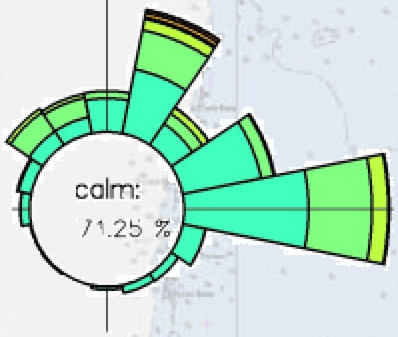
EIA REPORT



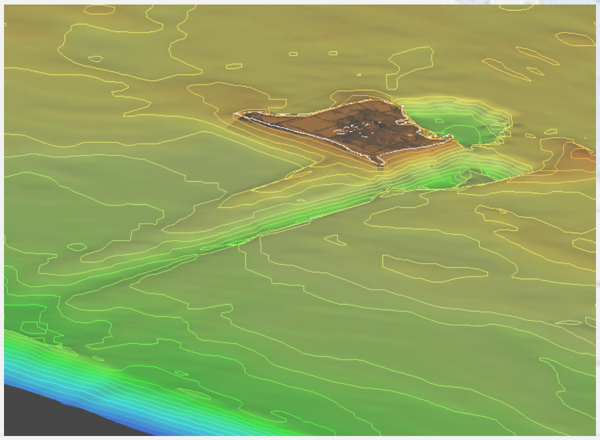
Ocean LNG

AES Ocean LNG, Ltd.

Environmental Impact Assessment

Prepared for:

Bahamas
Environment,
Science &
Technology
Commission



HALEY & ALDRICH

VOLUME I OF V

ENVIRONMENTAL IMPACT ASSESSMENT
OCEAN CAY AND THE BIMINIS, THE BAHAMAS

by

Haley & Aldrich, Inc.

for

AES Ocean LNG, Ltd.

File No. 27701-402
September 2002

EXECUTIVE SUMMARY

This Executive Summary provides an overview of the Environmental Impact Assessment (EIA) for the AES Ocean LNG, Ltd. (AES) project proposed for Ocean Cay and the Biminis, in The Bahamas. AES and the Government of the Commonwealth of The Bahamas are in the process of negotiating a Heads of Agreement; Article 6 of the current Draft of the agreement addresses environmental protection and safety and requires AES to prepare an EIA. This EIA was prepared to satisfy the evaluation criteria of The Bahamas Environment, Science and Technology (BEST) Commission, and has been developed in consultation with that agency and in accordance with applicable Bahamian regulations as well as in consideration of applicable State of Florida regulations, U.S. Federal requirements and World Bank Guidelines.

S.1 Introduction and Objectives

AES Corporation, the world's largest independent power producer, has conceived the proposed project in response to demands for natural gas in South Florida and the demand for alternative supplies of fuel and fresh water in The Bahamas. The project includes: a Liquefied Natural Gas (LNG) plant, a Liquefied Petroleum Gas (LPG) plant, a seawater desalination plant, two undersea pipelines to supply fresh water and natural gas from Ocean Cay to North Bimini (designated as AES Cay Express Pipeline), as well as Ocean Cay employee housing and associated facilities on South Bimini and a 610 mm (24 in) undersea natural gas supply pipeline (designated as the AES Ocean Cay Pipeline) to the U.S. Exclusive Economic Zone (EEZ) boundary. The Ocean Cay Pipeline will interconnect at the EEZ boundary with a new, 610 mm (24 in), undersea natural gas pipeline extending to delivery points in Broward County, Florida (Ocean Express Pipeline). The Ocean Express Pipeline will be constructed and operated by AES Ocean Express LLC, a U.S. affiliate of AES Ocean LNG, Ltd. The major project elements are shown on Figure 1.1. The construction of the project is expected to begin early in 2003 and will be completed within 36 months at an estimated cost of $550 million.

The specific objectives of the project are to:

- Locate, design and operate the project in a manner that results in minimal impact to the natural and socioeconomic environment of The Bahamas.
- Serve the growing demand for natural gas in Florida, which is projected to increase to 2.39 billion cubic feet (Bcf)/day by 2010, and to 4.54 Bcf/day by 2020;
- Create benefits for local economies through job creation and services;

- Serve the growing demand for alternative fuel supply and fresh water to the Biminis as well as other viable markets in the Bahamas;
- Distribute separated LPG to the US aftermarket by ship transfer; and
- Comply with all Bahamian regulations, with reference to appropriate U.S. Federal and State of Florida requirements, including constructing and operating the project to standards no less stringent than the regulations placed on a similar facility located in the United States.

AES has undertaken extensive studies of the natural and cultural resource environment on Ocean Cay and at locations along the proposed pipeline routes to define existing conditions in the project area. Starting in the Fall of 2001, AES initiated wave and weather studies, geophysical and video surveys of the underwater routes, and marine and terrestrial biological assessments. Archeological assessments, various engineering studies, and emissions modeling (air, water, noise) were performed in the area surrounding Ocean Cay and along the proposed pipeline routes. The methodology and results of these studies are presented and discussed within this EIA. The EIA also presents a detailed description of the project facilities, a summary of project construction methodologies, operational characteristics, an assessment of the potential environmental impacts, a description of environmental impact mitigation measures, an evaluation of alternatives to the project as proposed, and the framework for public review and comment on the project.

S.2 Project Description

The proposed LNG facility, discussed in greater detail in Section 2 of the EIA, will be located on Ocean Cay, situated approximately 30 km (18 mi) south of South Bimini island and 80 km (50 mi) east of the coast of Florida. The facility will receive LNG from ocean-going LNG tankers, store it, remove LPG from it, re-gasify it, and deliver natural gas via pipeline to Florida and North Bimini. LNG will be delivered to Ocean Cay in LNG tankers having various capacities, with the facility able to accommodate ships with storage capacities up to 160,000 m^3 (1 million bbl). In addition to the facilities located on Ocean Cay, an undersea pipeline will be constructed to deliver natural gas from Ocean Cay to the EEZ boundary with the U.S., and ultimately to a location near Fort Lauderdale, Florida by the Ocean Express Pipeline as described above. Two undersea pipelines will also be constructed from Ocean Cay to North Bimini, one to deliver natural gas and the other to deliver fresh water. The pipeline routes are shown on Figure 1.5. A small portion of the natural gas produced at the facility will be used as fuel for generating electricity to be utilized on-site.

The facility will also extract LPG from the LNG for export via ocean-going LPG tankers. The LPG tankers will have storage capacities ranging from 29,000 to 80,000 cubic meters (m^3) (182,000 to 500,000 barrels (bbl)). There are expected to be 150 LNG and 50 LPG shipments per year. The primary daily production of the LNG facility will be about 22.7 million cubic meters per day (mmcmd) (800 million cubic feet per day (mmcfd)) of natural gas via pipeline to Florida and up to 5,565 cubic meters per day (cmd) (35,000 bbl/day) LPG. The facility is also capable of delivering up to 77,000 cmd (2,719,210 cubic feet per day (cfd)) of natural gas and approximately 1893 cmd (500,000 gallons per day (GPD)) of fresh water to North Bimini.

Project improvements at Ocean Cay are discussed in detail in Section 2 and shown on Figure 1.4. A three-dimensional depiction of the completed facility is presented on Figure 5.5. Improvements that will support the tanker operations include expanding and deepening the existing approach channel and turning basin, installing berths, and providing loading and unloading facilities for the LNG and LPG terminals. Improvements that will support the LNG and LPG facilities will include: expanding the size of this man-made island, building two LNG storage tanks and one LPG storage tank, constructing LNG and LPG processing facilities, installing a once-through seawater system for process heat exchange, building a desalination plant and installing an electrical generating plant. Ancillary facility construction that supports the project will include airstrip improvements, a worker hostel on Ocean Cay and permanent employee housing on South Bimini.

S.3 Operational Framework and Procedures

As discussed further in Sections 2, 3 and 4, the project will be designed, constructed and operated in conformance with applicable environmental and safety requirements, and standards and guidelines set forth by The Commonwealth of The Bahamas, the World Bank, the U.S. Environmental Protection Agency and the State of Florida. An Environmental Management Plan (Section 10) has been created to describe the extensive environmental protection strategies that will be employed at the site, and to document planned emergency response actions in the unlikely event of spills or releases to the environment. The Environmental Management Plan addresses safe transfer and storage of liquid fuels and other petroleum products, as well as safe management of chemicals and waste products. It sets forth procedures for monitoring and documenting wastewater and stormwater discharges and air emissions. Contingency plans are also provided for possible natural hazards, such as hurricanes, and for accidental release of contaminants to the environment.

S.4 Baseline Description of the Project Environment

Ocean Cay is a man-made island, developed in approximately 1970, encompassing approximately 38 hectares (95 acres). Reports indicate that Ocean Cay was created adjacent to two small islets by using slurry dredging techniques, whereby sand and gravel were removed from the ocean floor and pumped to the eastern side of the islets. The island currently serves as a base of operations for an aragonite mining and processing facility.

The proposed 610 mm (24 in) diameter natural gas pipeline will depart from the western shore of Ocean Cay and extend westward to Florida along the route shown on Figure 1.1. Benthic habitats along the pipeline route in the survey area are primarily soft bottom/sand habitats with low diversity of benthic macrofauna. At some locations along the proposed route, there are small, isolated patches of seagrass and a few isolated patches of reef, rubble and soft corals. Marine habitats along the 60 mm (2 in) and 219 mm (8 in) diameter pipeline route to North Bimini are predominantly areas of soft bottom/sand with less than ten percent vegetative cover, though a small portion of the route is soft bottom/sand with up to fifty percent seagrass cover.

Section 4 of the EIA contains extensive information describing and characterizing the natural resources and existing environment of the project area. Data was collected in the areas of topography and climate, oceanographic conditions, land use, geology; hydrology; aquatic and terrestrial biology, air quality, parks, marine reserves and protected areas, and cultural resources.

S.5 Potential Environmental Impacts of the Proposed Project

As discussed further in Section 8, extensive evaluation and planning during the site selection and project design phase, as well as operational features and procedures discussed in Section 10, will be implemented by AES to avoid or minimize potential environmental impacts from the project.

The project will have minimal impact on the water and air resources. The majority of the potential impact on land resources is a direct result of the expansion of Ocean Cay from 38 to 112 hectares (95 to 276 acres) to accommodate both the proposed LNG facility, shore protection structures and the existing aragonite mining operations. The material for expanding Ocean Cay will come from the dredging operations needed to expand and deepen the approach channel and turning basin. The material not used for fill on Ocean Cay will be temporarily deposited in an excess materials shoal for future use by the mining operations. Proper construction techniques and other measures will help mitigate these potential impacts as outlined in section 2.4.1 . The project is not expected to impact the critical habitats of any endangered or at-risk species. Short-term impacts on certain human, institutional services are expected, however these are anticipated to be offset by the long-term positive economic benefits from the Project.

In addition to the development of LNG terminal facilities, the installation of the 65 km (40 mi) long pipeline between Ocean Cay and the EEZ boundary, and the 38 km (23.6 mi) long pipelines between Ocean Cay and North Bimini will result in a temporary disturbance to the ocean floor. Once construction of the pipelines, the approach channel and the turning basin is completed, no further disturbance is envisioned, and the ocean floor is expected to revert to its natural condition within an approximately 5 year period.

Various aspects of the proposed project will involve the withdrawal of 219,300 cmd (57,935,000 GPD) of seawater for heat exchange and desalination for potable water uses, most of which will be eventually discharged back to the ocean. Seawater discharge is expected to be 214,600 cmd (56,692,000 GPD), at a temperature approximately 15.5°C (28°F) cooler than the ambient seawater. AES modeled the discharge and discusses in detail the results of that model in Section 3.4.4 and Appendix H. In general, the mixing zone between the effluent and the ocean water will generally be confined to the approach channel and turning basin and will satisfy widely recognized national and international environmental standards and guidelines adopted for this project. No significant impact to the marine environment from the seawater discharge is anticipated.

The primary source of air emissions from the project will be the gas turbine generators and the LPG removal hot oil system heater. Modeling and evaluation of emissions due to operation of these facilities are discussed in detail in section 3.3 and 5.5. The modeling determined that maximum concentrations of contaminants in the environment will be less than the applicable significant impact levels. This conclusion was consistent for all pollutants and all averaging periods studied. Based on the modeling results, conducted in accordance with State of Florida and U.S. Environmental Protection Agency modeling guidance, compliance with applicable standards was demonstrated, and the facility will meet air quality requirements no less stringent than the regulations which would be applicable to a similar facility located within the U.S.

Modeling and evaluation of potential construction and operation noise emissions are presented in Section 4.2.2 and 5.6, respectively. This modeling determined that noise impacts will be negligible at neighboring inhabited islands, primarily due to the isolation of Ocean Cay from permanent residences and other sensitive receptors.

Visual impacts of the project were assessed using accepted viewshed evaluation procedures, including the development of renderings of proposed facilities from various perspectives and distances from Ocean Cay. Details of this assessment are presented in Section 5.8. No significant visual impacts are expected at the nearest inhabited island (Cat Cay).

No findings of significant land or subsea cultural resources (including shipwrecks) were made during the baseline studies; therefore, no impact to cultural resources is expected.

Socioeconomic impacts of the project are discussed in detail under Section 5.7. In general they will include the employment of workers for both project construction and operational phases. Project construction is expected to employ 450 people, who will be housed on temporary quarters barges or cruise ships anchored at Ocean Cay. During operations, approximately 25-35 people will be employed by the project on a full time basis, and new permanent housing to accommodate this increase in jobs will be constructed on South Bimini. The new housing represents a potential 5-8 percent increase in the population of South Bimini, and will increase needs for municipal services. Increases in demand for potable water and energy are anticipated to be offset by the new supplies of water and natural gas to the Biminis from Ocean Cay.

S.6 Environmental Management and Mitigation

The Environmental Management Plan (EMP), in Section 10, presents a series of measures that will provide for the mitigation of potential environmental impacts of project construction and operation. These include specific plans to address:

- Spill Prevention, Control and Countermeasures Plan (construction phase);
- Integrated Spill Control, Response, Pollution Prevention and Stormwater Management Plan (operational phase);
- Sediment, Erosion and Stormwater Control Plan;
- Contaminated Sediment and Soil Management Plan;
- Waste Minimization Plan;
- Marine Turbidity Monitoring Plan;
- Seagrass Mitigation Plan; and
- Marine Biological (Cetacean and Sea Turtle) Monitoring Plan;

Other Sections of the Environmental Management Plan address worker safety, marine safety, site and facility security and emergencies.

S.7 Evaluation of Alternatives

AES analyzed several potential project alternatives, as outlined in Section 8 of the EIA, during development of the Ocean Cay LNG project. Project alternatives considered include: no action and alternative project sites. Additional project alternatives were also considered including alternative pipeline routes to Florida and North Bimini, and technological alternatives for dredging, desalination, power generation, and heat exchange systems for LNG regasification. As described within the EIA, the proposed project best satisfies the overall economic, technical, environmental and safety criteria used to evaluate project alternatives.

S.8 Public Consultation

In consultation with BEST, AES will develop an appropriate approach for soliciting and adequately addressing relevant public concerns about the project. This approach, described in detail in Section 9 of the EIA, will include identifying and documenting the public consultation process to be used, and implementing methods for disseminating pertinent information about the project and obtaining public input, particularly from the Biminis, North and South Cat Cay, and the islands in the vicinity of Ocean Cay. BEST will take a lead role in the public consultation process, which will likely include, at a minimum, the organization and conduct of town meetings, open forums and consultations with community leaders, politicians, government officials, interest groups and other interested parties. AES will participate in all meetings with BEST, offer relevant technical assistance, and respond to questions and concerns. AES will be responsible for documenting the results of the public consultation process, and incorporating pertinent information into the final EIA documentation.

S.9 Project Benefits

Specific project benefits are discussed in detail in Section 1 of the EIA. To summarize, AES intends this project to provide the following short-term and long-term benefits to The Bahamas:

- Opportunities for skilled jobs and job training in the Family Islands both during the construction period (expected 3 years) and during the operational phase;
- A supply of natural gas to the Biminis allowing the Bahamas Electricity Corporation (BEC) the option to use natural gas in re-powering its existing diesel-fuel fired electrical generating units and for generating capacity expansions required to meet future demand growth;
- A supply of abundant fresh water to the Biminis for drinking and other uses;

- Additional government revenue expected from work permit fees and from annual business license fees;
- Additional revenue to local Bahamian suppliers for required products and services related to the construction and operational phases of the project;
- Affordable, new housing on South Bimini to support residence by permanent Ocean Cay employees and their families; and
- A potential improvement in the balance of trade with the United States, specifically by natural gas exportation.

