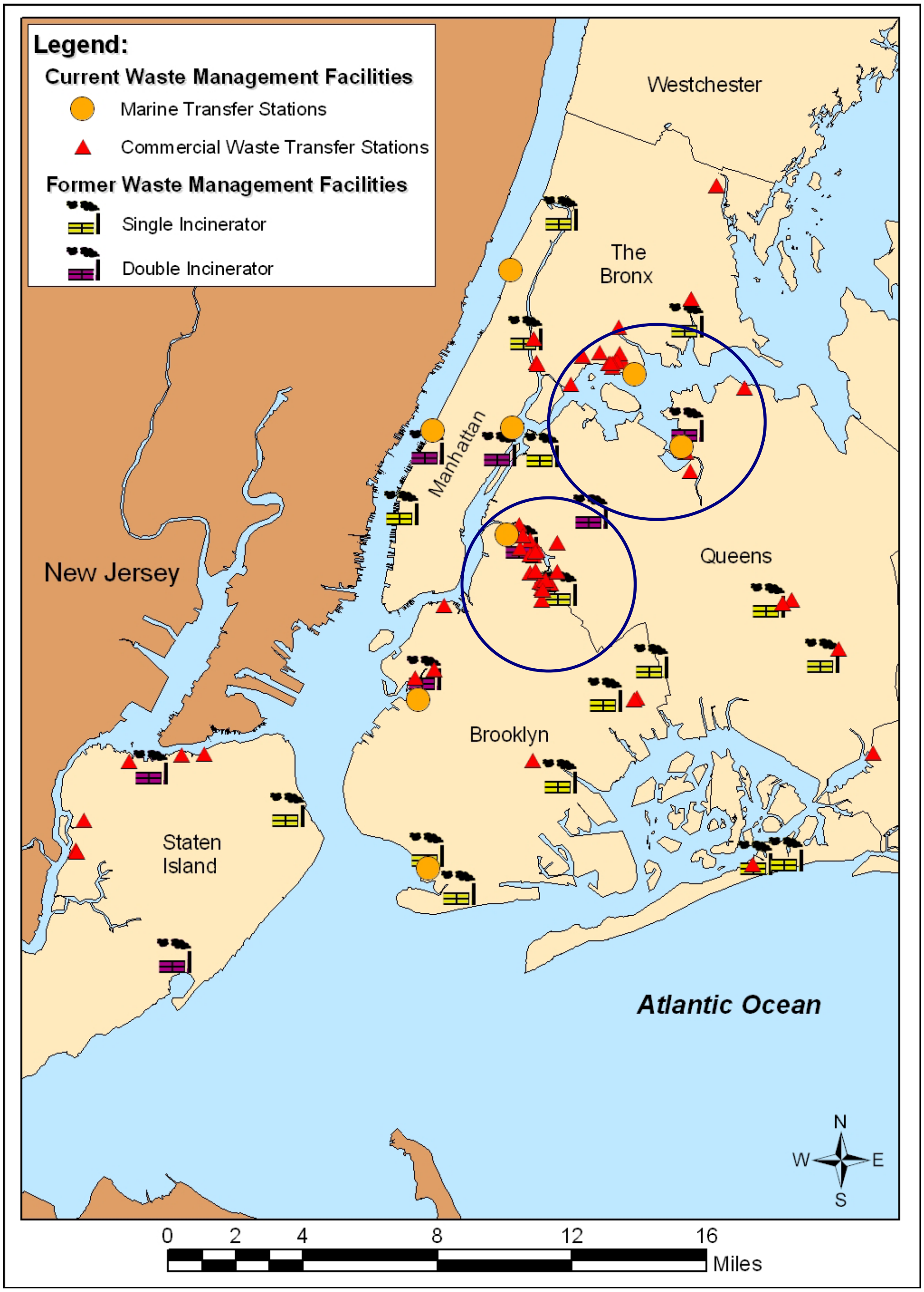

**Figure 5. NYC waste management: past and present**

Based upon the past and present impacts on the surrounding areas it is evident that two principal regions have been over-utilized both presently and in the past by NYC waste management. Therefore, the MSW transfer stations were further separated by GIS analysis into the two respective geographical regions; one in the Bronx and one near the Brooklyn/Queens border. Figure 6 shows these two areas of study: Area #1 includes all WTS in the Bronx and Area #2 includes a cluster of WTS in Brooklyn and Queens. The proportional symbols represent the 2000 total capacity in tons/year.

