Field Operations

Fresh Kills

Fresh Kills Utility Development Scenarios

DRAFT 1

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Contents

1 Introduction

This report outlines the sustainable utility choices for Fresh Kills Park. The choices made will be driven by the objective of integrating sustainability into all facets of the Park.

The report discusses:

- Energy reduction and supply
- Water conservation, capture and reuse
- Wastewater treatment and reuse
- Waste treatment

The report outlines four development scenarios for incorporating sustainable technologies in order to inform the project developers of potential strategies for the park's development. The scenarios are based on the proposed development described in the 2006 Draft Master Plan (DMP). The scenarios start with a conventional build scenario and work towards being 100% sustainable or "off grid".

The development scenarios can be loosely summarized as:

1. Conventional utility supply i.e. 100% grid connected with no sustainable technologies
2. 20% more sustainable
3. 50% more sustainable
4. 100% sustainable or "off grid"

The percentages are not truly representative of the scenarios, they are a guide which represents intermediate options between grid dependency and being off grid. Loosely, the 20% guide corresponds to efficiency improvements and the 50% is efficiency improvements with some renewables.

The report builds upon two other reports previously submitted to the client which presented various potential technologies that could deliver sustainable utilities to the site. These should be referred to for more detail on specific applications.

The report contains assumptions and exceptions and that must be read along with the findings of this report.

This report is intended to be a decision making tool for the New York City Department of Parks and Recreation (NYCDPR). Once NYCDPR has reviewed the scenarios a preferred scenario will be developed by Arup. Eventually, Arup will develop the preferred scenario into a utility Implementation Plan for Fresh Kills. The Implementation Plan will contain goals and strategies which will inform and guide the integration of sustainable technologies into the design and construction focusing on resource conservation, but also suggesting technologies.

2 Sustainability at Fresh Kills

Sustainability means different things to different people and projects. This report does not outline a strategy to make the whole of Fresh Kills Park sustainable. This report only considers the provision of utilities to Fresh Kills Park and does not address broader environmental, economic and social aspects of the project.

For the purposes of this report, we have reviewed **'technologies and strategies which conserve resources, reduce infrastructure requirements, reduce dependency on grid connected systems and provide an educational value'**. Not all technologies can meet all of these goals and in many cases there is a trade off. One example is the onsite treatment of wastewater; a local system may reduce pressure on the municipal sewerage system but it may use more energy and take up more valuable space than piping it out. Therefore, this report discusses technologies which are a balance of 'sustainability' and present the least overall impact.

Fresh Kills Park is a unique and important opportunity for integrating sustainability into a major public project. The highly developed New York metropolitan area presents few opportunities for larger new projects. Although the park is constrained by the former landfill, the open space and lack of infrastructure make some sustainable technologies a logical choice as they reduce the necessary infrastructure and construction required to link the entire park into grid utility systems.

The park also presents an excellent educational opportunity. By integrating sustainable practices and technologies into the design, the park visitors can see and experience low impact development which reduces resources, harnesses renewable resources and uses natural treatment systems.

Resource conservation

This report focuses on technologies that minimize resource use, as well as technologies that can supply utilities with lower infrastructure requirements than conventional technologies. Conserving resources in the park should be the primary strategy for Fresh Kills Park and reducing infrastructure should be the secondary focus. By reducing energy and water demand through design or by eliminating buildings/facilities from the plan, the volume of utility to be supplied will be reduced and systems can be downsized.

3 Approach

3.1 Scenario development

The approach taken for the project was to develop a 'business as usual' (BAU) scenario which reflects the full build program outlined in the 2006 DMP. Resource use and utility supply were estimated based on the DMP program. These estimates were used as baseline for different scenarios. Based on the BAU scenario, three further scenarios were developed to present potential strategies to move towards being 100% "off grid".

Figure 1 presents an example of this approach for energy.

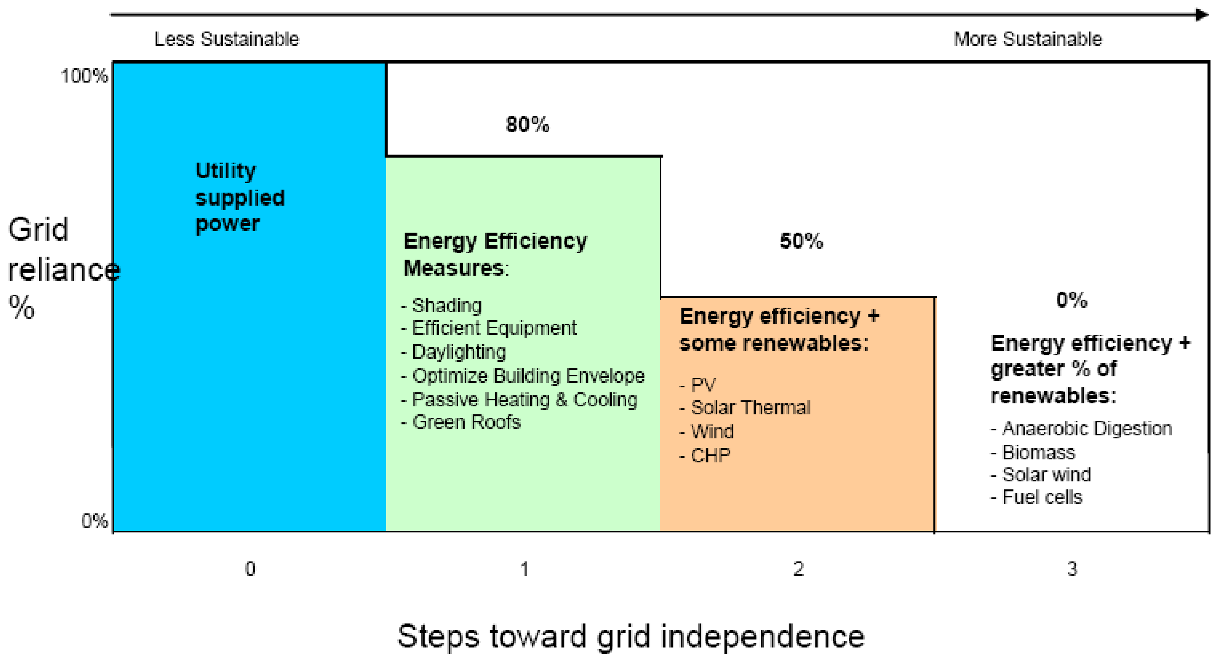

Figure 1 - Moving towards power grid independence

Providing scenarios for sustainable utilities is not straightforward. All solutions will be a mixture of technologies that complement each other. Some technologies have clear applications, such as solar water heating for comfort stations which are likely to experience high use during warm summer days. The high use will coincide with high solar radiation which can be used for heating water in the comfort stations. Other technology solutions are harder to match to uses and these options are discussed within each scenario. In other words the scenarios are not definitive and there are options within them.

Table 1 presents an overview of the scenarios.

Table 1 - Development scenarios overview

Scenario	Utility	Strategies
1. Business as usual	Energy	• Energy supplied through local grid connections
	Waste	• Compliance with DSNY waste management programs
	Water	• Water supplied through local grid connections
	Wastewater	• All wastewater is taken offsite via a connection to the main municipal system, with septic tanks in remote locations
2. 20% Sustainable	Energy	• Energy conservation which is 30% better than ASHRAE 90.1 2004
	Waste	• Waste reduction strategy and policies • Recycling of all recyclable materials
	Water	• Water conservation measures in all facilities • No water used in comfort stations
	Wastewater	• All comfort stations use composting toilets • Remaining wastewater is treated conventionally – septic tanks or municipal system
3. 50% Sustainable	Energy	• See Scenario 2 and; • All outdoor lighting is from photovoltaics (PV) • 10% of energy from wind • 10% of energy from PVs • Connect to the grid to sell surplus energy when possible
	Waste	• See Scenario 2 and; • Composting system for all organics
	Water	• See Scenario 2 and; • Greywater recycling and rain water harvesting (RWH) systems in all buildings or groups of buildings.
	Wastewater	• All comfort stations use composting toilets • Greywater recycling in all buildings • Remote facilities have their own constructed wetland treatments
4. 100% Sustainable.	Energy	• See Scenario 3 and; • Remainder of energy comes from either: o Anaerobic digester o Biomass CHP plant o Fuel cells o and/or mixture of other technologies
	Waste	• See Scenario 3 and; • Organic waste used for anaerobic digester or CHP plant, or default to Scenario 3
	Water	• All water including potable water is locally harvested or and treated to drinking water standards.
	Wastewater	• See Scenario 3 and; • All wastewater is treated on-site. Large unit to be established for treatment to potable standard.