In addition, during the three-year period of construction, a number of jobs for both skilled and unskilled workers will be created and it is anticipated to be an increase in demand for local goods and services.

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ACRONYMS AND ABBREVIATIONS

AES	AES Ocean LNG, Ltd.
API	American Petroleum Institute
AWWA	American Water Works Association
bbl	barrels
bcf	billion cubic feet
bcfd	billion cubic feet per day
bcm	billion cubic meters
bcmd	billion cubic meters per day
BEC	Bahamas Electricity Corporation
BEST	Bahamas Environment Science & Technology Commission
BOG	boil-off gas
CFR	Code of Federal Regulations
DCS	distributed control systems
DDC	deep dynamic compaction
EDI	electrodeionization
EEZ	Exclusive Economic Zone
EIA	environmental impact assessment
EPC	engineering, procurement, and construction
ESD	emergency shutdown system
FAC	Florida Administrative Code
FBE	fusion bonded epoxy
FGT	Florida Gas Transmission
FID	flameionization detector
FLDEP	Florida Department of Environmental Protection
FSRO	first stage reverse osmosis
ft	feet
gal	gallons
GEMSS	Generalized Environmental Modeling System
gpd	gallons per day
GTG	gas turbine generator
HP	horsepower
HSP	Health and Safety Plan
IWW	Industrial Wastewater Section
JSA	Job safety analysis
km	kilometers
kPa	kilopascals
kWh	kilowatt hours
LAT	Lowest astronomical tide
LBP	Length between perpendiculars
LFL	Lower flammability limit
LNG	Liquified natural gas
LOA	Length overall
LOTTO	Locked out/tagged out/tried out
LPG	Liquified petroleum gas
m^3	cubic meters
m^3/day	cubic meters per day

ACRONYMS AND ABBREVIATIONS
(continued)

MBM	marine biological monitoring
mi	miles
MLLW	mean lower low water
mmcfd	million cubic feet per day
mmcmd	million cubic meters per day
MMSCFD	million standard cubic feet per day
MSDS	material safety data sheets
MT	metric tons
MTU	mobile treatment unit
NFPA	National Fire Protection Association
NOAA	National Oceanic and Atmospheric Administration
NPL	National Physical Laboratory
NTU	nephelometric turbidity units
O.D.	outer diameter
OSCAC	Oil Spill Contingency Advisory Committee
OSHA	Occupational Health and Safety Administration
PAH	polynuclear aromatic hydrocarbon
PIANC	Permanent International Association of Navigation Congress
PIC	person in charge
PID	photoionization detector
PLC	programmable logic controller
POM	plant operations manager
ppm	parts per million
psig	pounds per square inch guage
PVC	polyvinyl chloride
RO	reverse osmosis
ROW	right-of-way
SECP	Sediment and Erosion Control Plan
SIGTTO	Society of International Gas Tanker and Terminal Operators
SOPEP	Shipboard Oil Pollution Emergency Plan
SSRO	second stage reverse osmosis
SVH	support vessel harbor
TDS	total dissolved solids
TLV	threshold limit value
TPH	total petroleum hydrocarbon
UPS	uninterruptable power supply
US	United States of America
USDOT	United States Department of Transportation
UV/IR	ultraviolet/Infrared
VOC	volatile organic compound

1.0 INTRODUCTION AND OBJECTIVES

This Environmental Impact Assessment (EIA) evaluates the potential environmental, social, economic, cultural, and natural impacts of the proposed AES Ocean LNG, Ltd. (AES) project, planned for Ocean Cay and the Biminis, The Bahamas. The project includes constructing and operating a Liquefied Natural Gas (LNG) terminal (inclusive of ship berthing and import facilities, storage tanks and regasification equipment), a Liquefied Petroleum Gas (LPG) removal plant (inclusive of storage, ship berthing and export facilities), an undersea natural gas supply pipeline to the U.S. Exclusive Economic Zone (EEZ) boundary (designated as AES Ocean Cay Pipeline), a seawater desalination plant and associated ancillaries, an undersea fresh water pipeline and a natural gas pipeline extending from Ocean Cay to North Bimini (designated as AES Cay Express Pipeline), and employee housing and associated facilities on South Bimini. Electric power will be supplied to the project by gas turbines to be constructed as part of this project and located on Ocean Cay. The location of the project elements are shown on the attached Figure 1.1. Dredging will be required to increase the size of the approach channel and turning basin. Dredged material will be utilized for the expansion of Ocean Cay and to construct shore protection structures to protect the investment in facilities from storm damage. The construction of the LNG terminal is expected to begin early in 2003 and will be completed within 36 months. The proposed construction schedule is shown on Figure 1.2. The estimated cost of the proposed project is $550 million.

This EIA has been prepared to satisfy the evaluation criteria of The Bahamas Environment, Science and Technology (BEST) Commission. AES and the Government of the Commonwealth of The Bahamas are in the process of negotiating a Heads of Agreement. Article 6 of the draft Heads of Agreement addresses environmental protection and safety and requires AES to prepare this EIA for the LNG Project and undersea pipelines. Applicable Bahamian, Florida State, U.S. Federal and World Bank Guidelines and regulations have been used as a reference in preparing this EIA.

The AES Corporation, the world's largest independent power producer, has conceived the proposed project in response to demands for natural gas in South Florida, as well as potential needs in The Bahamas. AES has undertaken extensive studies of the natural and cultural resource environment on Ocean Cay, North and South Bimini and at locations along the proposed pipeline routes to define the existing conditions of the area. Starting in the Fall of 2001, AES initiated wave and weather studies, geophysical and video surveys of the underwater routes and marine and terrestrial biological assessments. Archeological assessments, various engineering studies, and emissions modeling were performed in the area surrounding Ocean Cay, at areas of interest on North and South Bimini, and along the proposed pipeline routes. The methodology and results of these studies are presented and discussed within this EIA.

AES owns and operates energy facilities across the globe in a manner that provides significant benefits to the host nation along with minimizing impacts to natural, cultural and socioeconomic resources. Where significant potential construction or operational impacts from the proposed project have been identified, this EIA addresses proposed measures AES will implement to avoid or minimize their effects. This EIA also contains a discussion of alternative construction techniques and operating scenarios evaluated by AES during the conceptual design of the project and the justification, environmental and economic, for the selected alternatives.

This EIA is comprised of five volumes including:

Volume I Main text discussion of the project elements, baseline project area conditions, potential impacts during construction and operation, assessment of significance and permanence of the impacts, mitigation for significant impacts, discussion of alternatives considered and an environmental management plan for the project. Data tables are also included in Volume 1.

Volume II Maps and figures containing graphical materials referenced within this EIA.

Volumes III-V Appendices containing distinct technical studies conducted in support of the EIA.

1.1 Project Background

The Bahamas are comprised of approximately 700 islands and cays, spread over 259,000 km^2 (100,000 mi^2), with a land area totaling 13,942 km^2 (5,383 mi^2). Situated between 10 and 25 degrees North latitude, The Bahamas is placed almost entirely within the geographic tropics. The total population of the country is approximately 294,982 persons, of which 68% (200,588 inhabitants) reside on New Providence Island.

The Biminis, a Bahamian island group lying approximately 50 miles to the east of the Florida coastline, consists of two distinct islands (North and South Bimini) separated by a narrow ocean channel and a number of small cays. The Biminis total just under 26 km^2 (10 mi^2) in size. The majority of the population lives on North Bimini in Bailey Town. Alice Town, also on North Bimini, is the main tourist center where hotels, restaurants and fishing operations are found. An airport, marina, and hotel are located on South Bimini. Tourism, fishing and diving comprise the majority of The Biminis economic structure.

Ocean Cay, a man made island approximately 38 hectares (95 acres) in size, is located approximately 32 km (20 mi.) south of South Bimini. The closest populated island to Ocean Cay is located approximately 11.3 km (7 mi.) to the north (Cat Cay).

Ocean Cay currently supports an aragonite mining operation, as shown on Figure 1.3. The island has a more than 30-year history of industrial use. No permanent island residences have been established. An approach channel, turning basin, mining materials handling systems and other island support facilities are located at Ocean Cay. Due to its isolated location, historic industrial nature, and proximity to Southern Florida in the United States, Ocean Cay presents strong potential as a center for providing energy for both the Bahamas and Southern Florida.

The economy of The Bahamas is dominated by two sectors – tourism and banking. Tourism accounts for over 59% of the Gross National Product and provides about 79,000 jobs throughout the country, and attracts approximately 4.2 million visitors annually.

The current conditions regarding energy generation and supply in both The Bahamas and South Florida warrants the development of a new gas supply to augment the existing energy infrastructure. The Bahamas' electrical energy is derived from fuel oil, which accounted for 100% of electricity produced in 1998. Electricity production in 1998 was 1.34 billion kilowatt hours (kWh), with consumption set at 1.24 billion kWh. Currently there is no export or import of electricity. The Bahamas Electricity Corporation (BEC) is the national electrical utility.

The Biminis currently has insufficient water supplies to meet existing demand and projected growth. The lack of potable water represents an obstacle to further economic development of the Bimini islands. The proposed project will increase The Bimini's water supply by providing potable water through a pipeline from the Ocean Cay desalination plant. The proposed project will also provide a cleaner source of fuel and natural gas to North Bimini for electrical energy production through an underwater natural gas pipeline from the proposed Ocean Cay facilities. The supply of natural gas will be of sufficient capacity to serve future economic development and expansion in The Biminis. The proposed project will also create other significant benefits for The Bahamas, as described below in Section 1.4.

Similarly, the proposed project is designed to meet rapidly growing demands for additional natural gas capacity in South Florida. The demand for natural gas in Florida is expected to increase to 0.064 billion cubic meters per day (bcmd) (2.25 billion cubic feet per day (bcfd)) by 2010 and double to 0.119 bcmd (4.21 bcfd) by 2020. It is expected that over half of the increased demand will come from the southern portion of Florida. Natural gas and electrical distribution in Florida currently flows from north to south along the Atlantic coast to the Miami area. South Florida is a difficult market to service due to its population density and its location at the end of Florida's existing electricity and gas infrastructure. Siting additional gas transmission capacity in this region is difficult due the high population density, a lack of available port capacity and a lack of undeveloped land. The proposed AES project will provide a source of natural gas sufficient to supplement the existing supply and serve the anticipated increase in demand.

1.2 Project Objectives

AES has the objective of building, owning and operating an advanced energy services center located on Ocean Cay in The Bahamas. The specific objectives of the project are as follows:

- Respond to a need in the energy market place;
- Create benefits for local economies through job creation and services;
- Provide means of separating, storing, managing, and distributing a natural gas supply to Ocean Cay, The Biminis and Florida;
- Distribute separated LPG to the US aftermarket by ship transfer;
- Locate, design and operate all project facilities in a manner that results in minimal impact to the natural and socioeconomic environment of The Bahamas; and
- Comply with all Bahamian regulations, including constructing and operating the project to guidelines no less stringent than the regulations placed on a similar facility located in the United States.

1.3 Project Scope

The proposed project includes the construction of various facilities on Ocean Cay, as shown on Figure 1.4, a natural gas pipeline to Florida and a natural gas pipeline and a potable water pipeline to North Bimini, as shown on Figure 1.5. The proposed project components are summarized below:

- **LNG Terminal.** An LNG terminal will be constructed on the south side of Ocean Cay consisting of berthing facilities which will be designed and constructed to receive LNG from tanker ships;

- **LNG Storage.** LNG storage on Ocean Cay will consist of two 160,000 m^3 (1 million barrels (bbl)) LNG tanks within secondary containment berms constructed on the southwest of Ocean Cay. Associated compressor equipment will also be present;
- **LPG Terminal.** An LPG terminal will be constructed on the south side of Ocean Cay consisting of berthing facility used for loading ships for transport to market locations;
- **LPG Storage.** LPG storage on Ocean Cay will consist of a 40,000 m^3 (251,600 bbl) tank located within a secondary containment berm. The tank will receive LPG from the LPG removal operation for storage before shipment off the island;
- **LPG Removal Plant.** An LPG removal plant will be constructed adjacent to the LNG storage tanks. The plant will receive LNG from the tanks. Propane, butane and other gases will be removed from the LNG and piped to the LPG Tank for storage. Following the removal of the LPG, the LNG will be directed to the regasification and sendout system;
- **Natural Gas Pipeline to the EEZ Boundary.** A (610 mm (24 in) O.D.) undersea natural gas pipeline, designated as the Ocean Cay Pipeline, will be constructed extending from Ocean Cay to the Exclusive Economic Zone (EEZ) boundary between The Bahamas and the United States. At the EEZ boundary, the Ocean Cay Pipeline will interconnect with a new, 610 mm (24 in), undersea natural gas pipeline extending to delivery points in Broward County, Florida. This pipeline will provide 22.7 million cubic meters per day (mmcmd) (800 million cubic feet per day (mmcfd)) of delivery capacity;
- **Natural Gas Pipeline to North Bimini.** A 60 mm (2 in) diameter natural gas pipeline, designated as the Cay Express Pipeline, will be installed from Ocean Cay to North Bimini to provide 77,000 cubic meters per day (cmd) (2,719,210 cubic feet per day (cfd)) of natural gas. The natural gas pipeline will terminate at the BEC facility located on North Bimini;
- **Regasification and Sendout System and Ancillary Structures.** A regasification and sendout system, and ancillary support structures will be constructed on Ocean Cay. The ancillary structures will include an auxiliary equipment building, an administration building, a warehouse, and a compressor building. Auxiliary systems will include fire fighting equipment and leak detection systems;
- **Ancillary Electricity Generation.** Three 15-MW natural gas-fired turbine generators will be installed on Ocean Cay to generate electric power for the project facilities load, which is expected to be 30 MW, which will require 2 units in operation at all times. The third unit will serve as a

standby unit. One of these units will be dual fuel fired with gas and fuel oil for reliability purposes; and

- **Desalination Plant.** A 1,893 cmd (500,000 GPD) capacity desalination unit will be constructed and operated on Ocean Cay, for potable and process water supply. The desalination unit will be a two- stage reverse osmosis (RO) unit. Potable water will be supplied to North Bimini through a 219 mm (8 in) nominal diameter pipeline following the same route as the natural gas pipeline.

The following components will be constructed and operated to support the energy facilities:

- **Construction Housing.** Temporary barge or ship housing will be provided at Ocean Cay during the construction phase. Also during the construction phase, temporary living arrangements will be located at The Biminis for selected supervisors and professionals;
- **Permanent Housing.** Permanent housing will be constructed at South Bimini for employees during the operational phase. Hostel accommodations will also be provided on Ocean Cay for short-term shift assignments. An emergency shelter will be provided on Ocean Cay for use during storm events;
- **Ocean Cay Expansion.** The current footprint of the Ocean Cay will be expanded to accommodate the proposed facilities. Ocean Cay will be expanded through use of dredged materials removed from the approach channel and turning basin. The elevation of the island will be raised, and shore protection will be constructed to protect the facilities from storm events;
- **Channel Widening and Turning Basin Expansion.** The existing approach channel and turning basin will be expanded and deepened to accommodate LNG/LPG tanker vessels. Channel widening will extend to the east of the island to accommodate a dedicated berth for the mining operations;
- **Support Vessel Harbor.** A support vessel harbor will be constructed on the southeastern portion of Ocean Cay. The harbor will be designed to accommodate equipment barge deliveries, tug boats, small support vessels, and fuel oil deliveries to the operation. Fueling facilities for the tug boats and small support vessels will be provided. The support vessel harbor will also be utilized by a ferry, which will transport workers between The Biminis and Ocean Cay;
- **Other Marine Structures.** Groins, seawalls and related protective structures will be constructed at Ocean Cay to protect the facilities and approach channel from storm damage; and
- **Airstrip Improvements.** Improvements to the airstrip runway on Ocean Cay will be completed including increasing its length and landing capacity. A heliport will be added to the island to support helicopter transfers.

1.4 Project Benefits

AES intends this project to provide the following short-term and long-term benefits to The Bahamas:

- Opportunities for skilled jobs and job training in the Family Islands both during the construction period (expected 3 years) and during the operational phase;
- A supply of natural gas to The Biminis allowing the generation of cleaner, less expensive and more abundant electricity to support current and future needs;
- A supply of abundant fresh water to The Biminis for drinking and other uses;
- Additional government revenue expected from work permit fees and from annual business license fees;
- Additional revenue to local Bahamian suppliers for required products and services related to the construction and operational phases of the project;
- Affordable, new housing on South Bimini to support residence by permanent employees and their families; and
- A potential improvement in the balance of trade with the United States, specifically by natural gas exportation.