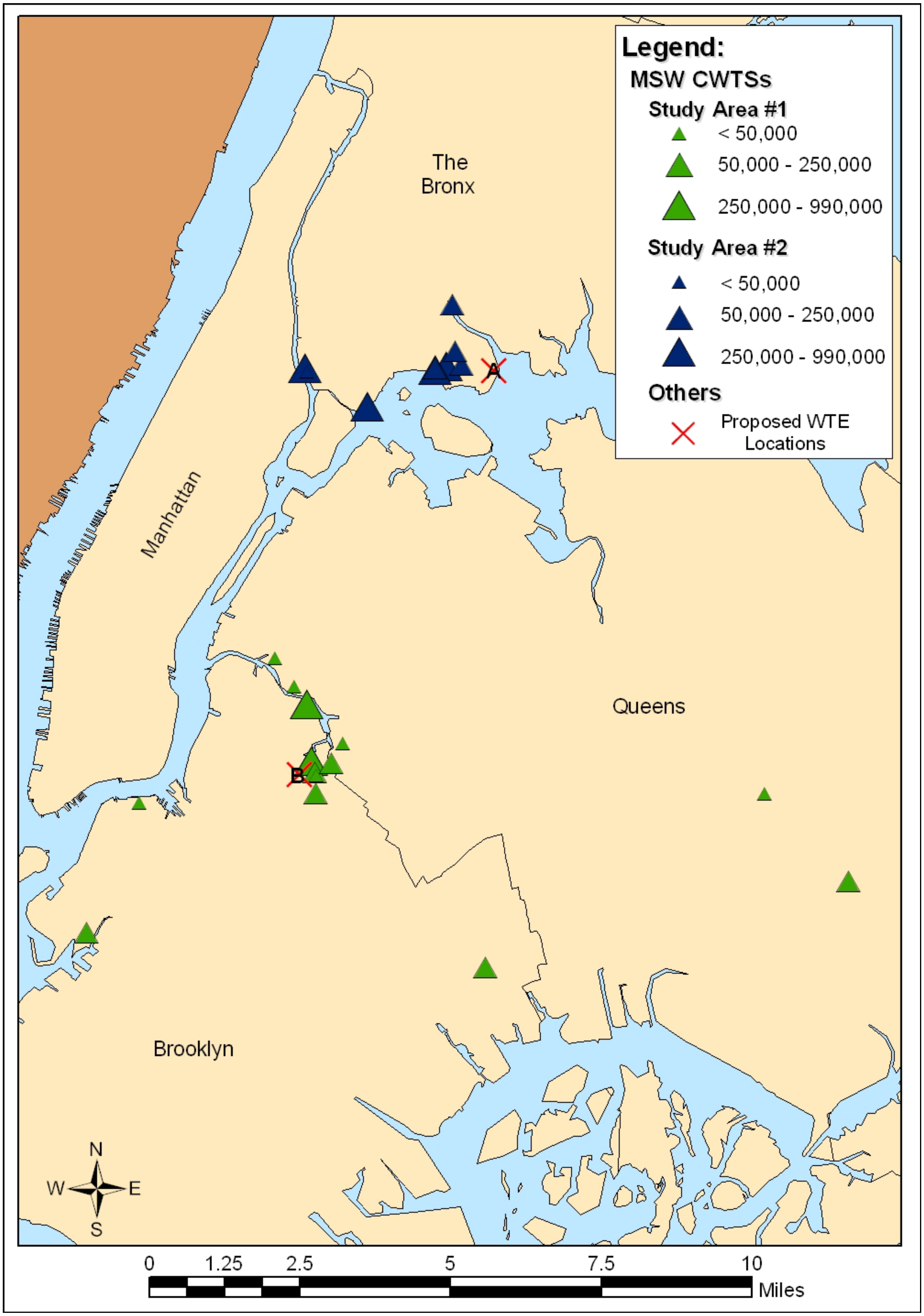


**Figure 6. Areas of significant impact**

Most of the transfer stations are located in the Bronx, Brooklyn, and Queens; Staten Island has no MSW transfer stations. The Bronx has nine, Brooklyn ten, and Queens has six MSW transfer stations. Of these, 72% operate six days per week (312 days/yr), 4% seven days per week (365 days/year), 4% five days/week (260 days/year) and 20% are presently inactive (7). Table 1 summarizes the operating statistics of WTS in Areas #1 and #2.

**Table 1. Statistics for Area #1 and Area #2**

| | Number of Transfer Stations in Area | Total Capacity Permitted (tons/day) | Total Operating Capacity (tons/day) | 2000 Total MSW Input (tons/year) |
|---|---|---|---|---|
| **Area #1** | 9 | 9,323 | 5,691 | 2,141,242 |
| **Area #2** | 16 | 10,961 | 7,284 | 2,379,492 |

### *4.1 Optimum locations for WTE in Areas #1 and #2*

As illustrated in Table 2, both areas have comparable inputs for the two regions, despite the difference in number of transfer stations. Using the past and present uses of waste management in NYC as a basis to determine suitable locations for future WTE facility locations (Figure 5), the tentative WTE facility locations were identified in Figure 6 as indicated by red X's.

The tentative WTE sites were selected in the following manner:

- Two areas were selected based upon geographic division of the transfer stations
- The tentative WTE sites were selected because both are within a cluster of nearby WTS that could potentially be eliminated.
- The sites are in close proximity to Marine Transfer Stations: South Bronx (tentative WTE A) and Greenpoint (tentative WTE B).
- The installation of a modern WTE at either of the tentative locations could eliminate the need for several WTS and, possibly, one or two MTS.
- The projected WTE facilities could be used in conjunction with the upgraded MTS.

### *4.2 Life Cycle Assessment of WTE Implementation vs Existing Transfer Stations*

In order to determine the relative impact of a WTE facility versus MSW WTS, a life cycle analysis (LCA) was carried out of two alternatives:

- ***Alternative 1*** *(present MSW transport: Source - Transfer Station - Landfill)*

  a.) Transporting MSW from source to an existing transfer station, b) transferring the waste via interstate truck, c) transporting the waste to a Pennsylvania landfill.

- ***Alternative 2*** *(proposed transport: Source - WTE)*

  b.) Transporting MSW from source to a new WTE, b) combusting the waste to generate energy, c) transporting the WTE ash by barge for transport to a landfill/monofill.

Five addresses from the furthest point of each borough were selected and the distance traveled to transport waste was calculated using the Mapquest® distance calculator. The following assumptions were made:

- Putrescible waste from Brooklyn, Manhattan and, if necessary, from Staten Island go to a transfer station in Brooklyn (Area #2).
- Putrescible wastes from The Bronx and Queens go to a transfer station in the Bronx (Area #1).
- The Keystone Landfill[1] in Dunmore, PA was used to calculate distance from the transfer stations in Areas #1 and #2 to disposal.