3.2 Today's technology

The recommendations and suggestions in this report are intended to be both visionary and realistic. As the scenarios work towards being 100% sustainable, more ambitious strategies need to be incorporated. Using today's technology it is difficult to make the project 100% sustainable without being very expensive and specifying significant numbers of photovoltaic (PV) panels or wind turbines, which would also need significant surface area. This report focuses on the technologies that are currently available and those which hold promise for future energy needs. It is likely that these future technologies will be feasible by the time the next design and construction phase is ready to start.

One advantage of implementing a number of technologies is that it gives flexibility. As new technologies are developed, a modular approach can make it easier to swap technologies out. Some technologies, such as gas micro-turbines, fuel cells and biomass burners also have the flexibility to change fuel source to reflect supply. If the possibility for using the landfill gas as an energy source increases then a fuel cell could be powered by the landfill gas. The park could then switch to hydrogen as the landfill gas runs out (over the next 50 years) and on-site hydrogen production becomes more feasible.

Where possible, the scenarios find synergies between technologies to provide maximum benefit, such as anaerobic digesters which can provide heat and energy as well as process waste.

3.3 Phasing

The Park is an ambitious public project which is constrained by a number of factors including public finance availability and landfill considerations. Therefore, a Park program has been developed comprising two main phases: projects built by 2016 and by 2036. As discussed below in 'costs', specifying which technology should be implemented at the various stages of development is not possible due the changing pace of technology and changes to the Park program as the design progresses.

Therefore, to accommodate the phasing, the scenarios should be viewed as strategies which can be proportionally applied at different stages of the park's development.

3.4 Costs

Predicting costs for each scenario from the existing information in the DMP is not possible. The lack of detail in the DMP coupled with changing costs of utilities and technology over time makes future predictions hard to determine.

It should not be assumed that sustainable options cost more than conventional techniques. By integrating sustainability practices at the beginning of the design process, capital costs can be reduced, energy and water requirements will be reduced and infrastructure requirements will be reduced. Infrastructure reduction is significant, as the costs for laying infrastructure for utilities throughout the site could be as much as three times more than a non-landfill site.

Nonetheless, where possible, the report discusses the potential costs in terms of high, medium and low and includes actual costs of specific technologies, where available.

Once a preferred development scenario has been selected, specific options can be explored in more detail to determine potential costs.

3.5 Methodology

As described above, four scenarios were defined ranging from 100% dependence to 100% off grid. To define the content of the scenarios, Arup built on its previous work for Fresh Kills which suggested potential technologies for the Park. The methodology used for determining the technology potential is included below.

3.5.1 Estimating demand

The standard approach for determining load (or demand) is to design the buildings or facility and infrastructure and then calculate the total capacity (such as power) for utilities at peak demand. Using this method, one can specify the infrastructure requirements to safely meet the load at peak times.

As the park is still at conceptual stage there are no building and infrastructure specifications, only approximate building footprint areas. Therefore, to calculate loads estimated visitor numbers were drawn from Liberty State Park in New Jersey which was identified by NYC DOT as a park with enough similarities to Fresh Kills to serve as a model. The data is also being used by AKRF for traffic and parking projections in the development of the General Environmental Impact Statement for Fresh Kills.

3.5.2 Assessing site conditions

Many potential technologies are sensitive to regional and local conditions for geothermal, wind, rain, topography, solar and ground conditions. A data review was undertaken to understand site conditions and these are discussed with each potential technology.

3.5.3 Investigating potential technologies

Following the establishment of an order of magnitude estimate for demand and an evaluation of site conditions, a review was undertaken of potential technologies that could meet the demand for each utility. This report describes technologies that are available in today's marketplace and have a realistic potential for use at Fresh Kills.

3.6 Assumptions

To determine the potential sustainable technologies for the park it was necessary to calculate the load (demand) for utility services. However, there is limited information on the proposed buildings and infrastructure at this stage.

The potential load and subsequent predictions for utility use are, therefore, 'order of magnitude' only. Each assumption and exception is listed below in more detail.

1. Building specification. The approximate size of each building is known but there is limited information available for lighting, water use, heating and cooling requirements. There is no information available on building materials and engineering constraints.
2. Visitor profile. There is no accurate information available on the predicted number of visitors at the park or for each facility. Also there is no data available on the visitor profile which could help predict waste generated, length of stay in park or other information. However, the client has provided data from Liberty State Park in New Jersey which has similarities to the proposed Fresh Kills Park.
3. Visitor numbers. Visitor numbers are predicted to be 16,800 per day average for the 2036 full build scenario described in the DMP. To accommodate these visitor numbers we have assumed 200 staff across the park.
4. Load profile. Load profile is a model of how the utility requirements change throughout the day, week and seasons. As with the visitor profile there is no information available to do this. Demand for power and water is likely to increase at peak times but without

further information this is difficult to predict, therefore, it is assumed that there is a constant load throughout the day and less at night.

5. Non-building infrastructure requirements. There is limited information on infrastructure in the park, such as lighting and water use, which have significant potential for affecting energy and water use. See assumption on hours of operation.
6. Irrigation. It is assumed that the park will have no irrigation with the exception of areas which may have heavier use, including soccer pitches and 25% of lawns.
7. Landfill gas. The site has significant quantities of landfill gas which are exported off-site for conversion to energy. It is anticipated that the gas and subsequent conversion to energy could provide a significant amount of the park's energy requirements. However, as the processing and sale of the gas is part of a long term contract with KeySpan Energy it has been excluded from all calculations.
8. Natural gas. Consideration of gas infrastructure was not included in the scope of this work. It is assumed that gas would need to be supplied for cooking and potentially heating in some cases. Gas could be supplied to the site through conventional piping or by being trucked onto the site. However, the 'off grid' scenario suggests measures for alternatives to gas.
9. Hours of operation have been estimated to be dawn till dusk for most of the park (approximately 6am to 6pm). Areas such as Creek Landing and The Point will be open until 1am. Outdoor lighting will be activated throughout the park before dusk until dawn.
10. Costs. All costs discussed in this document are broad estimates and must be verified by a cost estimator or contractor. A cost estimating exercise should be carried out at detailed design stage.

4 Development scenarios

4.1 Scenario 1: Total grid dependency (conventional design & construction)

This scenario reflects a conventional build approach, where all utilities would be supplied using standard technologies which are 'grid' connected. In this case water would be supplied by municipal services, they would also take away and treat the wastewater. Energy would be supplied from private utility providers (but potentially sourced from NYPA) and waste would be taken offsite by municipal or private waste service providers. The conventional build scenario also assumes that all buildings and facilities will be built using conventional technologies that are compliant with city codes but are not to the most efficient design standards available.

Estimates for the base loads associated for each utility based on the DMP are shown below in Table 2.

Table 2 - Load estimates

Utility	Estimate load	Comment
Energy	54,000 kWh per day	Includes all roads and buildings in the DMP
Water	350,000 gallons per day	180,000 gallons for irrigation and 170,000 for all other uses.
Wastewater	170,000 gallons per day	
Waste	10 tons per day	This could range up 20 tons per day and does not include landscape green waste.

These loads are conservative estimates for utility use and serve as order of magnitude estimates to enable broad predictions for technology scenarios to be developed.

Discussions with infrastructure providers are ongoing to determine the exact capability and capacity of the current infrastructure supply in the area. However, it is anticipated that there will be capacity in the system to accommodate the estimated loads.

4.1.1 Energy

The energy requirements for the park include lighting throughout, as well as the heating and cooling of all buildings. Of the total Park energy budget, approximately 25,500 kWh/day or almost 50% is from outdoor lighting.

The major building facilities will be located in both South Park and the Confluence. They include a 174,000 square foot tennis center, a 30,000 square foot indoor sports center, a 7,500 square foot indoor track and field center, as well as a banquet hall, three visitor centers, a "restaurant row," and two additional restaurants. These major facilities will consume approximately 25,000 kWh/day, or 9 million kWh/year.