AES has assessed the potential impacts of the proposed project activities in the remainder of this document. The project benefits are also explored further in the discussion of socioeconomic impacts found in Section 5.7.

1.5 Overview of Siting Process

AES has sited the proposed facilities on Ocean Cay through a process that is described more thoroughly in the alternatives section of this EIA (Section 8). Generally, the location on Ocean Cay was selected for reasons including:

- Its proximity to Florida and the feasibility of constructing a pipeline to the United States for natural gas delivery to the Southern Florida market;
- The existence of an approach channel and turning basin that require moderate expansion to accommodate the LNG/LPG shipping vessels;
- The existence of an AES subsidiary operation interested in continuing the current mining operation;
- The historical industrialized land use of Ocean Cay;
- The lack of permanent residents residing on Ocean Cay that may be disturbed or displaced during construction or operation;

- Ocean Cay's distance from the nearest population centers reduces the potential for impacts on existing populations, Cat Cay is located 11.3 km (7 mi.) across water. The Biminis are located approximately 32 km (20 mi.) to the north; and
- The significant potential benefits to the Commonwealth of The Bahamas from the proposed project.

AES is committed to this project and has demonstrated the ability to develop energy facilities across the globe that are operated and maintained to the guidelines required by the local governments, industry standards and AES corporate standards.

2.0 PROJECT DESCRIPTION

2.1 Project Location Description

This EIA evaluates the potential environmental, social, economic, cultural, and natural impacts of the proposed AES project, planned for Ocean Cay and the Biminis, The Bahamas. For the purpose of this EIA, the term “project boundary” refers to all temporary construction and permanent work spaces, including the rights-of-way, storage yards, staging areas, vessel anchor areas, and any additional work spaces required to construct or operate the project, as described further in Section 3.

As described in Section 1, the LNG facility will be constructed on Ocean Cay which is located at approximately 25^{O} 25.2’ N, 79^{O} 12.4’ W in The Bahamas, approximately 80.5 km (50 mi) east from the Florida coastline. The project also includes the construction of a co-located 38.4 km (23.9 mi), 60 mm (2 in) natural gas pipeline and a 219 mm (8 in) potable water pipeline to be installed from Ocean Cay at 25^{O} 25.3’ N, 79^{O} 12.4’ W to a landfall on the west shore of North Bimini at 25^{O} 43.8’ N, 79^{O} 17.8’ W, as shown on Figure 1.5. From the North Bimini landfall location the co-located 60 mm (2 in) and 219 mm (8 in) pipelines will extend onshore to the Queen’s Highway and will be installed beneath the roadway for approximately 265 m (870 ft), terminating at the existing BEC facility.

Permanent housing to support the operational phase will be constructed on South Bimini for operators and supervisors of the facilities planned for Ocean Cay as shown on Figure 1.5.

A 64.7 km (40.2 mi) long, 610 mm (24-in) O.D. natural gas pipeline will be constructed from Ocean Cay at N 25^{O} 25’ 20.344” W 79^{O} 12’ 33.294”to the EEZ boundary at N 25^{O} 41’ 27.419” W 79^{O} 42’ 35.307” as shown on Figure 1.1. The pipeline will extend from the U.S. Exclusive Economic Zone (EEZ) boundary to make landfall in Dania Beach, Florida. The pipeline will extend approximately 10 km (6.2 mi) onshore to a tie in point with the existing Florida Gas Transmission (FGT) system.

2.2 Site Description

For the purposes of this EIA, the project has been divided into four components. These four components are:

- Ocean Cay and the surrounding waters;
- The natural gas pipeline route from Ocean Cay to EEZ boundary;

- The co-located natural gas and potable water pipelines route from Ocean Cay to North Bimini; and
- Permanent housing located on South Bimini.

A brief description of each of the four site components is presented below.

2.2.1 Ocean Cay

Ocean Cay is located within a linear north-south oriented string of cays bounded by the Biminis on the north and South Riding Rock to the south. This string of small islands lies on the northwestern edge of the Great Bahama Bank.

The island is primarily a man-made landmass built in approximately 1970, as a base of operations for an aragonite dredging and processing facility. The island was constructed adjacent to two small "islets", portions of which can still be seen on the west flank of the island. The island was reportedly constructed primarily using slurry dredging techniques, whereby sand and gravel were removed from the ocean floor and pumped to the eastern side of the islets. The island is currently trapezoidal-shaped, encompassing approximately 38 hectares (95 acres), as shown on Figure 1.3.

2.2.2 Proposed Natural Gas Pipeline to the EEZ Boundary

The proposed 610 mm (24 in) natural gas pipeline will depart from the western shore of Ocean Cay and extend to the EEZ boundary along the route shown on Figure 1.1. The baseline conditions along the proposed pipeline route are discussed in Section 4. Both the construction and permanent rights-of-way will be 61 m (200 ft) in width with a total length of 64.7 km (40.2 mi). The total area occupied by the submerged portions of the corridor will be approximately 395 hectares (976 acres).

The pipeline route crosses six distinct geomorphic provinces: the Ocean Cay Shelf, Bahamas Shelf Break, Upper Bahamas Slope, Lower Bahamas Slope, the Bahamas Margin, and the Florida Straits.

The Ocean Cay Shelf is carbonate sand covered limestone. Reef and numerous pinnacles are prevalent towards the shelf break. The Bahamas Shelf Break is characterized by slopes of generally 35-40 degrees, in many cases along the steepest areas reaching slopes up to 55 degrees. Probable carbonate sands overlie the seafloor. Outcrops with seafloor expression up to 4 m (13.1 ft) are numerous at the crest of the slope break. The Upper Bahamas Slope is a gentler slope of approximately 8 to 15 degrees. Numerous braided surface flows emanate in this region continuing onto the Lower Bahamas

Slope. The Lower Bahamas Slope comprises the farthest-reaching extensions of the shelf break region with a gentle slope.

The Florida Straits is a deep valley, which is approximately 80.5 km (50 mi) wide. Water depths of the Straits range from 700 m (2,296 ft) off West Palm Beach to 1,750 m (5,741 ft) off of Key West. The seafloor profile is generally planar or convex upward. A large sediment bank forms a ridge through the Straits. The strong Gulf Stream and Florida Currents contribute to the topographic relief and prevent sediment build up in the high-energy regime of the valley. North-south trending ridges exist along the eastern margin of the Florida Straits. These ridges have been found to be lithified biohermal mounds or "lithoherms" at water depths of 600 to 800 m (1,969 to 2,625 ft). Water depths along the proposed pipeline route range up to 868 m (2,848 ft) Mean Lower Low Water (MLLW).

2.2.3 Proposed Natural Gas Pipeline and Potable Water Pipeline to North Bimini

The proposed co-located 60 mm (2 in) natural gas pipeline and 219 mm (8 in) potable water pipeline to North Bimini will depart from the northwestern shore of Ocean Cay (Figure 1.5) and extend north along the east side of Victory Cay, the Cat Cays, and Gun Cay on the Bahamas Shelf for approximately 38.4 km (23.9 mi). The proposed route extends to the northeast past Turtle Rocks to the west side of North Bimini along the Bahamas Shelf Break prior to its landfall on the western coast of North Bimini, as shown on Figure 1.5. The area is characterized by shallow tropical waters (depths up to 7.5 m (24.6 ft)) to the east of the islands, and a relatively steep drop off to deeper waters (up to 14 m (45.9 ft) as the pipeline route passes to the west of North Bimini. The baseline biological conditions along the pipeline route are described in Section 4.

2.2.4 Bimini

Located 50 miles from Florida, Bimini is made up of two main islands, North Bimini and South Bimini. The majority of the population resides on North Bimini. South Bimini is occupied by an airport, marinas, private residents and a hotel. The proposed pipeline landfall on the western coast of North Bimini, is predominantly a sandy beach area. The onshore portion of the project route will travel east within the Queen's highway in the existing power line right-of-way (ROW) as it proceeds to the interconnection point at the BEC facility.

2.3 Proposed Project Facilities and Required Infrastructure

2.3.1 Proposed Facilities

For the purposes of this EIA, the project has been organized into the following components.

- Island Expansion;
- LNG/LPG Terminal;
- LNG/LPG Ancillary Facilities;
- Pipelines; and
- Housing.

The facilities proposed for each of the project components are described below.

2.3.1.1 Island Expansion

To accommodate the proposed facilities and to provide more extensive shore protection, the project includes the expansion and upgrade of Ocean Cay. The proposed expansion includes an increase in the area of the island, as well as an increase in site elevation grades, as shown on Figure 2.1. The island expansion will accommodate the proposed LNG receiving terminal, a LPG export terminal, a Support Vessel Harbor (SVH), LNG and LPG tanks and ancillary facilities.

The aerial extent of Ocean Cay will be increased by approximately 74 hectares (181 acres) as shown in Figure 1.4, which illustrates the existing island area and the proposed new footprint of the island. The dredge spoils from the channel widening and turning basin expansion, as discussed below, will be utilized for fill. The island will be expanded to the north approximately 400 m (1,312 ft) to accommodate a larger runway as well as hostel facilities for employees working on Ocean Cay. The island will also be expanded to the west approximately 240 m (787 ft) to accommodate the proposed LNG and LPG storage tanks, containment dikes, a desalination plant and associated equipment, and shore protection structures, as shown on Figure 1.4. The total expansion will increase the aerial extent of the island to 112 hectares (276 acres). The expansion will include the placement of 966,081 m^3 (1,263,583 yd^3) of material for cobble beaches, and 3,857,802 m^3 (5,045,815 yd^3) of fill for upland areas, totaling 4,823,883 m^3 (6,309,401 yd^3) of fill placement for the island expansion.

The southeastern portion of the island will remain at its current grade. The northern portion of the island in the vicinity of the proposed runway will be raised in elevation to approximately 5.5 m (18 ft) above mean lower low water (MLLW), and the southwestern portion of the island will be raised to approximately 6.0 m (19.7 ft) above MLLW, as shown in Figure 2.1. The elevation grade will be raised for flood protection purposes.

A. Site Preparation

Site preparation activities will include mobilization to Ocean Cay of the temporary construction housing, sanitary services and other support vessels required during the construction phase of the project. Site preparation activities include the following:

- Anchorage or mooring of quarters barges or cruise ship for temporary housing;
- Set up of the construction worker sanitary systems on Ocean Cay;
- Anchorage or mooring of the construction service vessels such as the fuel barge and vessel tender at the support vessel harbor;
- Anchorage or mooring and placement of intake and outfall structures for the portable RO desalination barge;
- Placement of temporary sheet pile bulkheads at two locations on the east side of Ocean Cay for the barge mounted concrete batch plant and the barge loading location for the formed caissons;
- Anchorage or mooring of the barge mounted concrete batch plant and the aggregates barge adjacent to the batch plant; and
- Placement of the portable fuel storage tanks adjacent to the support vessel harbor.

Quarters barges and/or a cruise ship for housing of construction personnel will be anchored or moored along the east side of Ocean Cay. A gangway or temporary bridge will be installed between the temporary housing and the shore. The vessels and gangway will be located in an area that will be dredged first during the expansion of the approach channel and the turning basin.

Sanitary systems required to support the construction workers while on Ocean Cay are described in Section 2.3.1.1. Incinerating toilets will be constructed on Ocean Cay at selected locations during the construction phase. The incinerating toilets will not discharge wastewater, and therefore no measurable impact is anticipated to the surrounding terrestrial or marine environment.

A concrete batch plant barge will be moored on the east side of Ocean Cay to provide concrete for construction purposes. An aggregates barge will be placed adjacent to the concrete batch plant to supply the batch plant. As the aggregates barge empties, it will be replaced by a fully loaded barge as required by the concrete production schedule. In order to provide a docking location for the concrete batch plant, temporary sheet pile bulkheads will be placed north of the Support Vessel Harbor, as discussed in Section 2.4.1.1.

Temporary fuel storage tanks with integral secondary containment systems will be placed onshore and adjacent to the support vessel harbor as shown on Figure 1.4. These tanks will be delivered new and empty to the site and placed by crane operators. Management of the tanks will follow procedures in the Integrated Spill Control Response, Pollution Prevention, and Stormwater Management Plan, discussed in Section 10.

The construction phase RO desalination unit, as described in Section 2.4.1.1, will supply water to the concrete batch plant and for other construction phase needs. During construction, potable water for personnel will be supplied from an outside source (or vendor)

Marine structures previously utilized by the mining operation will be removed prior to the initiation of dredge activities in the area south of Ocean Cay. These activities will be performed under Crown Lease #959 issued by The Department of Lands and Surveys, and therefore are not evaluated in this EIA.

B. Dredging

Proposed dredging activities will include deepening and widening of the existing turning basin and approach channel. The approach channel will be increased in depth to 15.0 m (49.2 ft), and the turning basin will be deepened to 14.5 m (47.6 ft). The lateral limits and depths of the proposed dredging activities are shown on Figure 2.2. Spoils from the dredging operations will be pumped to Ocean Cay, dewatered in settling basins, then used to expand the existing island and raise the island grade as shown on Figure 2.1.

Excess dredge spoils, beyond those required for the proposed island expansion, will be used to form a shoal south of the enlarged approach channel, as shown on Figure 2.2. At Ocean Cay, geotubes, or equivalent, will be used to stabilize/contain the temporary stockpile of excess dredged material. Geotubes are large tubes fabricated using woven geotextile material, which are permeable fabrics able to hold back materials while allowing water to flow through. The standard geotube is made of woven geotextile sheets of widths of 4 to 6 m (13 to 20 ft) sewn along the edges with inlets and outlets sewn at regular intervals. Geotubes will be installed along the perimeter of the excess dredge material stockpile area. The perimeter dike will be constructed by stacking geotubes on top of one another. It is expected that the top geotubes will have a nominal elevation of +2.0 m (6 ft) MLLW. The geotubes will be removed once the excess dredge material has been harvested as part of the mining operations at Ocean Cay.

The channel widening and turning basin expansion requirements are described below. Dredging and island expansion techniques are described in detail in Section 2.4.1.1.

B.1. Channel Widening

The extent of the proposed channel widening was determined based upon a selected design vessel. The design vessel and the resulting channel width and depth are discussed below.

B.1.1. Design Vessel

The LNG berth will be designed to accommodate the dimensional characteristics of the 98th percentile of all existing LNG tankers greater than 18,000 m^3 (113,216 bbl) in capacity, the largest of which is 138,000 m^3 (867,993 bbl). It is anticipated that this berth will be suitable for tankers up to 160,000 m^3 (1,000,000 bbl), when such tankers are placed in service in the future. The design ship dimensions were determined using the 2002 edition of Clarkson Register, as summarized below in Table 2-1.

Table 2-1

Preliminary Characteristics of LNG Design Vessels

Main Parameters	Preliminary Values
Length Overall (LOA)	297.5 (m) (976.1 ft)
Length Between Perpendiculars (LBP)	290.0 (m) (951.4 ft)
Breadth	48.2 (m) (158.1 ft)
Loaded Draft	12.2 (m) (40.0 ft)

The LPG berth is expected to accommodate LPG vessels ranging in size from 29,000 m^3 (182,000 bbl) to 80,000 m^3 (500,000 bbl). The design ship dimensions for LPG ships were also determined using the 2002 edition of Clarkson Register, as summarized below in Table 2-2.

Table 2-2

Preliminary Characteristics of LPG Design Vessels

Main Parameters	29,000 m^3 Vessel	80,000 m^3 Vessel
LOA	178.0 (m) (584 ft)	225.8 (m) (740.8 ft)
LBP	165.0 (m) (541 ft)	218.4 (m) (716.5 ft)
Breadth	26.1 (m) (85.6 ft)	36.4 (m) (119.4 ft)
Loaded Draft	10.0 (m) (32.8 ft)	12.5 (m) (41.0 ft)

B.1.2. Width

At Ocean Cay, the required width of the approach channel is determined by the beam of the largest vessel expected to call at the terminal. Two sets of guidelines – promulgated by the Society of International Gas Tanker and Terminal Operators (SIGTTO) (1997) and the Permanent International Association of Navigation Congress (PIANC) (1997) - were used in the preparation of the preliminary layout for the approach channel.

The SIGTTO guidelines stipulate the minimum channel width requirement irrespective of site conditions. The guidelines recommend that the width of the approach channel should be 250 m (820 ft), a minimum of five times the beam of the design vessel.