These locations are shown in Figure 7 and the corresponding data are presented in Tables 2 & 3.

**Table 2. Refuse Transport Distances Utilizing WTE A**

| Address | Borough | One-way Travel from Source to Transfer Station to Landfill | One-way Travel from Source to Proposed WTE A | Decrease in One-way Travel (per truck) by Using WTE | Daily tonnage to WTE A from Borough (tpd) | Averted Truck Miles per day (Roundtrip) | Total Averted Truck Miles per year |
|---|---|---|---|---|---|---|---|
| Hopping Ave | Staten Island | 155.4 | 42.6 | 112.8 | 64.0 | 722 | 216,576 |
| South Street | Manhattan | 131.7 | 14.8 | 116.9 | 256.0 | 2,993 | 897,869 |
| West 261st & Palisades Ave | Bronx | 134.4 | 9.0 | 125.4 | 1280.0 | 16,055 | 4,816,512 |
| Bayview Avenue | Brooklyn | 142.4 | 27.8 | 114.7 | 1280.0 | 14,675 | 4,402,560 |
| Marathon Parkway | Queens | 135.6 | 10.2 | 125.4 | 320.0 | 4,014 | 1,204,128 |
| | | | | | | **Total:** | **11,537,645** |

**Table 3. Refuse Transport Distances Utilizing WTE B**

| Address | Borough | One-way Travel from Source to Transfer Station to Landfill | One-way Travel from Source to Proposed WTE B | Decrease in One-way Travel (per truck) by Using WTE | Daily tonnage to WTE B from Borough (tpd) | Averted Truck Miles per day (Roundtrip) | Total Averted Truck Miles per year |
|---|---|---|---|---|---|---|---|
| Hopping Ave | Staten Island | 155.4 | 29.7 | 125.7 | 64.0 | 805 | 241,363 |
| South Street | Manhattan | 131.7 | 6.0 | 125.7 | 256.0 | 3,218 | 965,453 |
| West 261st & Palisades Ave | Bronx | 143.4 | 17.9 | 125.4 | 1280.0 | 16,055 | 4,816,512 |
| Bayview Avenue | Brooklyn | 142.4 | 16.7 | 125.7 | 1280.0 | 16,091 | 4,827,264 |
| Marathon Parkway | Queens | 138.7 | 13.3 | 125.4 | 320.0 | 4,014 | 1,204,128 |
| | | | | | | **Total:** | **12,054,720** |

[1] The Keystone Landfill, Dunmore, PA was randomly selected as the final disposal site because the author grew up in Dunmore, PA and is familiar with its location.


**Figure 7. Waste flow from source to transfer station to landfill**

Tables 2 and 3 compare the savings in distance traveled by transporting MSW refuse to the hypothetical WTE A and WTE B instead to the Pennsylvania landfill.

.The distance averted per day (Column 7 of Tables 2 and 3) is obtained as follows:

*Averted distance per day (Column 7) =*

*=2 x distance averted per one way trip (Column 5) x*

*x daily tonnage from each borough (Column 6) / 20 tons per truck trip*

The total averted yearly distances (Column 8 of Tables 2 and 3) are by multiplying the averted distance per day by assuming 300 working days per year for truck travel..

The daily tonnages were calculated as percentages of the total export of 3,200 tpd (maximum that each WTE could receive) based upon the proximity of the transfer stations to the proposed WTE facilities. In order to demonstrate the flexibility of the program, it was assumed that the majority of waste transported to each WTE would come from the immediate surrounding region, therefore, 80% of the waste was assumed to come from Brooklyn and the Bronx (40% each), 10% from Queens, 8% from Manhattan, and 2% from Staten Island.

Tables 2 and 3 show that implementation of WTE A would avert 11.5 million truck miles. By implementing both WTE A and WTE B, approximately 24 million truck transport miles would be averted annually.

Figure 8 visually depicts the amount of miles averted (one-way) by transporting waste directly from the source to a WTE Facility, as opposed to, source to WTS to WTE Facility.