4.1.1.1 Energy Supply

There are major feeder cables crossing the site along Richmond Avenue and the West Shore Highway, but these are transmission cables only i.e. the voltage is too high for park uses. Other more localized distribution exists throughout the perimeter of the site and there is an existing connection to the DSNY facility on Muldoon Avenue. Other links to facilities may also exist but are not yet known. Although the capacity of existing links is unknown it is anticipated that links to power supplies could be made for each area of the park at the locations described in Table 3.

Table 3 - Potential utility connection locations

Park Location	Utility Link
North Park	Wild Avenue in the Travis neighborhood
The Confluence area (east side: Creek Landing, The Marsh, The Terrace)	West Shore expressway or existing connection at the flare station construction staging area (power lines to be confirmed)
The Confluence area (west side: The Point)	Muldoon Avenue
East Park	Richmond Avenue
West Park	Muldoon Avenue and existing connection to landfill leachate system
South Park	Arthur Kill Road

Connecting to these locations could be through existing infrastructure where available although there may be a need to increase the line's capacity. New cables would have to be laid for more remote locations. Laying new cables in a landfill site can be similar to conventional costs in unconstrained sites if laid alongside new road infrastructure suitable for vehicles. However, if lines need to be laid in other areas of the landfill which will not have paved roads, then laying cable infrastructure can be more expensive. Laying cables in landfills requires greater engineering solutions to deal with subsidence and can require ongoing maintenance inspections and work.

An alternative to laying cables is to have them above ground, this may be a less aesthetic option but may reduce installation costs.

If energy was to be supplied from grid sources, then it is likely to come from the NY grid. The mix of power sources in New York's grid (Figure 2) from NY ISO's (which monitors the NY grid) shows that New York has a relatively diverse fuel mix.

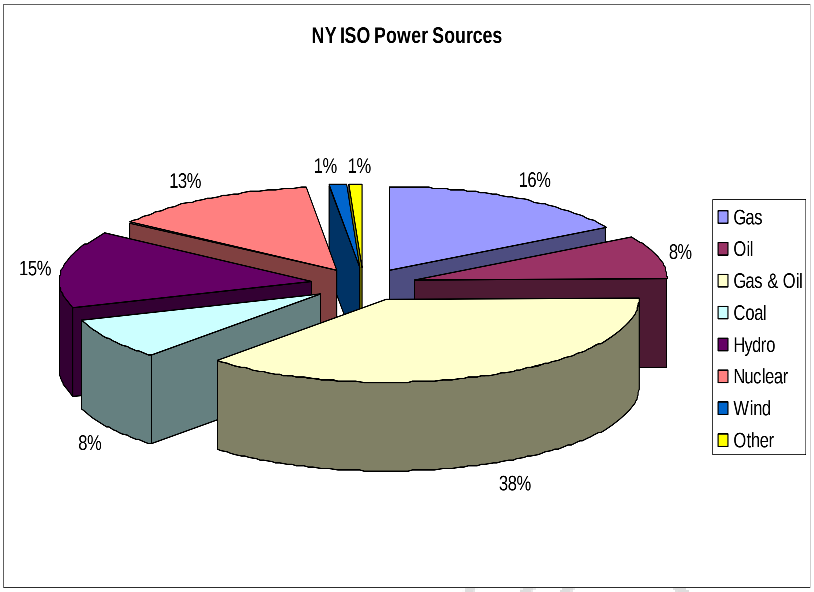

Figure 2 - NY ISO Power Sources

If the Parks Department has the potential to secure a contract with the New York Power Authority (which ranks among the cleanest utilities in the Unites States[1]), the fuel mix is approximately 80% hydroelectric, and 20% fossil fuels. Therefore, by securing an energy contract with NYPA, the park will theoretically use a more sustainable source of electricity, even if it is supplied from the ISO grid.

4.1.2 Water

It is estimated that the park will consume 350,000 gallons per day. This is based on 180,000 gallons for irrigation and 170,000 for all other uses.

A preliminary water demand estimate has been calculated based on estimated visitor numbers to the Park (16,800 per day)[2]and 200 employees. The water demand estimate is an approximation based on anticipated visitor numbers and should be used as an order of magnitude to understand the scale of water use on the site for potable and non-potable uses. It was calculated using an estimated usage of 10 gallons/person/day[3]. Irrigation was calculated using the areas of land being irrigated with average irrigation values from Federal Water Use Indices[4].

The Fresh Kills estimates could be substantially higher if the area irrigated is increased and/or other program elements are introduced.

Under this scenario all water would be supplied using conventional connections to the main municipal supply. It is anticipated that connections could be made at the same locations shown in Table 3.

Supplying locations throughout the site would be through conventional supply technology and there will be similar constraints to those described in the energy distribution case i.e. water pipes being at risk from landfill subsidence.

[1] CNY Business Journal, September, 1998 “Study Ranks NYPA Among Nation’s Cleanest Utilities.”
[2] Based on Liberty State Park Values average of 2036 visitor
[3] Water Volume Requirements of the NJDEP Safe Drinking Water Act Regulations (N.J.A.C. 7:10), adopted November 4, 2004
[4] US Department of Energy http://www1.eere.energy.gov/femp/water/water_useindices.html

4.1.3 Wastewater

The volume of wastewater generated would be broadly similar to that of water consumed for other uses, i.e. 170,000 gallons per day. All water required for irrigation would be lost through evapotranspiration to the atmosphere.

It is understood (but to be confirmed by DSNY) that the existing water treatment system in place at Fresh Kills for the Department of Sanitation Facilities is independent of the municipal wastewater network. All wastewater is treated on-site by a septic system. The leachate from the landfill is treated by a separate plant which is also not part of the municipal system.

Under a conventional build scenario it is likely that there would be a mixture of technologies used to handle wastewater. The cluster of buildings at Owl Hollow, Creek Landing, The Point and park entrances will probably be connected to the main municipal system managed by NYCDEP. Staten Island has two wastewater treatment works and the project site is mostly within Oakwood Beach and it is likely that any wastewater would be treated there. The more remote facilities such as comfort stations are likely to have their own septic tanks, which will need to emptied and maintained on a regular basis.

As with the other utilities the same constraints exist in relation to laying pipes and pumping stations within a landfill. Waste pipes are also wider than water pipes which needs to be taken into consideration when calculating fill depth above the cap.

4.1.4 Waste

It is estimated that approximately 10 tons of garbage will be created from visitors at Fresh Kills each day. This is a conservative estimate based on one pound of garbage per person. Waste was also calculated by building type and average waste generation per square foot and this provided a slightly lower waste volume but this did not take into account waste generated by park visitors not using park buildings i.e. those using paths and outlook stations only. The actual amount may be more depending on the typical visitor profile of the park and the activities they take part in.

Green waste was not calculated as part of the program because the extent and type of landscape maintenance is unknown. However, by extrapolating data from a semi-rural park (Heaton Park) in the UK, it can be estimated that a park of this size could generate 5 tons a month from the areas scheduled for activity planning (330 acres). This assumes that the grassland, wooded areas and new habitats would not produce any green waste for processing. Manure from the equestrian center would also boost the volume.

Under this scenario, all waste would be taken offsite and processed by DSNY. The 2006 NYC Solid Waste Management Plan (SWMP) has committed to achieving new aggressive recycling programs which will recycle 25% of its curbside collection. Pilot recycling programs are in place in various park locations throughout New York but these are limited to heavily used commercial areas. Therefore, it may be possible to have a Park recycling program in place under a business as usual scenario which would contribute to reduction the amount of waste going to landfill. The SWMP also commits to continue to research new waste technologies such as gasification and anaerobic digestion, so there may be potential to partner with DSNY in piloting these new technologies at Fresh Kills.

Other waste from the park is likely to go to landfill. This process would involve truck collection (or possibly boat collection) from the site to the local DSNY transfer station and then it will be trucked to landfill locations in neighboring states. As landfills fill up, the traveling distances are becoming larger and this represents a sustainability impact from vehicle emissions, community and ecological disruption at the landfill site. However, the

SWMP is proposing moving towards marine and rail based transport to reduce vehicle emissions which would make the movement of waste more sustainable.

4.1.5 Scenario summary

Table 4 presents a summary of the Scenario 1 and its implications for Phases 1 and II.