Considering measured environmental conditions such as the wave climate, currents, and meteorological conditions (e.g. winds, temperatures, and precipitation) as described in the MetOcean report (Appendix A), as well as the results of fast-time simulations performed for this project (Appendix B, Navigation Study), a 250 m (820 ft) wide channel, as recommended by SIGTTO (1997), was determined to be appropriate for the approach channel into Ocean Cay.

B.1.3. Minimum Depth

The required channel depth is a function of the draft of the largest vessel expected to call at the terminal, vertical ship motion due to wave action, squat, keel clearance, dredging tolerances, and depth sounding accuracy. The guidelines of the Permanent International Association of Navigation Convention (PIANC) (1997) suggest using a depth to draft ratio of 1.10 to 1.15 for protected approach channels. For channels subject to wave action, a depth to draft ratio of 1.3 or more may be used.

Wave induced motions of ships vary significantly for different ships depending on the wave and swell conditions to which they are exposed. For the purposes of this EIA, it is assumed that a vessel is permitted to transit the approach channel only when the significant height associated with waves in the approach channel is less than 2.0 m (6.5 ft). This threshold has been selected based on the ability of tugboats to effectively and safely escort a large vessel. Using British Standard Code of Practice for Maritime Structures (PART 1), the mean depth of ship motions due to wave action have been estimated at 0.5 m (1.6 ft).

Squat is the tendency of a vessel to sink and trim when underway. The depth is highly dependent on the ship's speed and is accentuated in shallow water. Squat values were estimated using a methodology developed by the National Physical Laboratory in London (NPC, 1975) and Römisch (1989). A conservative squat estimate of 0.5 m (1.6 ft) will be used in the estimation of minimum channel depth during final design.

The required under keel clearance is typically between 1.0 to 1.5 m (3.2 to 4.9 ft) for LNG and LPG ships. Typically, the dredging tolerance is set between 0.1 to 0.5 m (0.3 to 1.6 ft) and the sounding accuracy is normally approximately 0.25 m (0.82 ft) (Agerschou, et al., 1983). According to tide tables provided by National Oceanic and Atmospheric Administration (NOAA), the mean tide range is 0.7 m (2.3 ft) and the lowest recorded tide is 0.1 m (0.3 ft) below chart datum, indicating the tides at the site are mild. The required channel depth after considering the combined effect of draft, squat, wave induced motion, under keel clearance, dredging tolerance, sounding accuracy, and tide is approximately 15 m (49 ft) MLLW.

B.2. Turning Basin Expansion

The turning basin will be designed to allow the safe turning of a fully loaded design LNG or LPG carrier with tug assistance. The required turning basin diameter, minimum water depth and associated sedimentation issues are discussed below.

B.2.1. Diameter

Applying SIGTTO (1997) guidelines a preliminary turning basin diameter of 600 m (1968 ft) has been selected.

B.2.2. Minimum Water Depth

As squat is not expected to be significant in the turning basin due to slow ship speeds, the turning basin will be dredged to a depth of 14.5 m, (47.6 ft) MLLW.

B.2.3. Sedimentation Issues

According to discussions with the current Ocean Cay bulk terminal operators, the existing approach channel does not experience significant sedimentation. Additionally, based upon available data showing the sediment transport patterns at the site, it is expected that sedimentation will not occur to an extent that would interfere with vessel traffic. Thus, no allowances have been made for potential sedimentation of the approach channel and the turning basin in the estimation of minimum water depths. Nevertheless, should there be a need, maintenance dredging operations may be carried out utilizing equipment permanently stationed at the island as part of the aragonite mining operations.

C. Site Fill and Soils Improvement

Reclamation of land at Ocean Cay will be achieved by placing dredge spoils (from the approach channel and turning basin expansion) in areas adjacent to the existing island. Filling areas and extents are shown on Figure 2.2. Expansion of the island will involve the pumping of dredged material from the cutter head of the dredge to spoils settlement/dewatering areas on Ocean Cay. These areas will be sized to minimize the release of fine materials into the sea. Proper sizing of the settlement areas will allow the turbidity to be minimized in the effluent. The non-turbid effluent from the settling areas will be discharged into the waters surrounding Ocean Cay, as described further in Section 2.4.1.3.

Site fill and soil improvement techniques proposed for the project include the use of Deep Dynamic Compaction (DDC), drilled on-land piles, drilled offshore piles, interlocking pre-cast concrete retaining walls, steel sheet pile retaining walls, stone columns, and preloading. These site fill and soil improvement techniques are discussed in Section 2.4.1.3.

D. Shore Protection

A comprehensive shore protection system will be provided for the perimeter of Ocean Cay in order to prevent erosion and provide adequate protection against coastal flooding. These facilities are being designed for wave and storm surge conditions associated with the nominal 100-year frequency hurricane event.

The preliminary proposed layout is shown schematically on Figure 1.4 and consists of the following major elements:

- North and west coasts – artificial gravel beaches with shore protection structures (artificial headlands and T-shaped groins, or equivalent);
- East coast (north of SVH and South of Runway) – rock revetment or equivalent; and
- South coast (LNG and LPG berths) and SVH – concrete caissons, steel sheet pile wall, or equivalent.

Shore protection for the west coast of Ocean Cay requires special consideration because of the critical upland facilities that will be located immediately adjacent to the reclaimed shoreline. These facilities include the LNG and LPG storage tanks and containment dikes and other ancillary facilities. A protective gravel beach system has been selected as the preferred shore protection structure in lieu of a conventional seawall, as discussed in Section 8.

The beach will be created using material dredged from the approach channel and turning basin, as discussed in Section 2.4.1.2.D. This material will consist primarily of limestone rock that will be dredged using cutter head suction dredge.

Terminal headland structures and intermediate groins will be needed in order to maintain the gravel beach and prevent excessive erosion losses due to long-shore transport. The T-groins and the terminal structures will be low crested rubble mound structures that will be constructed using the conventional three-layer method (i.e., core, filter, and armor). It is anticipated that concrete armor units will be used rather than rock armor because of the scarcity, high cost, and questionable durability of large rock armor available from local quarries.

Once the groins are constructed, the beach fill material will be hydraulically placed as described in Section 2.4.1.2.B. The beach toe, as shown on Figure 1.4, is the "design" toe for the initial construction. Once the T-groins are constructed on the west and north coasts, beach fill material will be hydraulically placed. The cobble beach system will be designed and constructed to allow for future changes in planform geometry and cross-sectional geometry due to the design hurricane conditions. Over time, as the beach is exposed to wave action, the shoreline of the gravel beach will no longer be straight but will become curved (logarithmic spiral), with embayments developing within each groin cell.

During significant storms, some material will be lost due to cross-shore and along-shore transport. During the design phase, care will be taken to minimize such losses by fine tuning the length and orientation of the terminal structures. The gravel beach system will be designed to allow for future changes in planform geometry and cross sectional geometry due to the design hurricane conditions.

Near shore wave approach direction will be in the range of +/- 20 degrees relative to the mean shoreline orientation, based on preliminary wave transformation numerical modeling. Based on empirical methods, the maximum erosion offset for the spiral beach will be in the range of 25 percent of the effective gap spacing between the artificial headlands. A 30 m (100-ft) setback or "buffer" distance will be provided inshore of the predicted limit of the eroded shoreline. Minor, low crested seawall construction will be provided at the inshore end of the beach as needed to accommodate wave run-up.

A "U" shaped pre-cast concrete caisson system is planned for the south coast. Each caisson will be approximately 5 m (18 ft) long, 7 m (23 ft) wide, and 10 m (32.8 ft) to 11 m (36 ft) high. The final dimension of each unit will be defined during the design process and will depend on selected design criteria and constructability considerations, as discussed in Section 2.4.1.4.B.

On the southeast shore of Ocean Cay in the support vessel harbor area, concrete caissons or steel sheet pile may be used for shore protection. This vertical retaining wall system is described more fully in Section 2.4.1.4.

Wave conditions along the eastern coast of Ocean Cay are less severe than those expected at the other coasts on the island. The proposed shore protection scheme for most of the eastern coast of the island will consist of a conventional three-layer rock revetment (i.e., core, filter, and armor). The main purpose of this revetment system is to hold the fill material in place and protect the shoreline against wave induced erosion. On infrequent occasions during storms with a low probability of return, the revetment is expected to experience significant overtopping and some level of damage that will require repair.

E. Support Vessel Harbor

A Support Vessel Harbor (SVH) will be constructed on the east shore of Ocean Cay. This facility will have a dual purpose:

- To provide a protected berthing area during construction for material delivery barges up to 80 m (262 ft) LOA; and,

- To provide a permanent berthing facility for three large harbor tugs, one smaller mooring launch, and a ferry.

The small boat harbor will not provide tanker husbandry services such as fueling and waste disposal that are typical of multi-purpose commercial ports. Shore leave or repatriation activities will not be allowed at the terminal for tanker personnel.

The berths will be provided with electrical power, diesel fueling capability, and other utilities to service the terminal support vessels described below.

The facility will be "U" shaped and comprised of a composite type breakwater for partial wave protection as shown on Figure 1.4. The breakwater will be designed for 100-year frequency storm conditions, as discussed previously in Section 2.3.1.1. The shore protection that will be constructed in the SVH is also discussed in Section 2.3.1.1. The SVH will be dredged to a nominal depth of 6 m (19.7 ft) to accommodate the support vessels described below.

E.1. Tug Boats

Tug boats will be required to escort LNG ships while in transit in the approach channel and to assist the ships in the turning basin and during berthing maneuvers. SIGTTO requires that sufficient tug assistance be provided to control the largest LNG carrier assuming that the engines are not available during maximum permitted operating conditions.

SIGTTO suggests that for 135,000 m^3 (849,047 bbl) capacity LNG carriers, three to four tugs with a combined ballard pull between 120 to 140 metric tons (MT) (132.3 to 154.3 Tons) be available to provide assistance as necessary. These tugs should be able to exert approximately half of this total power at each end of the ship. Hence, for the purposes of estimating the size of the required SVH, it is assumed that three tug boats will be required, each having engines with a minimum of 4,000 horsepower (HP) and 40 MT (44 Tons) ballard pull. Preliminary fast-time navigation simulations and limited real-time berthing simulations indicate that the proposed tug power requirement (3 tug boats) is reasonable for the Ocean Cay site. The length, width, and depth of the tugs utilized for planning purposes are outlined below in Table 2-3.

Table 2-3

Preliminary Tug Boat Characteristics

Main Parameters	Preliminary Values
LOA	30.0 (m) (98.4 ft)
LBP	24.0 (m) (78.7 ft)
Breadth Moulded	9.8 (m) (32.2 ft)
Depth Moulded	4.8 (m) (15.8 ft)
Draft	4.2 (m) (13.8 ft)
Gross Tonnage	298.4 (Gross Tonnage)
Main Engines	4,000 (HP)
Bollard Pull Ahead	50.0 (MT) (55 Tons)
Bollard Pull Stern	40.0 (MT) (44 Tons)

E.2. Launches

It is assumed that one mooring launch will be moored at the SVH. The mooring launch will have a maximum length of 15 m (49.2 ft), width of 5 m (16.4 ft), and draft of 2 m (6.5 ft). The launch will be utilized to assist mooring operations for the ships arriving at the SVH by running mooring lines from the ships to the moorings. Table 2-4 provides a summary of the main characteristics of this vessel.

Table 2-4

Preliminary Mooring Launch Characteristics

Main Parameters	Preliminary Values
LOA	15.0 (m) (49.2 ft)
Breadth Moulded	5.0 (m) (16.4 ft)
Depth Moulded	2.0 (m) (6.5 ft)
Draft	1.5 (m) (6.5 ft)

E.3. Ferry Facility

During the construction period as well as during operation of the terminal, employees will be transported between Ocean Cay and South Bimini via a high speed, low-draft commuter ferry. The SVH will be equipped with a ferry terminal. Existing docking facilities will be used on South Bimini. The expected characteristics of the proposed ferry are shown below in Table 2-5.

Table 2-5

Preliminary Commuter Ferry Characteristics

Main Parameters	Preliminary Values
LOA	25.0 (m) (82 ft)
Breadth Moulded	8.5 (m) (27.9 ft)
Draft	1.8 (m) (5.9 ft)
Passenger Capacity	50 to 149
Fuel Capacity	4,500 (l) (1188.8 gal)
Main Engines	1,000 (HP)
Speed	30 (knots)
Fuel Consumption	375 (l/HR) (99 gal/HR)
Range at Full Power	672.3 (km) (363 nautical miles)

E.4. Construction Barges

During the construction period, barges up to 80 m (262 ft) in length will be in use for the project. The SVH will be designed to accommodate two of these vessels at one time. In addition, the SVH will be equipped with a Roll-On/Roll Off and a Lift-On/Lift-Off berth.

E.5. Diesel Fueling System

Diesel fuel for fueling vehicles, service/tug boats, and emergency generators will be supplied to the island by barges. Diesel fuel will also be utilized as backup fuel for the duel fired gas turbine generator. The diesel fuel will be stored in a main 1,135-m^3 (300,000-gal) capacity aboveground storage tank within a containment dike, as shown on Figure 1.4. Two double walled 75.7-m^3 (20,000-gal) day tanks, supplied from the main storage tank, will be provided near the SVH. The SVH will be equipped with a manifold, aboveground piping, and a metered fueling station for offloading diesel from barges. Another metered fueling station will be provided for servicing the tugboats, mooring launch, and other vessels in the SVH for vehicle fueling and tanker truck filling. These tanker trucks will be used to distribute diesel fuel throughout Ocean Cay, as required. All piping associated with the fueling operations will consist of aboveground piping

E.6. Fresh Water

During the construction period, fresh water will be supplied to the construction operations from a portable, barge mounted reverse osmosis (RO) unit. The barge will be positioned in the vicinity of the SVH. The intake and discharge from the system will be located on the east side of the Ocean Cay. Total water demand is expected to vary significantly during different stages of construction. The peak construction demand for water is approximately 2,271 m^3 per day (600,000 gallons per day (gpd)). The main construction demand for fresh water is from the concrete batch plant that will be used to make caissons, for shore protection structures, and the foundation for the LNG and LPG tanks. Potable water requirements during construction and operation are discussed in Section 2.3.1.1, Site Preparation, and 2.3.1.5, Housing.

During the operational phase of the project, barges will no longer be used for delivery of fresh water. Instead, fresh water will be produced using the desalination plant described in Section 2.3.1.3. and stored for use on Ocean Cay and Bimini.

E.7. Sanitary Facilities

During the construction period each contractor will provide temporary stations to provide sanitation facilities consisting of potable water, wash sinks, and toilet facilities. The facilities will at a minimum meet US Occupational Health and Safety Administration (OSHA) guidelines. The number and locations of the facilities will depend on the construction activities and the expected number of workers. In accordance with the guidelines a minimum of one station for every fifty workers will be provided. The toilet facilities will be of the incinerating type and will not require conventional treatment or disposal off-site and the wastes generated will not require conventional treatment or disposal off-site.

Incinerating toilets are designed with a chamber that receives and incinerates wastes. Products of combustion are removed through a venting system with a catalyst for odor control. An electric heating unit cycles on-and-off while a blower draws air from the chamber and passes over a heat activated catalyst bed designed to remove odor components. Upon leaving the catalyst bed the air is vented. Makeup air for the chamber is drawn from the toilet area. The blower motor continues to operate after the heating cycle to cool the unit. The toilet can continue to be used while incineration is in progress. Sanitary wastes generated during housing of the construction workers will be contained in the cruise ship or quarters barge holding tanks and will be transferred to barges for transport and disposal as described in Section 3.

2.3.1.2 LNG Terminal

A. Berthing

The proposed LNG terminal will be constructed on Ocean Cay to receive and store LNG unloaded from ships and to transport natural gas off-site through pipelines. The terminal design regasification/send out capacity will be 22.7 million cubic meters per day (MMCMD) (800 million standard cubic feet per day (MMSCFD)) with a maximum of 28.3 MMCMD (1,000 MMSCFD) at a normal operating pressure of 14,800 kPa (2150 psig). The LNG terminal is expected to operate continuously in a base load mode of operation. The facility will be designed in accordance with National Fire Protection Association (NFPA) 59A, Standard for the Protection, Storage, and Handling of Liquified Natural Gas (LNG) 2001 Edition. In order that natural gas exported from Ocean Cay meets pipeline specifications in the U.S., a LPG removal system will be incorporated into the facility to separate, as necessary, LPG constituents from the LNG. The extracted LPG will be loaded on ships via a separate berth for export.