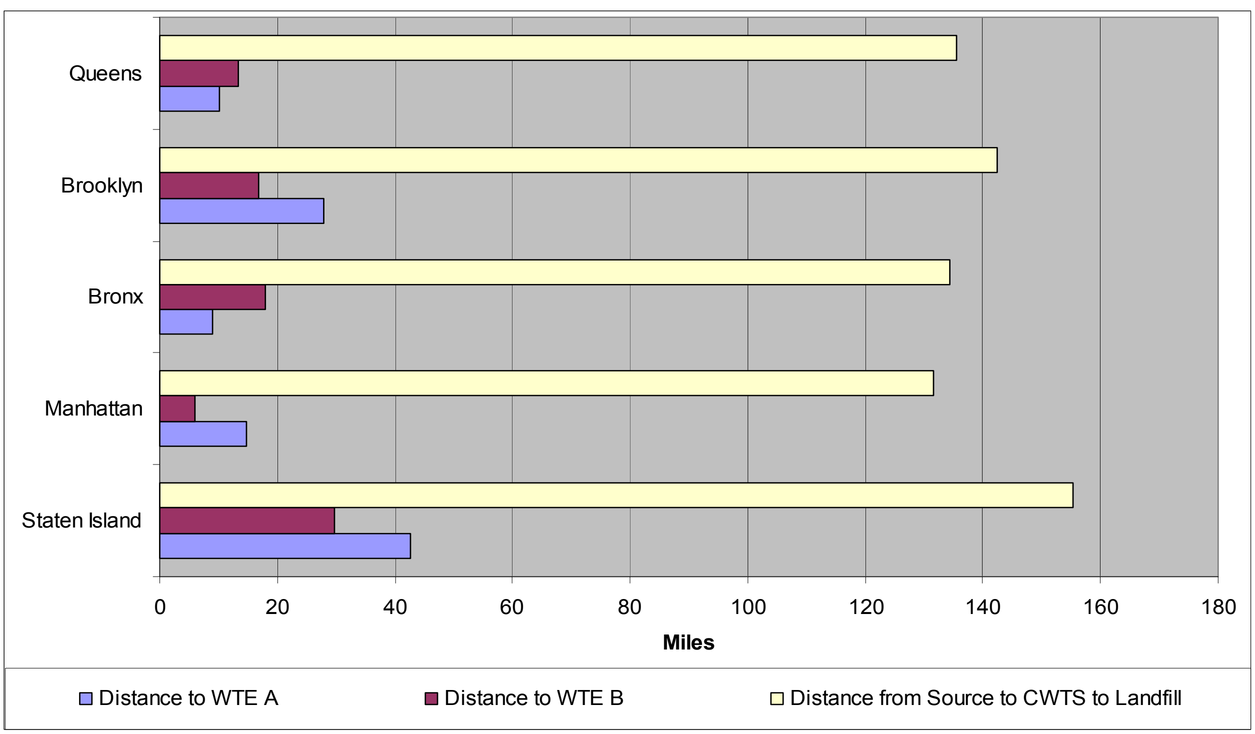


**Figure 8. Waste transport distances**

Assuming that each WTE facility has a capacity of 3,200 tpd and that 20% of the input into each WTE results in ash, 640 tpd of ash will be produced on a daily basis for each WTE. This ash will need to be transported to a final disposal, either a monofill or a facility that could utilize the waste ash in their product, such as a concrete or asphalt plant. Due to the fact that both facilities have barge access and nearby rail access, it is assumed that minimal trucking will be necessary for the final disposal of ash and therefore this was not factored into the net truck transport miles.

### *4.3 Diesel emission reduction*

Diesel engines use compression instead of spark plugs to ignite the fuel. The high temperatures typical of diesel compression ignition cause oxygen and nitrogen from the intake air to combine as nitrogen oxides ($NO_x$). $NO_x$ reacts with hydrocarbons (HC) and sunlight to form ground-level ozone (smog); $NO_x$ also combines with other atmospheric constituents to form fine particulate matter. Ozone and particulate matter are associated with many adverse health and welfare effects, including respiratory illness, acid rain, eutrophication, and visibility problems (haze). Despite previous design improvements, diesel engines contribute a substantial portion of the $NO_x$, PM, and the HC emissions from mobile sources (14).

With the reduction of travel distance, there will be a definitive savings in $NO_x$ emissions and particulate matter (PM) produced from the exhaust of the old 6 ton (2) “in City” transport trucks as well as the large, long haul 20 ton (2) transport vehicles. Table 5.5 illustrates EPA’s emission standards for new trucks and buses built on or after the indicated dates. EPA's emission standards are based on mass of pollutant emitted per unit of energy expended by a truck (expressed in grams per brake horsepower hour).

**Table 4. EPA Standards for New Trucks and Buses built in or after 1984 (13)**

| Year | NOx (g/bhp-hr) | PM (g/bhp-hr) |
|---|---|---|
| 1984 | 10.7 | 0.6 |
| 1991 | 5 | 0.25 |
| 1994 | 5 | 0.10 |
| 1998 | 4 | 0.10 |

In order to understand the relationship between the grams of $NO_x$ and PM emitted per ton of MSW transported, the following equation was used:

- **Gram emissions/ton MSW** = [g/bhp-hr * bhp (for long haul transport truck) * hours (travel time to final disposal)] / (20 tons MSW/truck)

Table 5 compares the emissions per ton of MSW for the transport of MSW to a landfill with the emissions per ton of MSW from a WTE facility. It was assumed that the long haul transport trucks carry 20 tons of MSW per trip using 400 bhp and on the return trip are empty, using only 300 bhp. The travel time to the landfill with a load was assumed to be 2.5 hours and the return trip, 2 hours. Also, the EPA emission data that were used in the calculation were for trucks manufactured in or after 1984.

The emissions per ton of MSW for a WTE facility were obtained from an EPA database (16) for emissions from all WTE facilities in the United States. The total emissions were divided by the total input of MSW along with conversion factors to determine the average grams of emissions per ton of MSW.

**Table 5. Comparison of emissions from MSW transport to emissions from a WTE facility**

| | Transport Emissions to Landfill g/ ton MSW | Emissions from WTE Facility g/ ton MSW |
|---|---|---|
| **NOx** | 685 | 1,557 |
| **PM** | 180 | 24 |

The above calculations show that the per ton particulate emissions of a hypothetical NYC WTE are seven times lower than the emissions of the trucks that are presently transporting the NYC MSW to Pennsylvania and other states. The $NO_x$ emissions of the WTE facilities are 2.3 times highes than the corresponding truck emissions.

## 5. Discussion of Results

### *5.1. General observations*

By transporting all of the putrescible waste to WTE A (Alternative 2) instead of landfilling it in the Keystone Landfill, PA, (Alternative 1) the truck travel distance (one-way) will be decreased from 595 to (a maximum of) 43 miles, resulting in a net savings of 552 miles per truck trip. By transporting it to WTE B, the travel distance will be decreased further from 616 miles to (a maximum) 30 miles saving a net of 586 miles per truck trip one way. Therefore, as shown in Tables 2 and 3 eliminating the need to export waste to outside landfills would decrease the total round-trip truck travel distance for all of New York City's MSW by about 24 million miles per year.