Table 4 - Scenario 1 Summary

Utility	Strategies	Phase 1 implications	Phase 2 implications
Energy	• Energy supplied through local grid connections	Strategy applied throughout phase	Expansion of phase 1 approach
Waste	• Compliance with DSNY waste management programs	Strategy applied throughout phase	Expansion of phase 1 approach
Water	• Water supplied through local grid connections	Strategy applied throughout phase	Expansion of phase 1 approach
Wastewater	• All wastewater is taken offsite via a connection to the main municipal system, with septic tanks in remote locations	Strategy applied throughout phase	Expansion of phase 1 approach

4.2 Scenario 2: Green Design (20% more sustainable)

This scenario focuses on resource conservation and presents an approach that reduces water and energy demand, as well as producing less wastewater and waste. If this approach is integrated into all future planning considerations for the Park's development then it is likely to deliver significant reductions with little or no cost compared to conventional building capital costs.

Local Law 86 requires that public projects of a certain cost that are receiving City funding must become LEED® accredited. Depending on the funding source, this may not apply to Fresh Kills but this scenario broadly considers that getting all buildings to LEED® standard (not necessarily certified) should be the objective of this scenario. Figure 3 below shows the savings that can be achieved through implementing LEED® building strategies compared to building conventionally.

Under this scenario, all utilities with the exception of some irrigation water will be supplied using the same conditions as Scenario 1, i.e. by connecting to the grid at various locations. The key difference between this scenario and the previous scenario is that although they use the same utilities the demand on those utilities is significantly reduced.

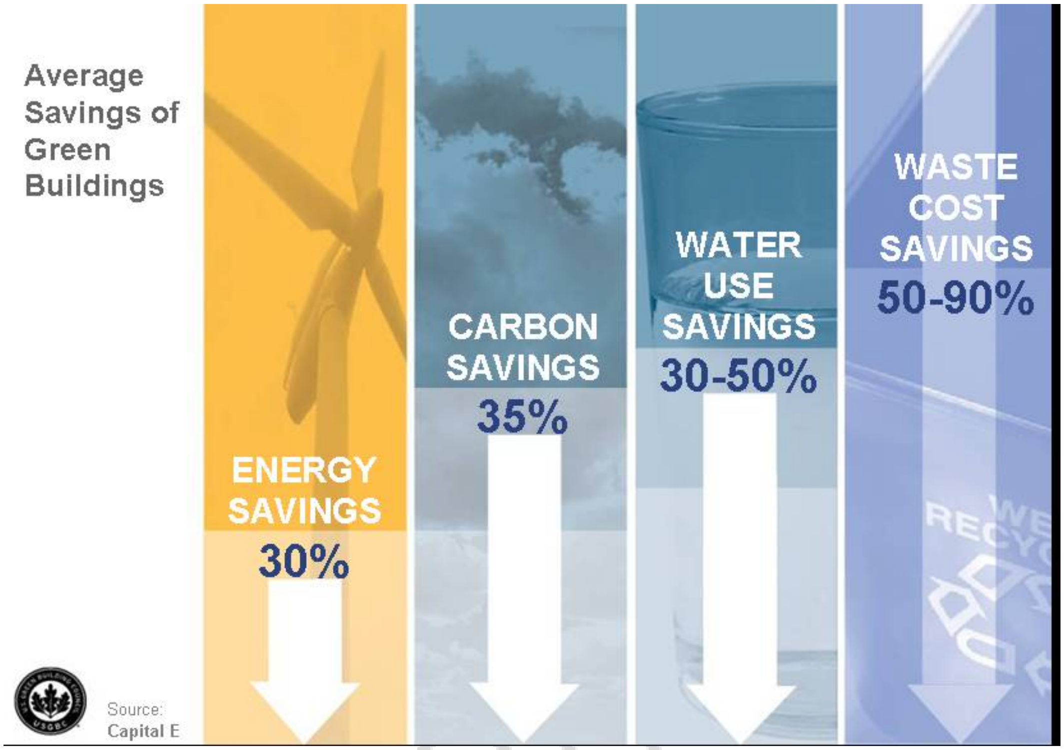

Figure 3 - Average utility savings for LEED® buildings

4.2.1 Energy

As discussed in Arup's report, *Applied Energy Sustainable Technologies*, previously submitted to the Department of Parks and Recreation, good design can reduce energy demand for buildings by 20%, and often more. At the same time, many of these measures are not expected to cost more than the business as usual case.

The passive load reduction strategies that are options at the Fresh Kills site are:

- Optimize orientation. Buildings and facades should be oriented to respond to the sun. Distinct north, south, east and west facades should be established based on solar impacts, passive solar gain and control.
- Optimize building envelope. Insulation of roof and wall systems can achieve a significant improvement over ones that are currently a part of local construction standards.
- Natural ventilation. Natural ventilation can be a sole source or supplemental source of conditioning and ventilation at the Fresh Kills site.
- External shading elements. Solar insolation falling on the building facades can be passively controlled by external building shades. The external building shades could also incorporate photovoltaics (PV), see Scenario 2, for the generation of energy
- Vegetated "green" roofs. Roof plantings can be used to attract and retain moisture to the building, which reduces the heat island effect and, as a result, decreases energy costs.

The active strategies that are options at the Fresh Kills site are:

- Installing energy efficiency equipment. Energy efficient equipment and appliances will reduce the building energy density (Watts/ft^2). Such equipment can include efficient HVAC equipment.

- Energy efficient lighting. Energy efficient lighting can reduce the building energy density (Watts/ft^2) and the energy use. Such technologies include low energy fixtures and automatic lighting control systems.
- Heating & Cooling. Space heating can be provided by an underfloor heating system (embedded hydronic system) within the buildings at the Fresh Kills site. Biogas generated from an anaerobic digester (See Scenario 4) can be used directly to heat the water within the potential hydronic system. For cooling, the buildings standards/guidelines should be established to state the minimum efficiency of all installed cooling equipment.
- Energy recovery. All energy systems at the Fresh Kills site should incorporate heat recovery wherever possible. For example, in all cogeneration and biogas conversion to electricity (see Scenarios 2 & 3) all heat recovered can be utilized for space heating, cooling and/or hot water.

Little or no up-front costs would be required to implement the above measures. A further detailed, site-specific analysis is required to determine the technologies that are both economically and technically feasible as building designs are further developed.

4.2.2 Water

Using the same approach for energy, this scenario would focus on technical measures to reduce water demand. The majority of technical measures comprise low-flow plumbing fixtures which discussed in the previous *Applied Sustainable Water and Waste Technologies Report*. Low flow plumbing fixtures could potentially reduce the amount of wastewater about 40% to 105,417 GPD (not including composting toilets). These technologies include:

- Low flow toilets and urinals
- Waterless urinals
- Dual flush toilets
- Composting toilets (discussed in section 4.2.3)
- Low flow fixtures on faucets and showers (aerating and sensors)

This scenario would also specifically recommend that all remote comfort stations do not have water supplied to them. As described in the wastewater section below, these comfort stations would have composting toilet and hand sanitizer for hand washing.

In addition to this an education campaign based around green building and environmental awareness can contribute to more sensible use of water resources.

4.2.3 Wastewater

Wastewater load is linked to water demand. If water conservation measures are installed, wastewater demand will be reduced. The wastewater load of the Park is approximately 170,000 gallons per day (GPD). Approximately, 71,400 GPD is blackwater, 34,000 GPD is shower and faucet water and 64,600 GPD is kitchen sink and other water loads (maintenance, food preparation, etc.). Potentially, 98,600 GPD of greywater (everything except blackwater) could be recycled, although kitchen waste needs additional grease traps, filters and restrictions on deposits of organic waste.

A 20% scenario would use composting toilet comfort stations only in remote areas of the park.

All facilities will use low flow plumbing fixtures, which should reduce potable water use and wastewater discharges by a minimum of 20%. The wastewater could travel to an on-site wastewater treatment plant and discharge into the Arthur Kill River. This type of plant could be a septic system with a Membrane Bioreactor (MBR), or any other traditional wastewater treatment method such as Electro-flocculation Systems, Sequencing Batch Reactor (SBR), etc. Another option is to connect the discharge pipes to the current NYCDEP sanitary sewer pipelines surrounding the park. For buildings and facilities close the park perimeter or existing connections, it is likely that connecting to mains system will be easier and cheaper. This will reduce the need to treat the wastewater on-site.