LNG carriers will normally arrive at the pier loaded and will leave in ballast condition, while LPG vessels will arrive at the pier ballasted or partially loaded and leave partially or fully loaded. As described in Section 2.3.1.2, the LNG berth will be designed to accommodate the dimensional characteristics of the 98th percentile of all existing LNG tankers greater than 18,000 m^3 (113,216 bbl), the largest of which is 138,000 m^3 (867,993 bbl) in storage capacity. The proposed terminal is anticipated to be suitable for tankers up to 160,000 m^3 (1,000,000 bbl), when such tankers are placed in service in the future. The LPG berth is designed to accommodate LPG vessels ranging in storage capacity from 29,000 m^3 (182,000 bbl) to 80,000 m^3 (500,000 bbl).

The main components of the terminals will include the following:

- Loading platforms;
- Breasting dolphins;
- Mooring points;
- Access trestles for vehicles and a pipeway;
- Walkways for two means of egress;
- Mechanical systems;
- A boil-off gas compression system; and,
- Electrical, control, and hazard protection systems.

The features of the LNG/LPG terminal are shown on Figure 1.4 and Figure 2.38. A description of the individual components for the proposed LNG and LPG terminals is provided below.

A.1. LNG Breasting Dolphins

The breasting dolphins will support large resilient fender units against which the LNG/LPG tankers berth and breast. The dolphins will also support double quick release hooks for securing the vessels' spring mooring lines. Three breasting dolphins are proposed at the LNG berth so that both membrane type and spherical type LNG tankers can be accommodated. The cargo manifold on membrane type tankers is located at approximately the center of the vessel, while on spherical type tankers it is located substantially forward of the center. As a result, the two types of tankers are positioned differently in the berth. The breasting dolphins will be located so that at least two are in position to properly support either type of tanker. The breasting dolphins will consist of a cast-in-place concrete cap supported on steel pipe piles. The outboard face of the concrete cap is extended downward to provide sufficient surface to support the resilient fender unit. LNG breasting dolphins are shown on Figure 2.3 and 2.4. Each breasting dolphin for the LNG Berth will measure approximately 12 m (39.4 ft) long by 9 m (29.5 ft) wide, with the top elevation at +7.0 m (23 ft)(MLLW). The conceptual design and installation procedures for the breasting dolphins are discussed in Section 2.4.2.1.A.

A.2. LNG Mooring Points

The mooring points on the seawall will consist of triple quick release hooks to accommodate either the membrane type or spherical type vessels. The LNG berth will have six mooring points. A 0.75 m (2.5 ft) thick pre-cast concrete slab will be provided on top of the caissons that form the seawall, as shown on Figures 2.3 and 2.4.

A.3. LNG Access Trestle

The access trestle will consist of an approximately 10 m (32.8 ft) wide deck, divided into an approximately 4 m (13.1 ft) wide roadway and a 6 m (19.7 ft) wide pipeway. It is a pre-cast/cast-in-place concrete superstructure supported on steel pipe piles.

The access trestle superstructure consists of pre-cast concrete pile caps placed on two 600 mm (2.0 ft) diameter steel pipe piles in bents spaced 12 m (39.4 ft) to 18 m (59 ft) apart. Both piles in each bent will be battered at 1:3 (horizontal to vertical) to develop resistance to the lateral loads generated by seismic loading. Pre-cast and pre-stressed box beam sections will be used to span the distance between the bents. Adjacent box beams will be post-tensioned in the transverse direction and topped with a 0.15 m (0.5 ft) thick concrete slab. Pre-cast curbs will be keyed to the cast-in-place topping. The trestle will also be supported by the parapet on top of the north edge of the seawall, thus eliminating one pile bent. To the north of the seawall, the trestle will be supported on vertical steel pipe piles driven to develop adequate capacity. As an alternative, cast-in-place concrete columns with conventional footings may be used to support the bents.

A.4. LNG Walkways

The walkways between the breasting dolphins will consist of a steel pipe truss, triangular in cross section with fiberglass grating as the walking surface.

A.5. LPG Breasting Dolphins

Two breasting dolphins will be utilized at the LPG berth. The breasting dolphins for the LPG berth will measure approximately 8 m (26.2 ft) long by 9 m (29.5 ft) wide, to accommodate the 6.5 m (21.3 ft) long foam-filled fender, as shown on Figure 2.3. The dolphins will be supported on fourteen piles arranged in four rows. All except two will be driven at a batter in order to resist the large horizontal forces imposed on the dolphin by berthing, mooring and seismic loading conditions. The piles will consist of 600 mm (2.0 ft) diameter steel pipes, installed in a similar manner as the piles for the LNG berth described above. The batter for the piles pointing south will be 1:4 (horizontal to vertical) to avoid interference with ship's hull, and 1:3 for all other piles. The deck for the breasting dolphin will also be constructed using cast-in-place concrete, and will be at the same elevation as the breasting dolphins for the LNG pier, as shown on Figure 2.4.

A.6. LPG Mooring Points

The mooring points on the seawall will consist of triple quick release hooks and to accommodate either the membrane type or spherical type vessels. The LPG berth will have six mooring points. A 0.75 m (2.5 ft) thick pre-cast concrete slab will be provided on top of the caissons that form the seawall.

A.7. LPG Trestle

The access trestle will consist of an approximately 10 m (32.8 ft) wide deck, divided into a 4 m (13.1 ft) wide roadway and a 6 m (19.7 ft) wide pipeway. It will be a pre-cast/cast-in-place concrete superstructure supported on steel pipe piles. The access trestle superstructure will consist of pre-cast concrete pile caps placed on two 600 mm (2.0 ft) diameter steel pipe piles in bents spaced 12 m (39.4 ft) to 18 m (59.1 ft) apart. Both piles in each bent will be battered at 1:3 to develop resistance to the lateral loads generated by seismic loading. Pre-cast and pre-stressed box beam sections will be used to span the distance between the bents. Adjacent box beams will be post-tensioned in the transverse direction and topped with a 0.15 m (0.5 ft) thick concrete slab. Pre-cast curbs will be keyed to the cast-in-place topping. The trestle will also be supported by the parapet, which is located on top of the north edge of the seawall, thus eliminating one pile bent. To the north of the seawall, the trestle will be supported on vertical steel pipe piles driven to develop adequate capacity, but not necessarily to rock. As an alternative, cast-in-place concrete columns with conventional footings may be used to support the bents.

A.8. LPG Walkways

The walkways between the breasting dolphins will consist of a steel pipe truss, triangular in cross section with fiberglass grating as the walking surface.

B. LNG/LPG Receiving

B.1. LNG Loading Platform

The loading platform will provide a means for berthing LNG tanker ships, and will support the articulated loading arms that connect the terminal piping system to the vessel manifold. The platform will also support the piping, manifold, spill collection system, and fire fighting monitors. The loading platform structure will consist of a pre-cast/cast-in-place concrete deck supported on steel pipe piles. The unloading system will be designed to unload the entire contents of a 138,000 m^3 (867,993 bbl) capacity LNG tanker within 12 hours. The design unloading rate is 12,500 m^3/hour (55,000 gpm). During normal terminal operations, when ships are not unloading, cool-down lines will be utilized to recirculate LNG through the loading lines to maintain the lines at product temperatures thus avoiding thermal cycling of the unloading lines.

The loading platform will measure approximately 36 m (118 ft) long by 20 m (66.6 ft) wide, as shown on Figure 2.4. The platform will be supported on forty-two steel pipe piles 600 mm (2.0 ft) in diameter. All piles will be coated with an epoxy coating to protect against corrosion. In addition, a cathodic protection system will also be provided. Four piles along the east, west, and north edges will be driven at an outward batter of 1:3 to provide resistance to lateral forces imposed on the platform under wind and seismic loading conditions. On the south edge (facing the ship), four piles will be battered at a steeper 1:4 slope, in order to avoid interference with the bulbous bow of some tankers.

B.2. LNG Mechanical Systems

The LNG ship unloading facility will consist of various mechanical systems to deliver LNG from the ship to the storage tank. The proposed mechanical systems will include the following:

- Four hydraulically actuated articulated unloading arms (three for LNG unloading and one for vapor return);
- Two blowers for returning vapors from the storage tank to the ship;
- Vapor desuperheater system;
- LNG sampling system;
- LNG flow, temperature monitoring instrumentation; and,
- Interconnecting piping systems.

B.3. LPG Loading Platform

The LPG loading platform will support the articulated arms that connect the terminal piping system to the vessel manifold. The platform will also support the piping, manifold, spill collection system, and fire fighting monitors. LPG for export will be delivered from the LPG storage tank to the ship at a rate of 3,500 m^3/hour (15,000 gpm), through two 305 mm (12 in) hydraulically operated loading arms, as shown on Figure 2.5. During normal operations, when ships are not loading, a cool-down line will be utilized to circulate the LPG through the loading line to maintain the line at product temperature. LPG vapor can be returned from the ship via a 305 mm (12 in) diameter vapor return arm. The returned vapor, as well as vapor from the LPG storage tank, will be recondensed by circulation of LPG which has been cooled by heat exchange with outgoing LNG.

The loading platform for the LPG pier will measure approximately 25 m (82 ft) long by 15 m (49.2 ft) wide and will be supported by twenty-two 600 mm (2.0 ft) diameter steel pipe piles. All piles will be epoxy coated to protect against corrosion. In addition, a cathodic protection system will be provided. Several piles will be battered to provide resistance to lateral forces imposed on the platform under wind and seismic loading conditions.

B.4. Boil-off Gas Compressor

The boil-off gas (BOG) compression system consists of two screw type boil-off gas compressors, which will both be used during active LNG ship unloading, as shown on Figure 2.6. During normal terminal operation, when no ships are unloading, one BOG compressor will be needed to lower boil-off gas volume. If the BOG compressor is inoperative due to power failure or other emergency, the boil-off vapors will be directed to the flare, as described in Section 2.3.1.2.

B.5. Electrical, Control, and Hazard Protection Systems

The hazard protection systems will include fire protection, spill containment structures and gas monitoring devices. These systems are also described in the LNG Terminal Hazards and Safety Considerations Report, attached as Appendix C. A fire and hazard detection system will be provided to monitor for the presence of flammable gases, fire, and LNG/LPG spills in areas where a hazard to persons or equipment could exist. Audible and visible alarms will be installed to warn an operator of a detected potential hazard. The operator will be required to analyze the potential hazard and determine if shutting down the equipment or activating the protection system is required. Shutdowns from fire or hazard detection will not be automatic, but will require activation by plant personnel.

Protection systems and manual alarms will be provided for fire exposure, cryogenic spills, gas detection, flame detection, smoke detection, and high and low temperature detection. The protection systems will consist of fire hydrants and monitors, sprinklers and fixed water spray systems, dry chemical extinguishers, and passive thermal and cryogenic spill protection.

The area around the loading arms will be sloped to drain any spills to the spill sumps located at the ends of the platform. Each sump will be sized for the contents of one loading arm plus piping up to the platform isolation valve. Fire fighting equipment in the platform area will include:

- Dry chemical fire extinguishers for small fire extinguishing;
- Wheeled dry chemical units with hoses;
- Hydrant hose lines providing firewater and stationary monitors for fire control and heat

protection of equipment and structures adjacent to the fire; and,

- A remote actuated dry chemical skid with preset monitor for fire extinguishing around the loading arm area.

Leaks that occur in the shore area will drain away from piping via natural drainage grades to spill sumps. Fire fighting equipment in the shore area will include:

- Dry chemical fire extinguishers for small fire extinguishing; and,
- Hydrant hose lines providing firewater for fire control and heat protection of nearby equipment and structures.

The four monitors located at the berthing area will be rated at 113.4 m^3/hr (500 gpm) at 685 kPa (100 psig) and fitted with an adjustable fog/straight stream nozzle. Each single monitor will have a full 360° rotation and adjustable elevation features. The manual shut-off valve for the monitor will a 100-mm (4 inch) wafer butterfly valve.

Fixed gas detection sensors will be located at various locations within the facility where the possibility of a gas leak is most likely to occur. These detectors will be programmed to alarm at 25 percent (high) and 50 percent (high-high) of the lower flammability limit (LFL). Alarms will be designed so that they appear on the operator terminals. Audible alarms (e.g. hazard horns) and beacons will also be activated by a high or high-high alarm. If a high alarm is acknowledged on any of the operator terminals, the horns will be turned off, but the beacons will stay on until the alarm condition clears. However, if the high-high alarm is initiated before the alarm condition clears, the horns will sound again.

Ultraviolet/Infrared (UV/IR) flame detectors will be located at various locations within the facility where the possibility of a fire is most likely to occur. These detectors will be programmed to alarm on all the operator terminals. The detectors will also activate audible alarms (e.g. hazard horns) and beacons.

Smoke detectors will be located at various areas within the facility. These detectors will be programmed to alarm on all the operator terminals. These detectors will also activate audible alarms (e.g. hazard horns) and beacons.

High temperature detectors will be located on each of the tank relief valve discharge stacks. These detectors will be programmed to alarm on all the operator terminals. The detectors will also activate audible alarms (e.g. hazard horns) and beacons.

Low temperature detectors will be located in the LNG/LPG impoundment sumps and drip pan located at the tank platform. These detectors will be programmed to alarm on all the operator terminals. An audible alarm will sound in the area if a spill is detected.

The emergency shutdown system is designed to be fail-safe for increased system reliability. The emergency shutdown system will have the capability of being activated from various locations throughout the facility to initiate a plant wide shutdown. Redundant logic controllers and operator terminals will also be provided for increased plant safety.

Automatic emergency shutdown valves will be provided in the ship unloading lines, in pump discharge lines, at the inlet to each vaporizer and in the plant main outlet gas line.

C. LNG/LPG Storage

Two LNG storage tanks and one LPG storage tank are proposed for construction on Ocean Cay. The LNG tanks will receive liquefied gas from tankers offloading at the terminal. The liquefied gas will be separated into a LPG fraction, which will be transferred to the LPG tank, and a LNG fraction, which will be vaporized and transported via the pipelines to the Biminis and Florida.

The components included in the LNG/LPG tank farm include the following:

- Two 160,000 m^3 (1 million bbl) capacity double walled tanks for LNG;
- A 40,000 m^3 (251,600 bbl) LPG double walled tank;
- Secondary containment structures surrounding each tank capable of containing 110 percent of each LNG tank and 100 percent of the LPG Tank;
- Low pressure pumps;
- Containment sump systems;
- Associated electrical, control, fire protection and gas detection systems.

C.1. LNG Tanks

The LNG tanks will be single containment insulated metal tanks about 56 m (183 ft) in height and 77 m (252.5 ft) in diameter, as shown on Figure 2.7. Each tank will be designed to store up to 160,000 m^3 (1,000,000 bbl) of LNG at a temperature of – 162 ^oC (–260 ^oF) and a pressure of 13.8 kPa (2.0 psig). Tank capacity is designed to offload the entire contents of a 160,000 m^3 (1,000,000 bbl) LNG tanker and to receive LNG shipments at intervals of approximately every 3 days. The tanks will be designed and constructed according to the requirements of the American Petroleum Institute (API) 620 Appendix Q, NFPA 59A.

Each LNG storage tank will consist of an inner and outer tank. Tanks will be supported below grade on ring wall foundations bearing on sand densified by soil improvements, as described in Section 2.4.1. The inner "liquid containing" tank will be a cylindrical flat bottom structure constructed of low temperature, 9 percent nickel steel. All welds of the tank will be radiographically (x-ray) tested to ensure integrity. To prevent the stratification of the tank's inventory into its constituent parts, the tank design will allow for both top and bottom filling. Bottom filling will be done through a standpipe inside the tank, and top filling will be carried out through a separate tank feed line to a deflector. The filling operation will use gravity to assist in mixing the unloaded LNG with the heel in the tank (i.e. a heavy LNG is unloaded on top of a lighter tank heel, and a lighter LNG is unloaded under a heavy heel).

During ship unloading, the LNG tank pressure will be maintained at approximately 13.8 kPa (1.9 psig) using three boil-off gas (BOG) screw type compressors and two vapor return blowers. During normal terminal operation (no ship unloading), the pressure in the tank will drop and one BOG compressor will be adequate to handle the lower boil-off gas volume.

The LNG outer tank will be constructed of carbon steel, and will have a flat bottom, dome roof, and cylindrical shell. The outer tank will be designed to contain product vapors and protect the insulation systems from moisture and other conditions. Insulation will consist of perlite installed between the inner and outer tank walls.