### *5.2 Option #1: Implement One WTE*

Assuming that each WTE has a capacity to process 3,200 tpd, i.e. the same processing capacity as the SEMASS WTE (Rochester, MA), and operates 330 days per year, then their processing capacity would be about 1.1 million tons per year. WTE A would be located in Area 1 which, according to Table 6, has total capacity of 5,691 tpd. Therefore, the WTE A could replace eight of the nine existing WTS. Comparing the maximum travel distance from source to WTE facility, implementing WTE B instead of WTE A would further decrease the truck travel distance by 13 miles per truck. By comparing this capacity to the actual processing capacities of the existing WTS in Area 2 (Table 6), the implementation of WTE B would result in the closing of thirteen out of sixteen WTS and would equate to a net mileage reduction of 12 million truck transport miles per year.

**Table 6. Tentative WTE locations and surrounding WTS data**

| | WTSs County | Operating Capacity (tpd) | Total Capacity (tpd) |
|---|---|---|---|
| **WTE A Area 1** | Bronx | 1,078 | 5,691 |
| | Bronx | 0 | |
| | Bronx | 2,227 | |
| | Bronx | 530 | |
| | Bronx | 200 | |
| | Bronx | 666 | |
| | Bronx | 0 | |
| | Bronx | 65 | |
| | Bronx | 925 | |
| **WTE B Area 2** | Brooklyn | 524 | 7,284 |
| | Brooklyn | 165 | |
| | Brooklyn | 355 | |
| | Brooklyn | 3,167 | |
| | Brooklyn | 1,002 | |
| | Brooklyn | 359 | |
| | Brooklyn | 194 | |

| | | | |
|---|---|---|---|
| | Brooklyn | 859 | |
| | Brooklyn | 0 | |
| | Brooklyn | 0 | |
| | Queens | 0 | |
| | Queens | 0 | |
| | Springfield | 184 | |
| | Queens | 12 | |
| | Queens | 314 | |
| | Queens | 149 | |

### *5.3. Option #2: Implementing Two WTE Facilities*

This option would be the optimal resolution for the city's waste. With two operating WTE facilities, an estimated thirteen putrescible WTS could be shut down. Because the transfer facilities are conveniently located near the Greenpoint and South Bronx MTS, all waste that exceeds the capacity of the new WTEs would be brought by the DSNY collection trucks to the MTS for transporting by barge to other locations for disposal. Therefore, for the assumed combined capacity of 6,400 tons for the two WTEs and the reported 2000 operating capacity of these transfer stations, thirteen transfer stations would be shut down. On the basis of the 2000 DSNY data, of the 12,975 tons of putrescible refuse thatpassed through the transfer stations each day, about one half would be combusted in the two WTEs and the remaining 6,575 tons would be divided amongst the nearby MTS.

Furthermore, if both the South Bronx and Greenpoint MTS were designed to accept about 3,300 tpd of putrescible waste, all putrescible WTS would be eliminated and only two MTS would be needed to handle all of the City's exported MSW. Also, implementation of both WTE A and WTE B would avert approximately 24 million truck transport miles per year with their attendant use of diesel oil and diesel truck emissions.

**PART II**

## 6. Aerial Imagery

Digital aerial orthoimages were processed by Ms. Hyo Jin Ahn, under the direction of Prof. Karl Szekielda of Hunter College (CUNY), New York, NY. Aerial orthoimages are aerial photographs referenced to exact coordinates on the earth and corrected for sun angle. Once processed, they can be analyzed to determine stressed areas or brownfield regions by locating the brown to beige colored regions on the orthoimages, which are indicative of vegetative stress. By using the results of the GIS analysis and overlaying the aerial orthoimages into GIS, it was confirmed that the areas selected by the analysis were areas of vegetative stress that could actually be revitalized with the implementation of a modern WTE facility. Figures 9-11 show the aerial orthoimages of the Bronx and Brooklyn tentative locations.

**Figure 9.Aerial image of Hunt's Point region. Red dots indicate nearby Waste Transfer Stations and area outlined in blue is tentative property.**