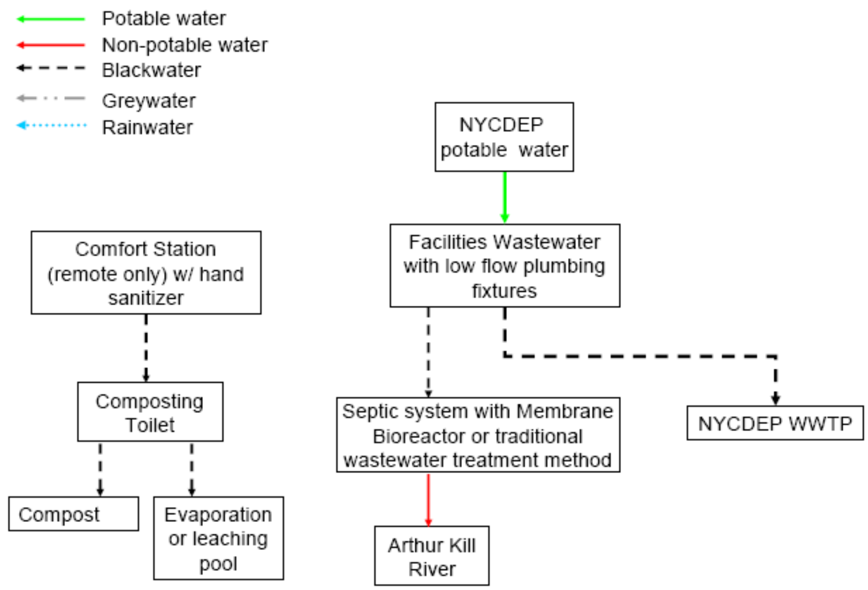

Figure 5 - 20% Sustainable wastewater flow diagram

Potential technologies that can deliver a 20% sustainable scenario are discussed below.

4.2.3.1 Composting Toilets

Composting toilets are a technology that requires zero water and produces zero wastewater. The system contains and processes excrement, toilet paper and sometimes food wastes through an aerobic bacterial process. Legally, the “compost” or “humus” created must be buried or removed. However, there are examples of the material being used as compost fertilizer in the United States.

The composting toilet process is illustrated in Figure 4. The costs of these units could be up to $20,000 (recommended for park use) and provide up to 500,000 uses per year.

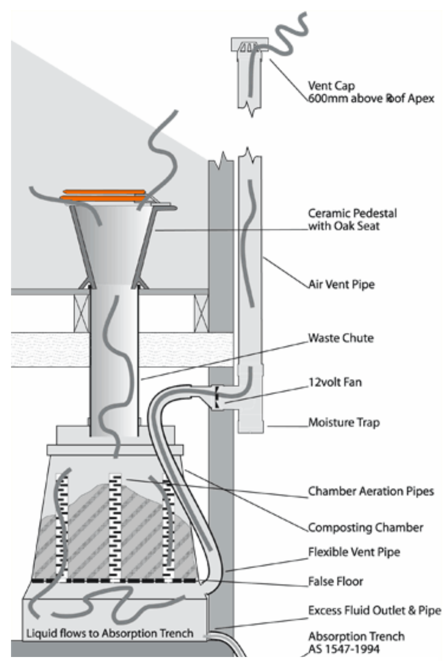

Figure 4 - Composting toilet

For health purposes, hand sanitizer will be used to wash hands in these comfort stations, preventing any need for potable water. Alcohol based Purell™ or non-alcohol based Hands2go™ are examples of hand sanitizers that guarantee killing 99.99% of germs.

Norman J. Levy Park, Merrick, NY, which is also on a landfill, currently has two composting toilets with hand sanitizer preventing the need for installation of a potable water and wastewater pipe network within the landfill.

4.2.3.2 Membrane Bioreactor

Membrane bioreactors (MBR) are a potential option   MBRs were first used for tertiary wastewater treatment, however, with improvement in technology, these units have been developed into full (primary, secondary and tertiary) treatment systems. MBRs are often installed for small scale treatment needs, but are also available as bigger units which could treat waste from an area like the Confluence. These types of systems can be designed for small communities and parks like Fresh Kills. One type of system is the Xpress™ MBR Packaged Plant. It is a prepackaged plant that screens the wastewater before entering the biological process. In the plant, oxygen is applied for the aerobic bacteria, which break down the waste and then the submerged membranes filter out all soluble and particulate materials. This type of system could cost $7 - $20/gallon treated and is illustrated in Figure 6.

Figure 6 - Xpress™ MBR Packaged Plant (left); MBR treatment diagram (right)

4.2.4 Waste

The LEED® process focuses on the use of recycling[5] as a means to reduce waste within buildings. While this is effective, it does not present a holistic approach to waste management throughout the Park as it only covers the buildings. Waste reduction is the most effective approach to waste management and therefore a Waste Management Strategy should be developed which addresses all aspects of waste management including education, recycling provision, on-site waste processing and policy within the park. Determining policy within the park is a key consideration as this can control the kind of waste generated such as packaging and residues produced by concessions within the park.

[5] The composition of waste (residential and street basket) in New York shows that 35.38% of waste is recyclable. 2004-05 NYC Residential and Street Basket Waste Characterization Study.

4.2.5 Scenario 2 summary

Table 5 presents a summary of the Scenario 1 and its implications for Phases 1 and II.

Table 5 - Scenario 2 Summary

Utility	Strategies	Potential reduction from baseline	Phase 1 implications	Phase 2 implications
Energy	• Energy conservation which is 30% better than ASHRAE 90.1 2004	30%	Strategy applied throughout phase	Expansion of phase 1 approach
Waste	• Waste reduction strategy and policies • Recycling of all recyclable materials (30%)	30 -40%	Strategy applied throughout phase	Expansion of phase 1 approach
Water	• Water conservation measures in all facilities • No water used in comfort stations	20-30%	Strategy applied throughout phase	Expansion of phase 1 approach
Wastewater	• All comfort stations use composting toilets • Remaining wastewater is treated conventionally – septic tanks or municipal system	20-30%	Strategy applied throughout phase	Expansion of phase 1 approach

4.3 Scenario 3: Green design with some sustainable utilities

This scenario builds on the previous scenario by assuming that green design principles and all the other measures discussed in the scenario will be incorporated into the project design. This scenario suggests measures that make the project more sustainable by focusing on technologies that can supply some, but not all, of the required utilities and rely less on municipal services or private contractors. With some exceptions this scenario, still suggests that the park is still "grid" connected for all utilities.

4.3.1 Energy

After reducing the site energy load requirements by at least 20%, the Park should consider a variety of distributed power generation strategies that further reduce Fresh Kills Park's reliance on grid power. In most cases, these distributed sources will be backed up by the grid, primarily for reliability purposes, but also to sell any excess power to the grid. In order to receive grants for renewables, two-way metering is often a pre-requisite.

In evaluating different on-site technologies, ones that include the use of renewable sources, such as wind, solar and bio-energy, are the more sustainable options.

A significant strategy would be to change the power input to all the outdoor lighting, except the floodlights (sports fields), to PVs. The total outdoor lighting daily energy demand is approximately 25,500 kWh which is almost 50% of the entire energy demand for the park. The floodlights account for approximately 10,000 kWh or 40% of the lighting energy use. It is unlikely that PVs can power the floodlights as they require a high power input. All other lights could be powered by PVs, see 'solar power' below which would reduce total energy demand by a further 30% from Scenario 1.

4.3.1.1 Wind

As described in the October 2007 "*Applied Sustainable Energy Technologies*" memo, the Fresh Kills site offers moderate potential for the implementation of wind power as an energy source. According to the BQ Energy Wind farm feasibility study, the wind conditions are Class 2 to Class 3 at a 50 m elevation, which translates to speeds between 4.4 m/s and 7.0 m/s. While these conditions are not considered optimal, they are sufficient to develop a wind farm could generate as much as 35,000 MWh annually, or enough to supply 5,000 homes.

Based on a simple analysis of kWh generated on a yearly basis, grid dependence could be reduced an additional 10% with the installation of 4 mid-sized turbines, such as the Fuhrlander FL 250.

A portion of the power could be supplied by micro-turbines, which would only have a power output at the Fresh Kills site of around 1 kW. The cost of these turbines is approximately $30,000 per kW output, but they would still contribute to reducing overall demand from the main grid.