LNG storage tank overpressure protection will be provided by a flare system. If the tank pressure exceeds the maximum operating limit, a pressure control valve will automatically relieve excess vapor from the vapor headers to the flare. The flare will be approximately 15.25 m (50 ft) high and will be sized to burn up to 13,608 kg/hr (30,000 lb/hr) of natural gas. The flare would be used in the event of a power failure, which would render the vapor handling systems inoperable. The flare also functions as a backup to the boil-off compressors.

A pressure makeup system and vacuum breaker valves will also be installed on the tank to protect the tank against vacuum conditions. The storage tank safety relief valves will provide protection against tank overpressure. Temperature and density measuring devices will be located in the LNG storage tanks, to provide the plant operator with the means to detect LNG stratification. Automatic continuous level measurements will also be provided for the LNG storage tanks.

C.2. LPG Tank

The LPG from the LPG removal unit will be stored in a 40,000 m^3 (251,600 bbl) single containment type LPG tank. The tank will be perlite insulated, double wall steel construction with a design pressure of 13.8 kPa (2.0 psig) and will be designed, constructed and tested in accordance with API 620 Appendix R. Circulation of sub-cooled LPG will be used to maintain the LPG tank pressure. The storage tank safety relief valves will provide protection against tank overpressure. LPG storage tank overpressure protection will be provided by the flare system described in Section 2.3.1.2.C.

The LPG tank will be a single containment insulated metal tank approximately 37 m (121.4 ft) in height and 50.6 m (166 ft) in diameter, as shown on Figure 2.8. Tank capacity is designed to store LPG recovered from the gas separating plant until it is loaded to tankers for off island shipments. A LPG shipment is anticipated approximately every 6 days.

C.3. Secondary Containment Structures

Containment structures will be sized to hold 110 percent of the liquid capacity of the LNG tanks and 100 percent of the capacity of the LPG tank will be constructed around each of the tanks as shown on Figure 1.4. The containment structures will be constructed of cemented sand and built to an approximate height of 6.1 m (20 ft) above grade for the LPG tank and 9.1 m (30 ft) above grade for the LNG tanks, as shown on Figure 2.9. Each containment structure will be constructed with an access roadway to allow entry to the diked area.

The tank dike spill sump will be sized for a one-hour spill based on the tank outlet nozzle size. The spill volume will be calculated per NFPA 59A. The one-hour spill scenario will be used for spill sump sizing purposes only. Fire protection facilities will be based on credible leaks as described in the LNG Terminal Hazards and Safety Considerations Report (Appendix C).

C.4. Containment Sump Systems

Rainwater collecting in the tank dike spill sump will be removed by automatically activated sump pumps. The sump pumps will be equipped with an automatic cutoff to prevent pump operation if low temperature is detected in the sump (i.e., a product release is detected).

C.5. Electrical, Control, Fire Protection and Gas Detecting Systems

The electrical, control, fire protection and gas detecting systems for the LPG system will be similar to those for the LNG systems, as described in Section 2.3.1.2.B.

D. LNG Regasification and Sendout

The ancillary systems and structures associated with the LNG terminal and tank farm include the following:

- Vapor handling system;
- Boil off gas recondenser;
- LNG tank withdrawal pump;
- LNG booster pumps;
- LNG regasification system;
- Natural gas metering station;
- Air compressors; and,
- Instrumentation and control.

The process flow diagram for these systems and components is shown on Figure 2.10. Piping, electrical distribution wiring and insulation of varying size and capacity will be installed throughout the facility. Several of the components will be housed in separate buildings, which will be connected via roadways and sidewalks.

D.1. Vapor Handling System

The LNG vapor handling system is designed to handle the vapor generated in the storage tanks with an unloading rate of 12,500 m^3/hr (55,000 gpm). During ship unloading, heat input into the system will be from pumping and leakage from the ambient surroundings. To suppress some of the vapor that would be generated due to the additional energy (heat) input, the storage tanks will be operated at a pressure above that of the ship. This allows part of the heat input of the system to manifest itself as a sensible heat increase in the LNG.

Two 50 percent capacity ambient temperature blowers will be used to remove a portion of the vapor generated in the storage tanks during ship unloading. The vapor from the discharge of the blowers will be returned to the ship through a 406.4 mm (16 in) diameter vapor return line and a vapor return arm, as shown on Figure 2.6. A desuperheater will be provided at the berth to provide cold vapor to the ship (approximately –104.4 °C (-220 °F)), if so required by the ship for cooling purposes.

The remainder of the vapor generated in the storage tanks during ship unloading will be handled by two 50 percent capacity screw compressors. The vapor from the discharge of the compressors will be condensed in the boil off gas recondenser. In the holding mode (i.e. no ship unloading), only one of the compressors will be required to operate.

D.2. Boil-Off Gas Recondenser

At the recondenser, the boil-off gas from the compressor discharge will be condensed by mixing with subcooled LNG from the low- pressure pumps at approximately 2055 kPa (300 psig).

D.3. LNG Tank Withdrawal Pumps

Two tank withdrawal pumps will be specially designed vertical, submerged, centrifugal, can-mounted pumps located external to each of the storage tanks. The pumps will discharge at approximately 2055 kPa (300 psig) into the low pressure LNG header which will be connected to the recondenser vessel.

D.4. LNG Booster Pumps

The outlet liquid stream from the LPG removal system, or from the re-condenser, flows to six LNG boost pumps six plus one spare which will bring the pressure up to approximately 15,207 kPa (2220 psig) before feeding it to the high pressure LNG vaporizers which will provide gas to the pipeline. The high pressure LNG booster pumps will be vertical, submerged, centrifugal, can-mounted pumps.

D.5. LNG Regasification

LNG from the low pressure in-tank pumps will flow to the recondenser vessel where the liquid will recondense the vapor from the boil-off compressors (if the LPG removal system is operating, the low pressure LNG will flow through this system before reaching the recondenser vessel). From the recondenser the LNG will flow to the LNG booster pumps. Six pumps plus one spare will be installed. Each pump will be sized to deliver 4.4 MMCMD (155 MMSCFD) at approximately 15,207 kPa (2,220 psig) to the LNG vaporizers. Six shell and tube type vaporizers (including one spare) will be installed. Each will be designed to deliver 5.3 MMCMD (186 MMSCFD) to the pipeline. The vaporizers will use seawater as the heating medium, as described in Section 2.3.1.3.

D.6. Natural Gas Metering Station

Metering stations will be provided for both the 60 mm (2 in) natural gas pipeline to the Biminis and the 610 mm (24-in) natural gas pipeline to Florida. The meter stations will be equipped with flow meters, shutdown valves and pressure control valves.

D.7. Air Compressors

The compressed air system will be designed to supply the service air and instrument air requirement of the plant. Dry instrument air will be provided for pneumatic operators and devices throughout the plant. Compressed service air will be provided to appropriate areas of the plant as utility stations.

Two, 100 percent oil-free rotary screw-type package compressors will supply compressed air to the service air and instrument air system. The compressors will discharge to two air receivers and supply the air to service air distribution systems. The instrument air system will include dual tower desiccant-type dryers with heatless regeneration.

D.8. Instrumentation and Control

The plant control system will be a micro-processor based Distributed Control System (DCS). The DCS will control and supervise the gas turbine generators, LNG, and desalination areas from the central control room. The primary control location will be the plant control room. The central control room will contain the DCS operator station with consoles, printers, engineering workstation and other auxiliary equipment. The DCS will provide remote control functions to the plant operators either directly from the DCS control processors or indirectly through hardwired connections or serial data links connected to the remotely located control packages.

The DCS will be provided with color graphic displays of the plant equipment with sufficient detail to allow proper control and monitoring of plant functions such as changing set points, placing a controller on manual or automatic, starting or stopping plant equipment, etc. The DCS will be interfaced with a control system for the gas turbine generators (GTGs), package auxiliary equipment, and electrical systems designed to achieve central control of the plant equipment. Required control, alarm and monitoring functions for miscellaneous equipment will be integrated into the DCS.

E. LPG Removal System

The LPG removal system will separate the propane and heavier components from the LNG in order to reduce the heating value of the outgoing gas, as shown on Figure 2.11. LNG will be delivered to the unit at approximately 2055 kPa (300 psig) from the LNG tank withdrawal pumps. Cold LNG will be heated and partially vaporized before being sent to a separator. The vapor from the separator will be routed to the suction of the cryogenic compressors where the pressure will be boosted by approximately 685 kPa (100 psig) to allow the stream to be re-condensed and sent to the booster pumps. The cryogenic compressors (2 plus 1 spare) will be single stage centrifugal compressors driven by 2500 HP electric motors through a speed-increasing gearbox. The liquid from the separator will go to the deethanizer column which will be approximately 3.8 m (12.5 ft) in diameter, 37.2 m (122 ft) tall. The deethanizer will separate the ethane and lighter fractions from the propane and heavier components.

The overhead (lighter fraction) from the column will be mostly methane and ethane. This stream will be re-condensed against the cold LNG feed and sent to the LNG booster pumps which will bring the pressure up to approximately 15,207 kPa (2220 psig) before feeding it to the high pressure LNG vaporizers, which will provide gas to the pipeline. The bottom product from the deethanizer column will be an LPG mix composed of propane, butanes and pentanes. The LPG stream will be cooled by heat exchange with LNG before being directed to the LPG storage tank. When operating at the design condition, up to 5,565 m^3 (35,000 bbl/day) of LPG will be produced.

The deethanizer hot oil system heater (reboiler) will use hot oil as a heating medium. The hot oil system will be designed for a maximum duty of 80 MMBtu/hr. The heating system will consist of a natural gas fired heater, surge tank, partial flow filters and hot oil circulation pumps. Vapor from the LPG tank as well as vapor returned from the LPG ship while loading will be re-condensed by circulating LPG, which has been cooled by the outgoing LNG. The circulation will be controlled to maintain the LPG tank pressure at approximately 6.85 kPa (1 psig).

E.1. Boil-Off Gas Recondenser

When the LPG removal system is operating, re-condensing takes place in the LPG removal system heat exchangers and the vessel serves only as the LNG boost pumps suction vessel.

E.2. LPG Ship Loading Pumps

Two pumps plus one spare with a capacity of 1750 m^3/hr (7500 gpm) each are provided to transfer LPG from the storage tank to the LPG berthing area.

E.3. LPG Circulation Pumps

Two LPG circulation pumps (1 plus 1spare) will serve both to circulate through the loading line and through the sub-cooling heat exchanger, which provides refrigeration for the LPG tank.

The LPG from the LPG removal unit will be stored in a 40,000 m^3 (251,600 bbl) single containment type LPG tank.

E.4. System Safety Measures

LPG storage tank overpressure protection will be provided by the flare system discussed above in Section 2.3.1.2.C. If the tank pressure exceeds the maximum operating limit, a pressure control valve will automatically relieve excess vapor from the vapor headers to the flare.

2.3.1.3 LNG Ancillaries

A. Water Intake and Discharge System

The seawater intake system provides feedwater for the LNG Vaporizer System, RO Desalination Plant and Sodium Hypochlorite Generation System. The intake system also supplies water to the Auxiliary Cooling System and Back-up Firewater Supply System. The seawater intake system will be designed to provide a steady supply of seawater under operating conditions of the different systems. The RO reject water, the cold water from LNG Vaporizer and the Auxiliary Cooling Systems will be directed to the discharge structure, designated as Outfall 001. The locations of the intake and discharge outfall piping are shown on Figure 1.4.

The seawater intake structure will be designed to minimize entrainment of marine organisms through effective use of a low velocity suction intake system, designed for less than 0.15 m/s (0.5 f/s) with a velocity-cap, as shown on Figure 2.12. The seawater will be drawn from the ocean through the velocity cap fitted to the pipeline located offshore. The intake pump house will be located on the western shore of Ocean Cay as shown on Figure 1.4. The intake will be positioned approximately 280 m (920 ft) west of Ocean Cay at a depth of 7.3 m (24 ft) where turbulence and intrusion of sand and debris are expected to be minimal. Water intake volumes will be less than 152 m^3 per minute (40,000 gpm).

Figure 2.12 shows the conceptual design for the arrangement of the intake system. The seawater intake velocity-cap will be located at approximately 253 m (830 ft) offshore. The support chamber for the velocity-cap will extend vertically from the buried pipeline. A velocity-cap will be located on top of the chamber and extend to approximately 3.1 to 4.6 m (10 to 15 ft) below the water surface. The support chamber will be firmly anchored to the seabed and will be designed to withstand the prevailing waves and currents. The intake pipe with an approximate diameter of 1.8 m (6 ft) will be connected to the support chamber and routed to the onshore pump house structure.

The intake structure will be designed for smooth and uniform flow with entrance velocities of less than 0.15 m/s (0.5 feet per second) at the intake velocity-cap. The design will ensure a low pressure drop around the intake to prevent entrainment of suspended solids and marine life.

The expanded outer tip of entrance to the intake will smoothly divide and direct the flow of water into the intake pipe. At a distance of approximately 4.6 m (15 ft) from the intake the velocity will be 0.003 m/s (0.01 ft/s), which is significantly lower than expected natural currents. In the downstream end of the guiding vane to the inlet pipe, the flow accelerates to about 10 times the entrance velocity through a smooth transition without formation of eddy currents or vertices. This design reduces pressure losses in the system and reduces the potential for entrainment of marine life.

The onshore intake structure will serve as a separation basin, pump suction chamber, and water screening area. The conceptual design arrangement for the onshore components of the intake system is shown on Figure 2.13. The main components of the intake structure consist of the following:

- Intake Structure - The intake structure will consist of pump bays designed to allow sand material to settle out prior to the seawater entering the pumps.

- Trash Rake - The trash rake will be provided to insure the exclusion and removal of any entrained debris from the seawater. It will be designed with a few degrees of inclination for ease of raking and removal of debris from the top deck.
- Stop Gate and Guides - The stop gates and guides will be provided to permit dewatering for periodic maintenance and repairs.
- Traveling Screens, Guides and Trash Trough - The traveling screens will be located behind the stop gate to prevent the passage of small or light debris. The traveling screens move up the front and down the back carrying debris to the top where it will be washed off into a sloping trash trough.
- Screen Wash Pumps - The vertical wet pit screen wash pumps will be mounted on the top deck behind the traveling screens. The pumps will discharge high pressure jets of water to the top of the traveling screens to wash debris into the trash trough. The screen wash pumps and traveling screens will be activated by a differential water level control system.
- Screen Openings - Openings on the top of the deck will be provided for all traveling screens to provide access for removal and repair.
- Manholes and Ladders - Manholes and ladders will be provided through the top deck for easy access into all parts of the intake structure.
- Seawater Pumps - Vertical wet pit pumps will supply water for the LNG regasification, the RO desalination plant and the auxiliary cooling water. The pumps are arranged to take suction from the intake structure and discharge to LNG heat exchangers. The pumps will be located adjacent to the RO intake water pumps.
- Back-up Fire Water Pump - One full capacity vertical wet pit pump will provide firewater supply to the fire fighting system, as a back-up supply, in case the normal firewater system is not available or additional water is required for fire fighting.

The seawater discharge outfall will be constructed to discharge cooled water from the LNG vaporizer, warm water from the auxiliary cooling system, brine from the RO desalination plant, and pre-treated wastewater from the plant equipment and floor drains. The streams from different sources will be combined and discharged into a common pipe and routed to an onshore discharge outfall. The discharge outfall will be arranged in such a way as to minimize discharge recirculation to the intake system. The system design will prevent sediment build up at the discharge outfall.

The discharge outfall (designated as Outfall 001) will be located on the south shore of the island, as shown on Figure 1.4. The discharge outfall will consist of reinforced concrete pipe and a duct structure placed below the caissons, as shown on Figure 2.14. The outfall structure will be approximately 5.5 m (18 ft) in diameter to accommodate the eventual larger flow from cooling water for the potential future power plant. The discharge point will be approximately 10 m (33 ft) below the water surface, within the approach channel area.

B. Desalination Plant

A desalinization plant will be constructed on Ocean Cay to provide service water for site operations, potable water for use on Ocean Cay, a potable water supply to the Biminis and demineralized water for injection into the gas turbines utilized for power generation on Ocean Cay, as required. The desalination plant will be a two-stage RO type, which will utilize seawater to produce clean fresh water. The plant will use two identical RO trains; each rated at approximately 946 m^3/day (250,000 gpd) to produce service water, potable water and supply water for the demineralization process.