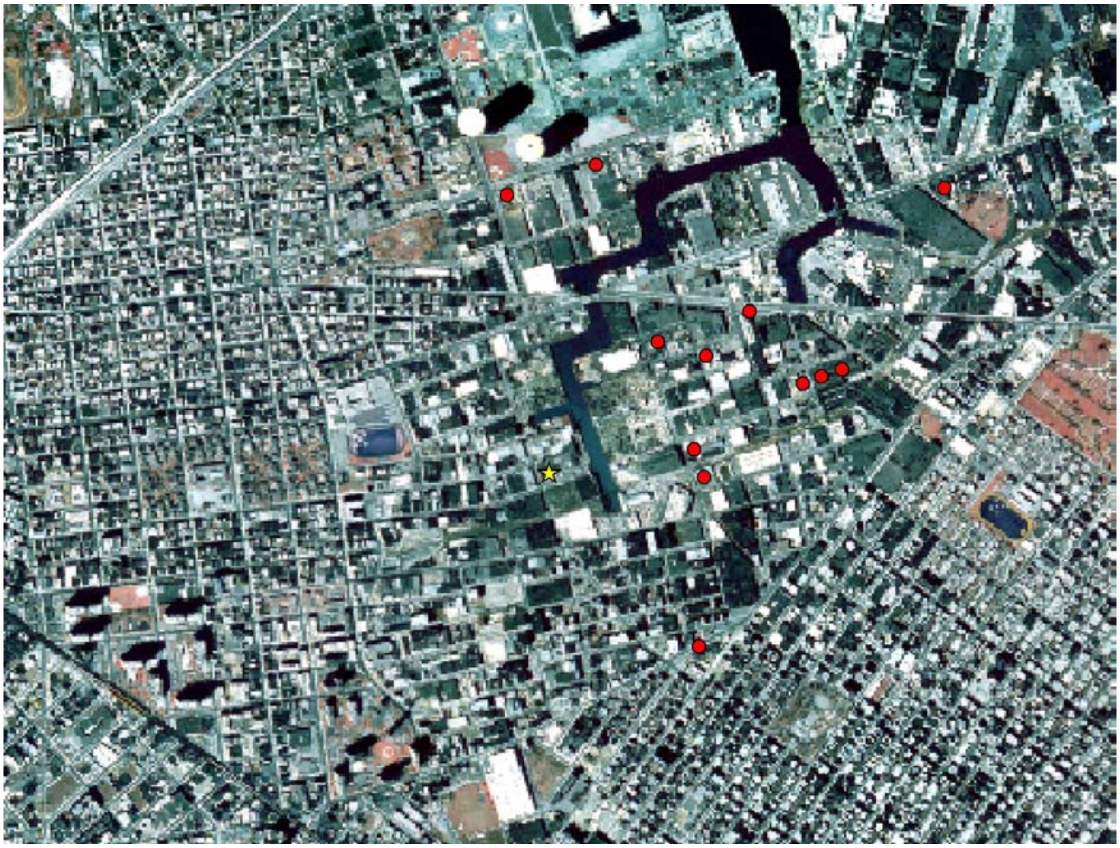

**Figure 10. Aerial image of Brooklyn site. Red dots indicate nearby WTS and star indicates tentative site.**

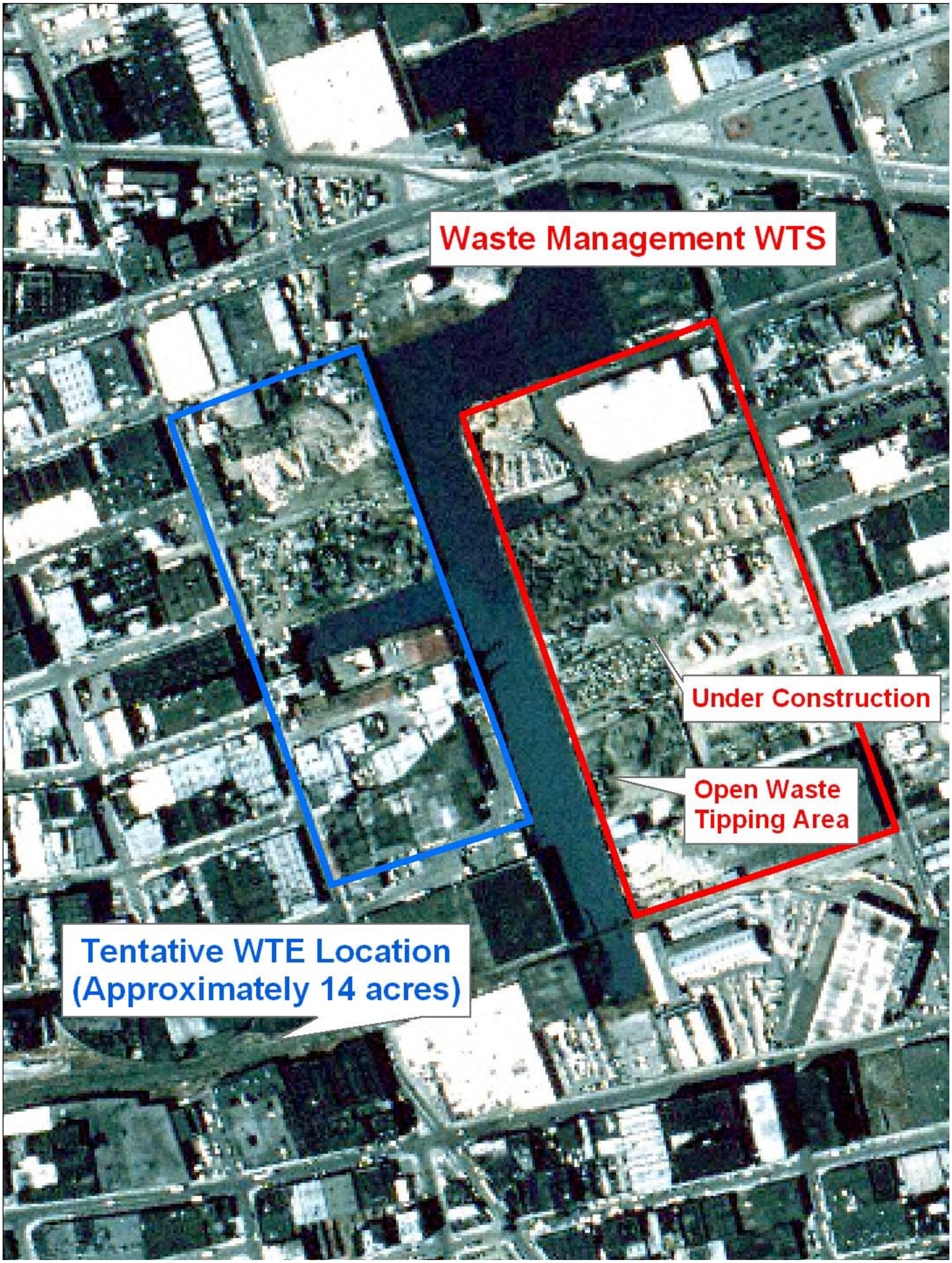


**Figure 11.Closer view of tentative Brooklyn site and adjacent WTS.**

## 7. Site Visits

### *7.1. Site Visit: Bronx – Hunt's Point*

The site visit confirmed that the site selected via GIS analysis and current aerial photography was brownfield areas in need of development.. The location of the hypothetical WTE A is in the Hunts Point Industrial Park, which consists mainly of food packaging and processing facilities. The Hunts Point Wastewater Treatment Plant is less than one mile away from the tentative area and also needs to be improved from the environmental as well as the esthetic points of view (e..g gas flares, odors, building appearance). For example, it is conceivable that the fugitive gas emissions of the WWTP could be collected and conveyed to the WTE to be used as part of the combustion air. The selected site is about 16 acres with rail access in the front and barge access in the rear. Directly adjacent to the property on the left is a lot which stores tanks of water and to the right is a food packaging facility. Figures 12-14 indicate the condition of the site and neighboring properties.

**Figure 12. Front view of Hunt's Point property. Note rail access.**

**Figure 13. View looking from rear end of property to front.**

**Figure 14. Rear of property.  Note barge access and existing marine transfer station in background.**

### *7.2. Site Visit: Brooklyn – Morgan Avenue at Stagg Street*

The site visit indicated that the site selected is indeed of a suitable nature for a WTE facility. It is a poorly maintained site located in an industrial region of Brooklyn. It is littered with metal drums, fragments of dilapidated buildings and assorted junk. The front of the property faces a well traveled street and the rear provides access to a canal. Directly adjacent to the building on the right is a building with an unclear use and to the left is a non-putrescible waste transfer facility. Directly opposite the channel from the site is a large putrescible, open-air WTS operated by Waste Management. Figures 15-17 show the condition of the proposed area.

**Figure 15. View of existing Brooklyn site.**

**Figure 16. Additional view of site from street.**

**Figure 17. View of Brooklyn site from canal. Waste management transfer station to the left and tentative site to the right.**

## 8. Siting Issues Addressed by GIS

A major problem with developing and implementing an effective solid waste management plan for NYC that would stop or decrease the exportation of MSW to other states is the political difficulty of siting modern WTE facilities in the City. Among these issues is the concern of environmental justice, which has been the key problem with New York City's waste management options in the past. A solution is to site a WTE in a current brownfield, thereby improving (parkland, built promenade by the water, use of waste hear for district heating or for light industrial heating/cooling) rather than degrading part of the City, as is commonly believed. Utilizing GIS in the siting process is a means of providing an unbiased analysis that uses factual data to provide a clear and fair picture as well as saving time and money.