4.3.1.2 Solar Power

Solar electric and/or solar thermal power has the potential to meet a significant amount of Fresh Kills Park's load requirements via one of the following applications:

- Large photovoltaic (PV) panels that transfer solar radiation to electrical energy for building use
- Small PV panels for individual applications such as lighting and/or outdoor installations
- Solar thermal systems, which transfer solar energy to heat, which can then be used for warming water in restrooms, restaurants and other buildings

In order to supply an additional 10% grid load reduction after the implementation of sustainable building technologies, the Fresh Kills site would require approximately 1700 Watts of installed power generation capacity. This equates to 110,000 square feet of installed PVs. The useful life of a typical PV system is over 30 years.

The Park could potentially use photovoltaic (PV) panels to power lighting applications, particularly the lighting required for the more pathways and outlook areas of the park. PV powered lights also reduce the need for grid connection and therefore offer a cost saving. Roadways are not normally powered by PVs due to DOT code issues and light intensity. However, the technology has improved significantly and if there is a low light requirement, PVs can be used for areas like sub-urban roads and would be a perfect application for the Park which may not be subject to DOT lighting codes. Outdoor sports grounds would typically require high-powered lighting from high-intensity discharge lamps and therefore, PV is not appropriate for these applications. Specific products are referred to in the *Applied Sustainable Energy Technologies* report.

Solar Thermal involves the concentration of solar energy to provide hot water and, depending on the technology, low pressure steam. This is an attractive technology for heat and hot water required in remote locations. The savings generated by solar thermal is the result of the reduced need for boiler fuel.

4.3.1.3 CHP

Combined heat and power (CHP) is the concept of generating electricity on-site and capturing and utilizing the heat by-product as thermal energy. CHP is an attractive alternative to grid power because it offers customers the following benefits: 1) yearly energy savings and attractive paybacks 2) increased power reliability (not exposed to grid blackouts), but can use the grid as a backup and 3) a more environmentally friendly power option than grid-fed electricity. This environmental benefit results from the increased efficiency (fewer losses in converting fuel to power and heat) and lower emissions realized by CHP systems versus the grid. The typical efficiency of a CHP is 68%, with some new systems exceeding 90%[6]

Facilities with the most favorable cogeneration economics are those that have significant simultaneous electrical power and heating requirements. Although it is not yet known if Fresh Kills Park will fully meet this criterion, the park's projected needs for heating and hot water indicate that CHP could be a part of the overall power generation mix.

These systems are typically fuelled by natural gas. However, as outlined in Scenario 4, they are capable of being powered by renewable fuels, or fuels manufactured with renewable energy.

Reciprocating engines are generally the most cost effective generators, whereas gas microturbines are better for smaller load requirements and for "peak shaving". Peak shaving is where a CHP system operates parallel to the grid. At peak times when electricity prices are at their highest, an operator can run the generator and disconnect from the grid. .

4.3.2 Water

This scenario would still require potable water to be supplied throughout the site except to remote comfort stations which would be waterless. The main emphasis of this scenario would be to capture and reuse water on-site by implementing rain water harvesting technologies and greywater recycling into buildings. By combining these strategies with the water conservation methods discussed in Scenario 2, this should deliver a 50% saving in potable water demand from the municipal system. The technology for rain water harvesting and greywater recycling was discussed in the *Applied Sustainable Water and Waste Technologies* and this should be reviewed for more detail on the technology.

4.3.3 Wastewater

In this scenario, (Figure 7), composting toilets and waterless urinals will continue to be installed in remote areas throughout the park with a hand sanitizer to wash hands. In high density areas, low flow plumbing fixtures will be installed. NYC potable water could be delivered to these facilities though a HDPE pipeline.

Blackwater from all toilets will be discharged to a constructed wetland through an HDPE pipe system and any greywater potential (showers, sinks and faucets) could be recycled through a greywater treatment system and be used for toilet or irrigation water. This water does not have to meet potable water standards and will not require a disinfection system nor reverse osmosis filtration. However, disinfection is recommended and can be achieved through chlorination or UV disinfection.

Small-scale systems or large scale greywater recycling systems will be dependant on what is required. In addition, rainwater harvesting systems are recommended for this scenario and these systems also do not require disinfection. It is recommended that kitchen sinks install grease traps and filters to prevent any organic substances from entering the waste stream. More information can be found on these technologies in the *Applied Sustainable Water and Waste Technologies* report.

[6] America Council for an Energy Efficient Economy

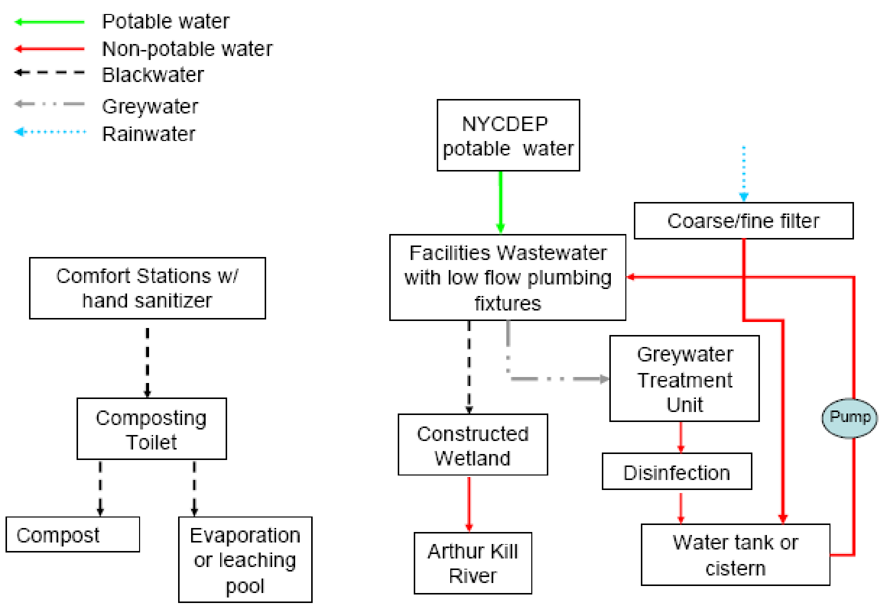

Figure 7 – 50% Sustainable wastewater flow diagram

4.3.4 Waste

In this scenario, composting is introduced to reduce the amount of waste going off site. The amount of organic waste varies between 30% and 70%. A 2005 study states an average value of approximately 40% for NY residencies and public trash cans.[7] If this were composted together with all the recyclables going offsite then up to 70% of waste would be diverted from landfill. Technologies for composting were suggested in the *Applied Sustainable Water and Waste Technologies* report and these should be reviewed. Without a detailed analysis it is not possible to specify a location but this should be reviewed in response to this report.

[7] 2004-05 NYC Residential and Street Basket Waste Characterization Study.

4.3.5 Scenario 3 summary

Table 6 resents a summary of the Scenario 1 and its implications for Phases 1 and II.

Table 6 - Scenario 3 summary

Utility	Strategies	Potential reduction from baseline	Phase 1 implications	Phase 2 implications
Energy	• Energy conservation which is 30% better than ASHRAE 90.1 2004 • All outdoor lighting is from PV • 10% of energy from wind • 10% of energy from PVs • Solar thermal technologies • Connect to the grid to sell surplus energy when possible	50-70%	• Energy conservation measures applied throughout. • North park visitor centers have PVs • All sports pitches have low energy fixtures • The following have 10% renewables from PVs and from wind: Creek landing café and market roof; South Park Sports barn and equestrian center • All roads and pathways are powered by PVs	Expansion of phase 1 approach. All roads and pathways are powered by PVs and all facilities have 10% renewables from PVs and from wind
Waste	• Waste reduction strategy and policies • Recycling of all recyclable materials (30% of total waste) • Composting system for all organics (40% of total waste)	70-90%	Strategy applied throughout phase. Location of composting plant to be determined	Expansion of phase 1 approach
Water	• Water conservation measures in all facilities • No water used in comfort stations • Greywater recycling and rain water harvesting (RWH) systems in all buildings or groups of buildings.	50%	Strategy applied throughout phase	Expansion of phase 1 approach
Wastewater	• All comfort stations use composting toilets • All comfort stations use composting toilets • Greywater recycling in all buildings • Remote facilities have their own constructed wetland treatments	50-70%	Strategy applied throughout phase. Creek Landing and Owl Hollow potentially have their own constructed wetlands	Expansion of phase 1 approach

4.4 Scenario 4: Towards totally sustainable utilities

This scenario presents solutions for the site to be totally sustainable, which for the purposes of this scenario is interpreted as being independent from the grid. This scenario also builds on the previous two scenarios, to bridge the gap to being totally sustainable. This scenario is more futuristic than the other scenarios as it considers technologies are currently at feasibility stage but are likely to be available when the Park is built.