The desalinization system will take in seawater and chemically treat it prior to transfer to a primary sand filtration bed. The primary sand filtration beds will remove suspended solids before the water is transferred to the first stage RO system. The first stage RO system will provide water to the service water storage tank to be utilized for plant operations and as feedwater to the potable water system. The potable water system will provide water to the site as well as to Bimini via a 219 mm (8 in) pipeline described in Section 2.3.1.4. The water from the supply tank will also be utilized as feedwater to the second stage RO system which will then feed an electrodeionization system to produce demineralized water for injection into the gas turbine generators, as shown on Figure 2.15. The desalinization plant proposed for Ocean Cay will include the following equipment:

- Pretreatment Equipment;
  - Intake seawater pumps,
  - Pre-treatment filters,
  - Cartridge filters,
  - Chemical feed skids
- Service Water;
  - RO feed tank,
  - First stage RO module,
  - Service water storage tank,
  - Service water supply system,
  - Potable water supply system,

- Demineralized Water;
  - Second RO module,
  - Electrodeionization (EDI) system,
  - Membrane cleaning system,
  - EDI feed pumps,
  - Demineralized water storage tank,
- Water Discharge;
  - Brine discharge,
  - EDI reject water,
  - RO reject water, and
- Control;
  - Programmable Logic Controller (PLC) based control system.

Each of the subsystems is briefly described below.

B.1. Pretreatment

Raw seawater will be supplied by vertical wet pit pumps arranged to take suction from the intake structure discussed in further detail in Section 2.3.1.3.A. The seawater will supply the LNG and desalination plant areas at the required flow and pressure. The incoming feedwater (seawater) will be pretreated to be compatible with the membranes by removing suspended solids and adjusting the pH value to control scaling. In the pretreatment process, suspended solids will be removed and a disinfectant will be injected into the seawater to prevent microbiological activity in the pipes and in the system. Acid will then be added to the seawater upstream of the filter unit. The inline coagulation process will be performed by adding coagulant to the acidified seawater.

The conditioned seawater will be passed through multi-media sand filters to remove the suspended solids. When the filter unit reaches a preset pressure drop, it will be taken out of service and backwashed with seawater. The backwash water will be discharged to Outfall 001, as described in Section 2.3.1.3 of this EIA. The filter units will be operated in parallel with one unit on standby. The filtered water will be polished by means of cartridge filters to remove fine particles to 5 micron size and protect the RO membranes from blockage by suspended particles.

B.2. Service Water

The pretreated feed-water will be pumped at high pressure through the first stage RO system which will utilize semi-permeable membranes to separate water from brine. High pressure pumps will be used to raise the pressure of the pretreated feedwater to the operating pressure for the membrane.

The membranes will inhibit the passage of dissolved salts while permitting the desalinated product water to pass through. Applying feedwater to the membrane assembly will result in a freshwater product stream and a concentrated brine reject stream. Only a small percentage of salt will pass through the membrane and remain in the product water. The quality of the first stage RO product water is expected to be less than 500 parts per million (ppm) total dissolved solids (TDS). Product water (permeate) from the first stage RO plant will be routed to the service water tank. The tank will provide storage for the service and fire water system and a supply source for the potable water system and the second stage RO system.

B.3. Demineralized Water

The first stage RO product water stored in the service and fire water storage tank will supply makeup water to the second stage RO system. The second stage RO system will operate on the same principals as the first stage RO system described above. However, product water quality from the second stage RO is expected to be less than 10 ppm (TDS). The product water from the second stage RO will be routed to the demineralized water tank via an electrodeionization (EDI) system. EDI will utilize a combination of membranes and ion exchange resins to force contaminants out of the feed stream into a waste stream while continuously regenerating the resin bed using an electric field.

Feed water will travel in the diluting compartment and through a bed of ion-exchange resins. The bed of resins will be lined on one side by an anion membrane and on the other by a cation membrane. Located beyond the membranes will be a concentrating chamber. The diluting and concentrating chambers will be placed in alternate series throughout the EDI system.

Direct current will be applied to the anode (positive electrode) on one end of the module and to the cathode (negative electrode) on the other end. In the diluting chamber negatively and positively charged resin beads will rest adjacent to each other, allowing ions and cations to travel through the resin bed toward the electrode to which they will be attracted. The ions will enter the concentrating chamber through the cation membrane but will be hindered from traveling to the cathode by the anion membrane on the other side of the concentrating chamber from which they entered. The ions will be forced to exit through the concentrate compartment. The current applied to the resin bed will cause splitting of water to produce hydrogen and hydroxide ions, which will regenerate the ion exchange resins. The product water from the EDI system will be stored in the demineralized water tank, which will be utilized as gas turbine wash water and for gas turbine water injection.

B.4. Water Discharge

The reject water or brine will be routed to the water discharge structure Outfall 001. The concentration of the brine discharge will have a salinity level of approximately 57,000 ppm prior to mixing with the cooling water flow from the LNG regasification. The brine discharge will be diluted more than 40 times in the final discharge. The process water discharge will have a combined salinity of approximately 37,000 ppm TDS which is close to or at ambient seawater conditions. The potential impacts to nearby marine resources resulting from the discharge of RO brine are discussed in Section 5. Reject water from the EDI system will be directed to the service water tank for further use on site prior to discharge.

C. Electrical Generation

Auxiliary electrical systems proposed for the project will be installed to supply the power required to operate the LNG and LPG facilities. The proposed auxiliary electrical systems will include the following:

- Gas Turbine Generators;
- Turbine accessory systems;
- Fuel storage;
- Fuel systems;
- Fire protection systems;
- Generator step-up transformer;
- 480 volt AC power system;
- 120/230 volt AC power system;
- DC power supply system;
- Uninterruptible power supply (UPS);
- Grounding and lightning protection; and
- A raceway system.

The elements of the auxiliary electrical system are shown on Figure 1.4. Concrete block buildings will be constructed to house these units. A description of the equipment to be supplied to support these listed systems is described below.

C.1. Gas Turbine Generators (GTGs)

Two 15-MW gas-fired turbine generators will be installed on Ocean Cay to generate electric power for the project facilities. One additional dual fuel fired, natural gas and fuel oil, 15 MW turbine will also be installed to provide reliable standby capacity. The three proposed GTGs will be single shaft, heavy duty industrial type, suitable for outdoor operation. Each GTG will consist of a multi-stage compressor, turbine, fuel system, combustion system and accessories. Each unit will be designed and packaged into fully integrated major modules complete with off base skids and accessories.

The combustion system will be of a Dry Low NO_x type or standard combustor with water injection, designed to minimize emissions when operating on natural gas. The system will include fuel nozzles, an ignition system, flame detectors and crossfire tubes. Fuel will be supplied to each combustion chamber through a nozzle designed to disperse and mix the fuel with the proper amount of combustion air.

The dual fuel fired GTG will primarily operate on natural gas but will be capable of utilizing distillate fuel oil as a back up fuel source. The fuel oil will be used as a backup fuel for the dual fuel fired GTG in the event that an interruption occurs in natural gas service.

Each generator will be a base mounted, totally enclosed, water to air-cooled synchronous unit. The generator windings will be designed with Class F insulation (designed for Class B temperature rise). The generator will be cooled by recirculating air stream cooled by air-to-water heat exchangers. The generator enclosure will be designed to be suitable for outdoor installation.

C.2. Turbine Accessory Systems

The lubrication for the turbine generator and accessories will be provided by a common forced feed lube oil system. The lube oil system will include a main pump, auxiliary pump and emergency pump, lube oil cooler, filter, valves and miscellaneous control and protection devices. A summary of oil usage and storage to support the project is described in Section 3.

Each GTG will be equipped with a starting system including the drive equipment to bring the unit to self-sustaining speed during start-up. The cool-down system will provide uniform cooling of the rotor after shutdown.

Self-cleaning air filters and high efficiency media filters will be provided on each GTG for intake air filtration. The filter will be automatically cleaned of accumulated dust, thereby maintaining the inlet pressure drop below a preset limit. The inlet air will be cooled by glycol returned from the LNG vaporizer, before entering the compressor through the inlet air duct.

The exhaust system arrangement for each GTG will include plenum, ducting, a silencing section and a stack. A continuous emission monitoring system (CEMS) will be installed to continuously monitor emissions of nitrogen oxides (NO_X) and carbon monoxide (CO) from each GTC as well as opacity of the stacks. The CEMS for NO_X and CO will consist of one time-shared system that will monitor emissions from the maximum of two GTGs that will be operated at the same time. A continuous opacity monitoring system (COMS) will be installed on each GTG stack to monitor for visual opacity due to particulate emissions.

Each GTG will be provided with an off base closed loop cooling water system to dissipate heat from the lubrication oil and generator air. The closed loop cooling system will include fan-coil heat-exchanger modules, an expansion tank, circulating pumps, valves and instrumentation.

Fixed temperature-sensing fire detectors and a carbon monoxide fire protection system will be provided for each GTG. The detectors will provide a signal to actuate the carbon monoxide automatic fire protection system. The fire protection system will meet the NFPA 12 requirements.

The GTG enclosures will consist of several connected sections forming a weather-protective housing, structurally attached to each compartment base. The enclosures will provide thermal insulation and acoustical attenuation. The enclosures will allow access to equipment for routine inspection and maintenance.

C.3. Fuel Storage

The primary fuel for the GTGs is natural gas. A backup 1,135.3 m^3 (300,000 gal) fuel oil storage tank will be provided to store distillate fuel oil (No. 2). The oil tank will be located to the north of the LNG storage area, as shown on Figure 1.4. The fuel oil storage and dispensing system associated with the

1,135.3 m^3 (300,000 gal) tank are shown on Figure 2.16. The 1,135.3 m^3 (300,000 gal) tank will also supply, through use of aboveground piping, two 75.7 m^3 (20,000 gal) day tanks located near the support vessel harbor, as shown on Figure 1.4. Other miscellaneous fuel demands will be served by the 75.7 m^3 (20,000 gal) tanks, including fire pumps, emergency generators and support vessels, as shown on Figure 2.16. All distribution lines will be installed aboveground.

The 1,135.3 m^3 (300,000 gal) tank will be constructed in compliance with the standards of API for bulk fuel storage and NFPA 30 – Flammable and Combustible Liquids. The tank will be provided with secondary containment by a concrete basin lined with an oil resistant coating. The secondary containment will be designed to hold 110 percent of the capacity of the tank. The aboveground 75.7 m^3 (20,000 gal) tanks will also be designed with secondary containment that will contain 110 percent of the capacity of the tank.

C.4. Fuel Systems

The GTGs natural gas fuel source will be taken from the pipeline supplied by the LNG vaporizers. A pressure regulation station will control the gas pressure at the level required by the GTGs. The incoming gas will be heated in a natural gas heat exchanger to the temperature required by the GTGs. The natural gas fuel system will be equipped with local instrumentation and control panels that will be integrated with the plant distributed control systems (DCS).

The fuel oil stored in the 1,135.3 m^3 (300,000 gal) storage tank will be filtered, metered, treated and supplied to the dual fuel GTG by the fuel oil pump, as required. The fuel oil system will be equipped with local instrumentation and control panels that will be integrated with the plant DCS.

The two 75.7 m^3 (20,000 gal) storage tanks located in the vicinity of the SVH will receive fuel oil transferred from the 1,135.3 m^3 (300,000 gal) bulk storage tank to be used to fuel vehicles used on Ocean Cay including tug boats, the Bimini ferry, emergency generators and other vessels and equipment used at Ocean Cay.

C.5. Fire Protection Systems

The GTGs will be provided with fixed temperature-sensing fire detectors. The detectors will provide signals to actuate the low pressure carbon dioxide (CO_2) automatic multi-zone fire protection system. The GTG fire protection system will be designed to meet the requirements of the NFPA.

The main firewater will be supplied from the 1,514 m^3 (400,000 gal) service water/firewater storage tank. The fire pumps will consist of one 100 percent electric driven pump, one 100 percent diesel driven pump and an electric motor driven jockey pump. The pumps will supply firewater through an underground piping loop with valves, hydrants and monitors around the power plant. A fire detection and alarm system, wet and dry sprinkler system, water spray deluge system, fire walls and manual fire suppression equipment will be provided to various equipment, buildings and locations around the facility.

C.6. 4160 Volt AC Power System

The 4160 Volt AC power system will supply the power source to plant auxiliaries requiring a medium voltage power source. The medium voltage AC power system will be powered by a unit auxiliary transformer. The medium voltage AC power system will consist of unit auxiliary transformers, medium voltage (MV) switchgear and station service transformers. The primary of each unit auxiliary transformer will be connected to its respective GTG via isolated phase bus between the generator breaker and generator step-up transformer. The secondary of each unit auxiliary transformer will be low resistance grounded to limit the line to ground fault current and will be tied to its respective MV switchgear section via non-segregated bus duct or MV power cables and its secondary main circuit breaker.

C.7. 480 Volt AC Power System

The 480 Volt AC power system will consist of secondary unit substations, station service transformers, motor control centers and panel boards. Secondary unit substations will be designed to provide power to 480 Volt motors, motor control centers, panel boards and low voltage transformers for 230 Volt loads. The secondary unit substation will receive power from the station service transformers and transform it to 480 Volt three-phase power. Each station service transformer will normally carry approximately 50 percent of the total load served by the respective secondary unit substation. In case of a transformer failure, the second transformer will carry the entire load. Downstream of the secondary unit substation, motor control centers and panel boards will be provided to distribute low voltage power throughout the power plant.

C.8. 120/230 Volt AC Power System

The 120/230 Volt AC power system will consist of low voltage (LV) transformers and panel boards. Power for the 120/230 Volt AC power system will be provided by the 480 Volt AC power system. Transformation of 480 Volt power to 120/230 Volt power will be via dry type LV transformers. The 120/230 Volt three phase AC power will feed panel boards for distribution of either 120 Volt or 220 Volt single-phase power. The panel boards will provide branch circuit protection and a means of disconnect for the branch circuit loads.

C.9. DC Power Supply System

The DC Power supply system will provide a reliable source of power for critical control and power functions during normal and emergency plant operating conditions and will provide the normal source of power for the essential service AC system. The DC power supply system will include a 60-cell-125 Volt DC lead-acid battery, solid-state charger, unit battery panel and DC switchboard panels. Under normal operating conditions the battery charger will supply DC power to the DC loads and supply float and equalizing charge to the batteries. The battery charger will receive 480 Volt, three-phase, AC power from the 480 Volt AC power system and continuously float charge the unit battery while simultaneously supplying power to the DC loads.

C.10. Uninterruptible Power Supply (UPS)

The uninterruptible power supply (UPS) provides 120 Volt AC, single-phase power to essential instrumentation and equipment loads that require uninterruptible AC power. The UPS will include an inverter, static transfer switch, manual bypass switch, panel boards and alternate source transformer.

C.11. Grounding and Lightning Protection

The Grounding System will provide an adequate path to permit the dissipation of ground fault currents, lightning, and switching surges for protection of plant personnel and electrical equipment. The plant grounding system and LNG grounding system will be interconnected. The ground grid system consisting of bare stranded copper conductors connected to ground wells will be installed to provide a low resistance path to ground for fault currents, lightning strikes, and other electrical current surges. The ground grid will be buried beneath and around all major plant buildings and structures.

C.12. Raceway System

A raceway system will provide support to electrical cables routed throughout the plant either directly to equipment or to areas of concentrated electrical loads. The system includes cable trays, conduits, duct banks, manholes and wire ways.

D. Storm Water Management System

Storm water runoff generated at Ocean Cay will consist of storm water from industrial process areas including, LNG/LPG storage tank dikes, LNG/LPG processing area, electrical generation and desalination plant buildings, outdoor equipment areas, and the pump house structure. Non-industrial areas include; site roads, paved areas, shore protection, graveled and naturally vegetated areas. The industrial areas of Ocean Cay have the potential to degrade the water runoff quality, and therefore will be separately collected, treated if required, and monitored prior to discharge through Outfall 001 to prevent the migration of pollutants to the ocean. For the project, the 24-hour duration 10-year return period historic rainfall intensity data of Florida has been used for storm water runoff estimates to develop design criteria.

The site storm water discharge will be collected and discharged to the ocean via three outfalls shown on Figure 1.4. These three outfalls are designated as:

- Outfall 001: Storm water from LNG regasification water, desalination plant brine reject water, auxiliary cooling, treated water from the oil/water separators and service water;
- Outfall 002: Storm water runoff from the external surface of the LNG/LPG dike areas, the western side of the desalination plant area, and the potential future power plant areas and the seawater intake screen wash water; and,
- Outfall 003: Storm water runoff from the eastern side of the external surface of the LNG/LPG dike areas, desalination plant, and potential future power plant areas.