### *8.1 Environmental Justice*

Environmental justice has been defined as the pursuit of equal justice and equal protection under the law for all environmental statutes and regulations without discrimination based on race, ethnicity, and/or socioeconomic status. This concept applies to governmental actions at all levels - local, state and federal - as well as to private industry activities. There are three categories of environmental equity issues as defined by Bullard (1):

- **Procedural Inequity** - This issue addresses questions of fair treatment: the extent that governing rules, regulations, and evaluation criteria are applied uniformly. Examples of procedural inequity are "stacking" boards and commissions with pro-business interests, holding hearings in remote locations to minimize public participation, and using English-only materials to communicate to non-English speaking communities.
- **Geographical Inequity** - Some neighborhoods, communities, and regions receive direct benefits, such as jobs and tax revenues, from industrial production while the costs, such as the burdens of waste disposal, are sent elsewhere. Communities hosting waste-disposal facilities receive fewer economic benefits than communities generating the waste.
- **Social Inequity** - Environmental decisions often mirror the power arrangements of larger society and reflect the still-existing racial bias in the United States. Institutional racism has influenced the siting of noxious facilities and has resulted in many black communities becoming "sacrifice zones."

Providing environmental justice goes beyond the stated definition and includes a guarantee of equal access to relief and meaningful community participation with government and industry decision-makers (1).

### *8.2. Environmental Impacts*

At least 60% of the municipal solid wastes generated in the U.S. are non-recyclable. In fact after much effort in many communities to increase recycling, the average rate of recycling throughout the nation is 26.7%, one quarter of which is estimated to be due to composting of food and yard wastes (20). The only alternatives for disposal of non-recyclables are combustion to produce electricity and heat or landfilling. An estimated 65.6% of MSW in the US is landfilled and 7.7% is combusted in waste-to-energy plants (20). The impacts of such processes on the environment can be beneficial, for example in terms of energy recovery, or detrimental, in terms of greenhouse gas emissions (10). There are environmental impacts shared by both the siting of a modern WTE facility and the siting of WTS and landfills. The pros and cons of each alternative are listed below in Tables 7 and 8:

**Table 7. Pros and Cons of WTE**

| PROS | CONS |
|---|---|
| Generation of electricity<br>Recovery of ferrous and non-ferrous metals<br>Elimination of WTS<br>Benefit to surrounding community<br>Economical<br>Becomes disposal site – no need for intermediate storage of refuse | Air quality concerns<br>Placement<br>Noise pollution |

**Table 8. Pros and Cons of WTSs and landfills**

| PROS | CONS |
|---|---|
| Economical - Combine several loads into one<br>Reduce number of trips to disposal site | Traffic Congestion (in immediate area)<br>Road degradation<br>Odor<br>Air Quality (fumes/particulate matter)<br>Dust<br>Debris<br>Noise<br>Vermin<br>Groundwater and soil impacts from uncontained leachate |