In order to be grid independent the simplest approach would be to scale down the park development. Minimizing the amount of development would reduce the resource need. Although this is not addressed as part of this option, it is suggested that the following facilities should be revisited with a view to downscaling them or eliminating them from the program. These structures are:

- The multi sports barn
- The use of outdoor lighting at soccer and sports pitches
- The banquet hall
- The esplanade and market roof
- The tennis center
- Restaurant row at the point
- Creek Landing café and restaurant

4.4.1 Energy

As previously stated this scenario builds on the previous scenario which could potentially reduce the grid supplied energy requirement by more than 50%. To reduce this further, there are several options, or mixture of options, which this scenario presents but does not conclusively specify as there are too many unknown factors. If this scenario is chosen, the technologies are likely to change as they mature, become cheaper and more feasible.

The main options available are outlined in Table 7. The technology that holds greatest promise for this site is the fuel cell powered by hydrogen. This has the potential to be an emissions free technology which can generate significant volumes of power quickly (see section 4.4.1.2).

However, to get to 100% energy independence it is likely a mix of each of these technologies will be needed to suit specific applications.

Table 7 - Technology Options

Technology option	Main benefits	Main constraints
Increase PVs	Technology available and improving quickly	Expensive, intermittent and low power supply
Increase wind power	Technology available	Expensive, intermittent and low power supply and foundation issues.
Anaerobic digestion CHP unit	Utilizes waste source	Needs constant and high load of organic waste
Biomass CHP plant	Good power output. Could be powered by onsite coppicing	Needs constant and high load of organic waste, needs to be in constant operation
Fuel cells powered by hydrogen	Good power output Can respond quickly (when other renewables technologies have a low power output) Can adapt to fuel sources	Technology for making hydrogen onsite is in feasibility stage

All of these technologies were discussed in the *Applied Sustainable Energy Technologies* report, but further information is included on anaerobic digestion and hydrogen powered fuel cells below.

4.4.1.1 Anaerobic Digestion

Anaerobic Digestion is a biological process where organic waste, such as municipal solid waste (MSW), sewage sludge, green waste (grass clippings), and/or manure are placed inside a hydrolysis reactor and mixed with water. The mixed solution is then transferred to a buffer tank to adjust the pH and then pumped into a biogas reactor. The reactor then produces approximately 15 ft^3 of gas per pound of organic solids that is comprised of 60 to 80% methane. The byproducts from the process include a humus, or compost, that can be used as a fertilizer or soil enhancer and water, which can be recycled.

The methane from the anaerobic digester, if sufficiently cleaned, can be used as fuel for a CHP plant using a reciprocating engine or microturbine manufactured to handle biogas. In the U.S., these systems are typically found on farms for use with manure or at wastewater treatment plants for use with sewage treatment sludge.

4.4.1.2 PV/Hydrogen/Fuel Cell

A potential sustainable strategy that the Park may want to consider in the future is the use of solar power to produce hydrogen which, in turn, can be used as fuel for heating and on-site power generation purposes. While the prices of hydrogen fuel cells is currently quite high and the electrolyzers used to convert water into hydrogen require a significant amount of energy per therm produced, these costs will undoubtedly decrease over time. It is anticipated that by 2016, using PV to create hydrogen on-site (currently undergoing feasibility testing at various sites) could well be a viable technology from both technical and economic perspectives. The hydrogen created during the day from PV can be stored to allow back up when other renewables cannot deliver power. Having several units throughout the site would be a potential solution to get the site to 100% with zero emissions and 24 hour reliability.

4.4.2 Water

To get to 100% sustainability for water, the park would increase its rainwater capture and wastewater treatment. The significant difference with this scenario is that the rainwater and wastewater should be treated to potable standards to have a closed loop cycle for water use on-site. However, based on preliminary calculations and experience of other projects, it is unlikely that the Park could be 100% self sufficient for its water needs.

This type of water recycling is currently not allowed in the United States but has been proposed and practiced for remote regions throughout the country. It is also practiced in developing nations.

Various greywater treatment systems exist. Mechanical, chemical, anaerobic or aerobic treatments may alter the biological and chemical properties of the wastewater. The basic elements are a storage/treatment tank, filter, treatment and delivery system (integrated into building design). Scale is an option with these types of units. Smaller scale units could incorporate an energy intensive (up to 10kW for smaller systems) reverse osmosis (RO) unit, which uses pressure and membrane which prevent most bacteria and viruses from entering the system. These types of units require flush-out for maintaining the membrane efficiency but some RO units already have this feature installed. This RO system is recommended with the addition of disinfection to treat the greywater to potable standards in remote/lower volume areas around Fresh Kills. The disinfection process could be combined with UV process recommended for the enhanced rainwater harvesting process.

For a sustainable larger scale greywater discharge, a commonly used system incorporates a tank to allow separation and anaerobic treatment. This is then followed by an aerobic treatment where the effluent is filtered over a coarse medium sometimes with plant material which treats and aerates the material to a useable greywater standard. To get the water to potable standards, a disinfection process is necessary such as UV disinfection or chlorination. If UV disinfection is required a larger more expensive unit will be necessary. This type of system is recommended in the indoor sports facility, restaurants and other dense facilities at Fresh Kills.

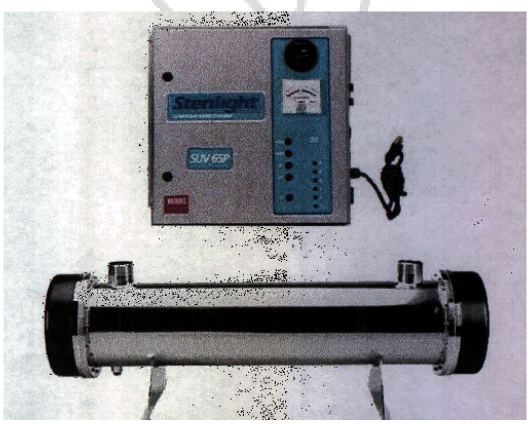

Figure 8 - UV treatment system

4.4.3 Wastewater

Distributing sewage pipelines throughout the park could create maintenance problems. For remote regions, comfort stations throughout the park will consist of composting toilets and waterless urinals. Hand sanitizer units will be installed for hand washing. High density areas throughout the park (the Point, Creek Landing, and the South Park facilities) could feature composting toilets and waterless urinals for all blackwater effluent. If composting toilets are not feasible in these facilities, an HDPE wastewater (blackwater) pipeline could be installed to follow the West Shore Expressway to allow the wastewater to be treated at a centralized constructed wetland. The constructed wetland effluent would be released to the Arthur Kill River.

The potable water source for bathroom sinks, kitchen sinks and showers could be from an enhanced rainwater harvesting or an enhanced greywater treatment system. All kitchen sinks will be required to have grease traps and filters to prevent any organic matter from entering the waste stream and producing blackwater. All grease and organic matter collected could be used in Park's composting areas.

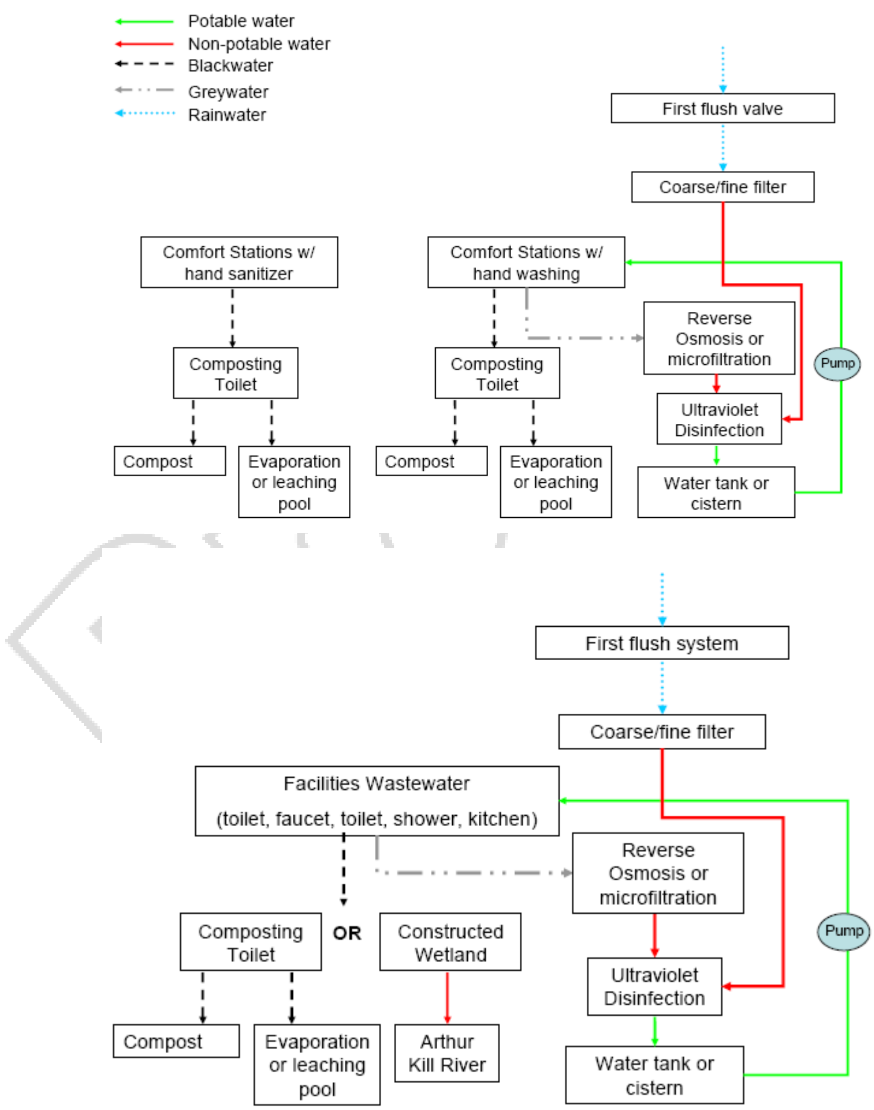

Figure 9 - 100% Sustainable wastewater flow diagram

4.4.4 Waste

The waste scenario cannot be improved on from scenario 3. The only option available is to use an anaerobic digester (mentioned above) which would serve the dual purpose of creating power and heat.

4.4.5 Scenario 4 summary

Table 8 presents a summary of the Scenario 1 and its implications for Phases 1 and II.

Table 8 - Scenario 4 summary

Utility	Strategies	Potential reduction from baseline	Phase 1 implications	Phase 2 implications
Energy	• Energy conservation which is 30% better than ASHRAE 90.1 2004 • All outdoor lighting is from photovoltaics (PV) • 10% of energy from wind • 10% of energy from PVs • Solar thermal technologies • Connect to the grid to sell surplus energy when possible • Remainder of energy comes from either: Anaerobic digester, Biomass CHP plant, or fuel cells, and/or mixture of other technologies	90-100%	• Energy conservation measures applied throughout. • North park visitor centers have PVs • All sports pitches have low energy fixtures • Creek landing café and market roof; South Park Sports barn and equestrian center all have fuel cells or other technology powering most of the facilities with 10% PV and solar. • All roads and pathways are powered by PVs	Expansion of phase 1 approach. Fuel cells, biomass generators and potentially more wind and PVs.
Waste	• Waste reduction strategy and policies • Recycling of all recyclable materials • Composting system for all organics • Organic waste used for anaerobic digester or CHP plant, or default to Scenario 3	70-90%	Strategy applied throughout phase. Location of composting plant, to be determined	Potential use of biomass generator for composting waste
Water	• Water conservation measures in all facilities • No water used in comfort stations • Greywater recycling and rain water harvesting (RWH) systems in	60-70%	Strategy applied throughout phase.	Expansion of phase 1 approach

Utility	Strategies	Potential reduction from baseline	Phase 1 implications	Phase 2 implications
	all buildings or groups of buildings. • All water including potable water is locally harvested or and treated to drinking water standards.			
Wastewater	• All comfort stations use composting toilets • All comfort stations use composting toilets • Greywater recycling in all buildings • All wastewater is treated on-site. Large unit to be established for treatment to potable standard.	100%	Strategy applied throughout phase. Creek Landing and Owl Hollow potentially have their own treatment centers	Expansion of phase 1 approach with another treatment center at the Point.

4.5 Financing Sustainability

Some options exist for the Park to finance some of its potential renewable energy installations. Other funding sources may also exist.

NYSERDA offers funding for energy efficiency, CHP and renewable energy projects for which Fresh Kills could be eligible. These initiatives are funded through System Benefits Charges (SBC) which is a supplement that New York customers pay towards energy efficiency.

Although NYPA does not fall under the regulatory jurisdiction of the Public Service Commission, the utility is currently exploring options to enter into long term power purchase agreements for renewable energy resources. The renewable energy purchases of NYPA could count toward the statewide Renewable Portfolio Standard (RPS) goal, which is to generate 25% of the state's energy from renewable sources by 2013. For example, NYPA has entered into long-term contractual agreements with two wind power developers for the purchase of 72 MW of renewable energy attributes.

In addition to Power Purchase Agreement (PPA) with renewable energy providers, NYPA has developed other programs to encourage the development of combined heat and power (CHP) and renewable energy projects in New York. In 2002, NYPA launched a major initiative to capture the energy from gases produced by solid waste or are byproducts of wastewater treatment. The Power Authority more than quadrupled funding – to $26 million – for its Landfill Gas Power Generation Program.

The Power Authority also ranks among the nation's leading developers of fuel cell technology, generating over 10 million kilowatt-hours through 2002 at the Yonkers facility and natural gas fuel-cell power plants at the New York Police Department's Central Park precinct, North Central Bronx Hospital and the New York Aquarium in Brooklyn.

As part of the NYPA Energy Services Program, NYPA finances the audit, design and installation for efficiency upgrades to energy using equipment. These projects have included the financing of CHP projects, including fuel cell installations throughout New York City.

A New York City Planning Board is being proposed as part of PlaNYC 2030 which would streamline all the public agencies and improve the facilitation of energy efficiency and renewable initiatives and their respective funding opportunities.

4.6 Other energy sustainability options

If the Park cannot achieve grid independence through energy conservation and renewables, other options are available to reduce their environmental and carbon footprint. These are:

- Green-e energy certificates; and
- Carbon offsets

The first option involves paying a marginal increase in energy costs for the knowledge that the park will be buying energy from a renewable source. The second option involves paying for a carbon saving that a project has made in another part of the US or the world. This is a more expensive option but projects can claim to be 'carbon neutral' if they buy enough credits that are equivalent to the parks potential carbon output.

5 Summary

This report presents four scenarios which combine options for that range from a conventional build scenario, 20% off grid, 50% off grid and being 100% off grid. It also presents an indication of how the Park might connect to utilities under a conventional build scenario.

Scenarios 2 and 3 present the most likely sustainability options, and are realistic considering the feasibility of current technology. Scenario 2 should be easy to implement as it can be achieved at no extra cost and may even be a prerequisite to City funding requirements. Given the costs of building on a constrained landfill site, it is likely that Scenario 3 will be similar in costs to installing conventional infrastructure, especially when operating costs over time are considered (or if LCA is used to assess costs).

Scenario 4 presents a much more difficult, although not unobtainable, option as the recommended technologies are not commonly used, proven, or currently meet with regulatory standards.

Recommending one scenario is difficult as the project is still at concept stage and will be phased-in over the next 30 years. However, in order to move the project forward it is likely that Scenario 3 presents the right mix for of an ambitious yet achievable implementation target when all things are considered. Especially as energy prices increase, existing technologies become cheaper and new technologies emerge.

As the project progresses it is likely that a fifth scenario will evolve that is somewhere between Scenarios 3 and 4 described in this report. This fifth scenario will use some of the technologies listed in scenario but will not reach 100% off grid.

Therefore, the recommendation going forward is to pursue Scenario 3 in this report but to include some of technologies from Scenario 4 as they become more feasible and the project develops.

Appendix A

Load Calculations