As shown in Tables 7 and 8, the pros of WTE outweigh the cons. They also outweigh the pros of utilizing WTS and landfilling. Most of the concerns or impacts of a WTE can be avoided or minimized with proper site planning and pollution control measures, such as state-of-the-art air pollution control technologies and noise mitigation techniques. Table 9 shows that the implementation of EPA's Maximum Available Control Technology (MACT) regulations for new plants has reduced WTE emissions to negligible levels:

**Table 9. MACT Regulations for New Large* MWC Plants (3)**

| Emission | Limit |
|---|---|
| **Total dioxins/furans**<br>**Toxic equivalent d/f**<br>**(Current TEQ d/f emissions in U.S. WTE stack gas)** | 13 ng/dscm**<br>0.26 ng TEQ/dscm<br>(<0.1 ng TEQ/dscm) |
| **Cd** | 0.020 mg/dscm |
| **Pb** | 0.20 mg/dscm |
| **PM** | 24 mg |
| **$SO_2$** | 30 ppm or 80% removal |
| **HCl** | 25 ppm or 95% removal |
| **Opacity** | 10% |
| **Hg** (/dscm) | 0.080 mg or 85% removal |
| **$NO_x$**<br>First year<br>After 1st year | <br>180 ppm<br>150 ppm |
| **CO**<br>Modular/Mass Burn, Fluidized Bed | <br>100 ppmv*** |

| | |
|---|---|
| RDF | 150 ppmv |
| **Fugitives**<br><br>Visible less than 5% of the time | |

* Large MWCs include any plant that processes over 250 tpd.

** dscm: dry standard cubic meter

*** ppmv parts per million by volume

The MACT regulations required: Replacing of electrostatic precipitators by better combustion practices to control volatile organics; Selective Non-catalytic Reduction (SNCR) to control $NO_x$; the use of dry scrubbers to control acid gas emissions; the injection of activated carbon to collect volatile metals and reduce dioxin/furan emissions; and fabric filter baghouses to reduce the emission of particulate matter (12). These measures have reduced mercury emissions of WTE facilities by a factor of 50 and dioxin emissions by a factor of 800.

As far as siting of the facility is concerned, in order to maintain environmental justice the adjacent community can be offered free electricity from the plant, possibly steam heat for distributed heating, and low cost waste disposal in return for allowing the WTE to be located in their community. There can be side benefits such as, in Bronx, refurbishing the adjacent wastewater treatment plant (WWTP) so as to eliminate fugitive odors, using contaminated air from the WWTP as combustion air in the WTE and providing a new park and promenade next to the WTE.  A well-designed and landscaped WTE that replaces a number of antique transfer stations can enhance the community aesthetically rather than the other way around. Negative aesthetic impacts can be prevented or minimized by proper site landscaping and architectural design of the WTE facility buildings so they are aesthetically pleasing.

With regard to WTS, the impacts that exist for old facilities would also be inherent in newer ones. There will always be a significant amount of truck traffic, which ultimately causes road degradation, air pollution, and noise pollution.  Due to the nature of waste transfer stations, especially in the case of MSW transfer stations, there will always be the odor of sitting garbage, which also brings with it vermin and trailing garbage.  On the other hand, the sheer scale of operation of a WTE makes it possible to provide an aesthetically pleasant site using a totally enclosed system.  A system of this type could utilize the air sucked from the tipping floor and storage building as the air for combustion, thus fully protecting the surrounding area from the gas and odor emissions that are now emitted by transfer stations which have no provision for using air contaminated with odors.

The existing transfer stations have little provision for capturing the gaseous emissions emitted as the small trucks unload and the big trucks load at transfer stations. In contrast, all modern WTE facilities are equipped with large, totally enclosed, unloading bays and tipping floors where the small trucks dive in through air curtains and all the air in that building is funneled and used as combustion air in the furnace, thus there are neither odorous emissions nor unpleasant sights in the neighborhood.

### *8.3. Benefits of WTE in NYC:*

Brownfield areas in NYC, which have been destroyed by past industrial use could be improved and "greened" by the siting of a modern WTE plant in the following ways:

1. The facility could be landscaped to enhance the surrounding environment
2. Implementation of a "living roof", which serves numerous benefits, including reduced runoff, increased thermal absorption (prevents reflection of radiation on surrounding area, keeps buildings cool in summer and locks in heat in summer), as well as providing a community attraction.
3. Adding value to surrounding properties.
4. The surplus heat remaining after generation of electricity in a steam turbine can be distributed to surrounding industrial buildings for heating/cooling purposes.
5. Community attraction fueled by:
    a. park
    b. recreation center
    c. swimming pool
6. Provide jobs to area residents
7. Generation of electricity and metals recovery

## 9. Conclusions

This study has shown that modern WTE technology is an environmental and economic solution for waste disposal in New York City. It was shown that implementation of one WTE in NYC would save about 12 million truck transport miles per year, or with two operating WTE facilities, approximately 24 million truck transport miles would be averted. This, in turn, would save money directly in transport costs, labor costs, and the reduction of environmental impacts such as air and particulate emissions/mile, road degradation, and odor. The alternatives examined in this study indicate that upon implementation of two WTE facilities used in conjunction with the South Bronx and Greenpoint MTS all putrescible WTS in Bronx and Brooklyn could be eliminated with significant environmental and economic benefits to the City.

To conclude, the use of GIS technology provides an unbiased means for examining potential WTE facility locations. It allows for viewing several sets of data at once to visualize historical as well as current practices, so that areas of extreme stress can be identified. GIS can provide a clear and fair solution to the political, social, and environmental issues surrounded by waste management decisions in a large metropolis.

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