Storm water will be managed via structures, improvements, and hazardous material management techniques, which will be designed to prevent impacts to the project site and the surrounding surface water during construction and operation activities. These structures will be designed to prevent storm water from carrying contaminants and sediment from the Ocean Cay project site to the ocean surface water, as discussed in Section 10, Environmental Management Plan. Details on each of the storm water outfalls are presented below.

D.1. Outfall 001 - Plant Water Discharge

Outfall 001 will normally discharge plant water streams from the LNG, desalination plant and other facilities including water treatment plant facilities. It will also discharge treated and monitored storm water from the plant areas with a potential for oil contamination.

All containment dikes will have locked closed drain valves. Prior to discharging rainwater collected in the dikes of oil storage tanks and containment areas at potential oil spill areas, the water will be monitored for contamination. If contamination is detected, the water will be processed through an oil-water separator. The treated water will be monitored and discharged to Outfall 001. This outfall will have the following discharges and associated low volume waste streams:

- LNG vaporizing water;
- Desalination plant brine reject water;
- Auxiliary cooling water;
- Service water;
- Equipment and floor drains; and,
- Monitored oil-free stormwater runoff.

The plant discharges will be collected in the outfall structure and piped to the discharge Outfall 001. Each discharge to the outfall structure will have a monitoring point established to allow collection of representative samples.

D.2. Outfall 002 - Storm Water Discharge

The proposed storm water collection areas for Outfall 002 discharges will include the following:

- LNG/LPG storage plant;
- Western side of the external surfaces of the LNG/LPG dike area;
- Western side Desalination plant;
- Seawater intake screen wash water; and,
- Western side of the Potential future power plant.

The seawater intake screens at the pump house will be periodically backwashed to remove any material that might collect over a period of time. The backwash water will be discharged through Outfall 002. The frequency of backwash will depend on the biological activity in the water and the amount of suspended materials in the water. The collected storm water runoff and seawater intake screen wash water will be routed through a ditch to Outfall 002 located on the southwest side of the LNG Terminal.

For Outfall 002, no storm water discharge monitoring is proposed during operation, as the discharge will be from clean drainage areas and the seawater used for screen-wash.

D.3. Outfall 003 - Storm Water Discharge

The stormwater collection areas for Outfall 003 discharges include the following:

- Eastern side of the external surfaces of the LNG/LPG dike area;
- Eastern side of the desalination plant area; and,
- Eastern side of the potential future power plant area.

The storm water drains will be routed to Outfall 003 located east of the southern docking area. No storm water discharge monitoring is proposed for Outfall 003 during operation, as the discharge will be from a clean drainage area.

Storm water discharges from construction activities will use best management practices (BMP) techniques that will be used to prevent storm water contamination and mitigation measures to minimize storm water quality impacts. Site surface erosion during construction will be managed with silt fences to prevent storm water from carrying sediment from the Ocean Cay project site construction areas to the ocean, as described in Section 10.

During construction, a storm water collection system will be created after rough grading is completed. Hay bales, silt sacks, or other devices will be added around the new catch basin inlets to prevent sediments from entering the permanent system. These devices will be inspected daily and after each storm event and cleaned as needed to maintain their operating efficiency.

Storm water pollution prevention measures will include a combination of silt fences, hay bales, stone filter dikes, and a sediment trap catch basin for equipment foundation excavation and building construction, as described in Section 10, Environmental Management Plan. The runoff from the first one half inch of precipitation is referred to as the “first flush”. The volume of the “first flush” will be the design volume for storm-water retention for the sediment trap catch basin used for the project construction. These pollution prevention features will be in place prior to the start of construction.

In the event that any contamination is discovered during the excavation of foundations, the contaminated materials will be protected from exposure to rainfall and runoff to avoid leaching of contaminants or discharge to surface water, as described in Section 10. Any suspected contaminated groundwater would be segregated to a separate settling area.

2.3.1.4 Pipelines

A. 610 mm (24 in) Natural Gas Pipeline to Florida

The project will include an offshore 610 mm (24 in) pipeline that will extend from Ocean Cay, The Bahamas, approximately 64.7 km (40.2 miles) to the EEZ boundary. The pipeline will continue from the EEZ, approximately 74 km (46 miles) to a landing site located in Dania Beach, Florida, as shown on Figure 1.1., and will tie into the Florida Gas Transmission (FGT) system approximately 11.1 km (6 mi) inland at the Florida Power and Light (FPL) Fort Lauderdale station.

The pipeline will be constructed using pipe and materials manufactured in accordance with American Petroleum Institute (API) Standard 5L, with a factory applied coating. The Project will be constructed to comply with applicable regulations for design, permitting, construction, testing, operation and maintenance.

The pipeline will be constructed using API 5L grade X-60 pipe 610 mm (24 in) outside diameter (OD) pipe with a 20.6 mm (0.812 in) wall thickness. The exterior of the pipe will be factory coated with 16 mils of fusion bonded epoxy (FBE) for corrosion protection. The field joints (at the welds) will have a similar coating applied in the field. FBE was selected because it has excellent mechanical properties, can withstand temperatures up to 90°C, and is commonly used both on and offshore. The offshore pipeline will also have a 63.5 mm (2.5-in) thick concrete coating (on top of the FBE) for on-bottom stability along its entire length. The concrete coating will also provide wear protection for the FBE coating.

A cathodic protection system using sacrificial anodes will be installed on the offshore pipeline. In the unlikely event that there is a break in the FBE coating, the cathodic protection system will provide additional protection by focusing galvanic corrosion through a preferential path (the sacrificial anode). Anodes will be designed to last the life of the pipeline (30 or more years). Similarly, sacrificial anodes will be used to protect the onshore pipeline. Changes in operating conditions detected on the cathodic protection network for the pipeline will also be used as a measure of pipeline integrity and trigger inspections if warranted.

The steel pipeline will be designed to withstand stresses during installation, testing and operation. The piping will be designed to accept mechanical pipeline inspection devices, or "smart pigs" for integrity inspections. Smart pigs have a variety of sensors (e.g. magnetic or ultrasound) that measure the wall thickness of the pipe around the circumference as it travels internally. All measurements will be recorded and plotted against the travel distance. The use of smart pigs will provide a reliable record of all faults (if present) and features of the internal and external face of the pipe, physical changes in pipeline mechanical conditions (e.g. wall thickness, loss of symmetry indicating stress, etc.). The frequency of pipeline inspections by pigging and other surveillance measures to confirm integrity will conform to industry standards.

The maximum allowable operating pressure (MAOP) of the pipeline will be 15,070 kPa (2200 psig), the working pressure of the 60 mm (2 in) natural gas pipeline will be 14,728 kPa (2150 psig). Based on the subsea survey completed in November 2001 (Appendix D, Hazards Report), the maximum water depth of the pipeline will be approximately 865 m (2850 ft). The pipeline will lay on the seabed at water depths greater than approximately 30 m (100 ft). For water depths less than 30 m (100 ft), the pipeline will be buried with a 1 m (3.2 ft) cover of bottom material. In areas where there is less than 1 m (3.2 ft) of cover available, articulated concrete mats will be used to cover the pipeline and protect it from potential anchor damage. The pipeline will depart Ocean Cay approximately from the north-west corner of the island, utilizing the dredging and trenching techniques described in Section 2.4.4.1.

Shown below is a generalized description of the proposed offshore pipeline alignment with the relevant Kilometer Post (KP) as referenced on Figure 2.17:

KP 0.32	Ocean Cay Landing.
KP 0.32 – KP 5.3	Pipeline buried in shallow waters, up to The Bahamas Bank.
KP 5.3 – KP 17	Pipeline, not buried, descending The Bahamas Shelf.
KP 17 – KP 65.03	Pipeline on seabed (Florida Straits).
KP 65.03	Crossing of EEZ boundary

Baseline conditions along the pipeline route are discussed in Section 4.

B. 60 mm (2 in) Natural Gas and 219 mm (8 in) Potable Water Pipelines to Bimini

The project will include an offshore 219 mm (8 in) potable water pipeline and a 60 mm (2 in) natural gas pipeline extending from Ocean Cay approximately 38.4 km (23.9 mi) to North Bimini. The 60 mm (2 in) pipeline will utilize pipe and materials manufactured in accordance with the API Standard 5L, with a factory applied coating. The 219 mm (8 in) pipeline will be constructed in accordance with the American Water Works Association (AWWA) M-11 –Steel pipes, Design and Installation Regulations. The project will comply with applicable regulations and standards for design, permitting, construction, testing, operation and maintenance.

The pipelines corrosion protection system will include a thin film external coating of FBE and a cathodic protection system using sacrificial anodes. Abrasion resistant material will be applied over the corrosion coating where the pipelines are laid on bedrock.

In the unlikely event that there is a break in the FBE coating, the cathodic protection system will provide additional protection by focusing galvanic corrosion through a preferential path (the sacrificial anode). Anodes will be designed to last the life of the pipeline (30 or more years). Similarly, sacrificial anodes will be used to protect the onshore pipeline. Changes in operating conditions on the cathodic protection network for the pipeline will also be used as an additional measure of pipeline integrity and trigger inspections if warranted.

The offshore pipelines will extend from Ocean Cay to North Bimini Island, following an approximately south-north route and keeping to the east of the cays, on The Bahamas Bank as depicted on Figure 1.5. The two pipelines will be fabricated in parallel and installed within the same trench. The pipelines will transport up to 76,739 m^3/day (2.71 mmscfd) of natural gas and 1893 m^3/day (500,000 gpd) of potable water to North Bimini. The gas compression facilities will be located on Ocean Cay as a part of the LNG regasification plant described in Section 2.3.1.2. The water will be pumped from the desalination plant described in Section 2.3.1.3.

The maximum allowable operating pressure of the gas pipeline will be 15,070 kPa (2200 psig), the working pressure of the 60 mm (2 in) natural gas pipeline will be 14,728 kPa (2150 psig). The maximum allowable operating pressure of the water pipeline will be 5,100 kPa (740 psig), the working pressure of the 219 mm (8 in) potable water pipeline will be 1,918 kPa (280 psig). Based upon The Hazards Report of Proposed 60 mm (2 in) gas and 219 mm (8 in) water pipelines included in Appendix E, the maximum water depth of the pipeline will be approximately 14 m (45.9 ft) of seawater. The pipelines will be buried with a 1 m (3.2 ft) cover on the majority of the route. In areas where bedrock is less than 1 m (3.2 ft) below the bottom sediments or where the hard bottom is exposed, the following installation techniques will be utilized:

- a short trench will be excavated in the rock to ensure a smooth transition of the pipeline; or,
- articulated concrete mats (6 m x 2.4 m x 23-cm thick) will be placed over the pipeline for protection.

A generalized description of the proposed offshore pipeline alignment with the relevant KP is described below and shown on Figure 2.18:

KP 0.00	Ocean Cay Landing.
KP 0.00 – KP 0.5	Pipeline trenched in shallow bedrock (<1m (3.2 ft)) or covered with articulated concrete mats.
KP 0.5 – KP 6.4	Pipeline buried in shallow waters (5m (16 ft)) with sandy bottom.
KP 6.4 – KP 9	Pipeline laid on the bedrock and covered by articulated concrete mats.
KP 9 – KP 28.4	Pipeline buried in shallow waters (5m (16 ft)) with sandy bottom.
KP 28.4 – KP 29.2	Pipeline laid on the bedrock and covered by articulated concrete mats.
KP 29.2 – KP 30.1	Pipeline in buried in shallow waters (5m (16 ft)) intermitted with sandy bottom.
KP 30.1 – KP 32	Pipeline laid on the bedrock and covered by articulated concrete mats
KP 32 – KP 37.1	Pipeline buried in shallow waters.
KP 37.7	North Bimini landing.

2.3.1.5 Housing

Temporary housing will be provided during the construction period and will consist of cruise ships or quarters barges anchored on the East side of Ocean Cay. Permanent housing will be constructed on South Bimini to accommodate permanent operations employees. A hostel will be constructed on Ocean

Cay for housing of personnel during scheduled work shifts. The proposed permanent housing development are discussed below.

A. South Bimini

A housing development will be constructed for AES employees on South Bimini as shown on Figure 2.19. The housing development will be for plant operators, plant managers and supervisors. The development parcel will be developed into a series of housing units, as shown on Figure 2.20. An existing commercial marina on South Bimini will be utilized for docking of a high speed ferry which will be used to transport personnel between South Bimini and Ocean Cay. The proposed housing site is further described below.

A.1. Housing Units

Permanent housing for plant operators, supervisors, management and their families is proposed for a 10-acre site on South Bimini, as shown on Figure 2.19. The housing units will consist of several duplex and triplex units capable of housing up to 25 families. The housing will be constructed in a community style as depicted on Figure 2.20. Each housing unit will contain three-floors. The first floor will consist of the main entryway and dining and living area. The second floor of each unit will be constructed with two bedrooms while the third floor will be constructed as a loft, as shown in the floor plan included as Figure 2.20.

A.2. Recreational Facilities

Recreational facilities will be installed in the development, which may include basketball and tennis courts as well as playgrounds.

A.3. Utilities

AES is currently designing systems to manage sewage, water, trash, and electricity at the proposed housing location on South Bimini. The sewer system will consist of an approved septic tank and leaching system constructed according to The Bahamas Building Code. It is expected that the existing water system on Bimini will be used to supply water to the housing development in conjunction with a deep well system and storage tank. The water supply on the Biminis will be augmented by transmission of clean fresh water from the Ocean Cay desalination plant to the Biminis water system via the pipeline to be installed as part of the project. All systems will be developed in accordance with Bahamian and local regulations.

B. Ocean Cay

B.1. Housing Units

A hostel will be constructed on the north portion of Ocean Cay to house workers during their work shifts. Plant operators will reside on Ocean Cay during their scheduled shifts to limit the quantity of ferry traffic between Ocean Key and South Bimini. The hostel will be constructed in a dormitory style.

B.2. Recreational Facilities

Recreational facilities will be constructed in the vicinity of the hostel on Ocean Cay. These facilities may include basketball courts, softball field, or other assorted sports facilities.

B.3. Utilities

The housing area on Ocean Cay will be equipped with a septic system designed to process the volume of waste expected to be generated from the employees while stationed on Ocean Cay. Potable water will be supplied to the housing area from the desalination plant. Electricity for the facilities will be provided via the natural gas turbine generators associated with the LNG and desalination facilities.

2.4 Construction Techniques

For the purposes of this Section, the project has been organized into the following components:

- Island Expansion;
- LNG/LPG Terminal;
- LNG/LPG Ancillary Facilities;
- Pipelines; and
- Permanent Employee Housing.

The construction techniques proposed for each of the project components are described below.

2.4.1 Island Expansion

2.4.1.1 Site Preparation

As described in Section 2.3.1.1.A, site preparation activities will include mobilization to Ocean Cay of the temporary construction housing, sanitary services and other support vessels required during the construction phase of the project.

Dredge equipment and support vessels (tugs and fuel tenders) will be mobilized to the site along with aboveground storage tanks for fuel oil storage during the initial stages of site preparation. The majority of the personnel employed in the dredge operation are expected to reside on the dredge vessel. The fuel storage tanks will arrive in a ready for placement condition and will be installed and secured according to manufacturer's recommendation. The concrete batch plant will also be constructed during the initial phases of the project on Ocean Cay.

Prior to the set-up of the batch plant, two temporary wharves will be constructed at the batch plant site. Both sheetpile bulkheads will be driven using land-based equipment and tied back to a deadman (see Figure 2.21). The complete bulkheads will be about 27 m (88 ft) wide. They will be located in an area that will receive rock revetment as part of the shore protection installation. One temporary wharf will be used to moor the concrete batch plant while the other one will be used to load caisson and concrete armor units onto barges for transport to the placement site. The concrete batch plant will be set-up on a 75 m by 25 m (250 ft by 75 ft) barge on the southeast shore of the island. The features of the concrete batch plant and casting yard operation are shown on Figure 2.21. These temporary structures will be removed once the batch plant is no longer required and all caisson and concrete armor units have been constructed. Sand and gravel will be supplied by 5,000 ton hopper barges tied alongside the batch plant barge. Cement will be stored in silos on the barge. The mixed concrete will be delivered by pump to a minimum of four 9 m^3 (12 yd^3) transit mixers that will transport the ready to place concrete to the casting yard, tank farm or other construction site on the Island

The casting yard will be used primarily for fabricating the caisson units for the south seawall and the concrete armor units for shoreline protection. The casting yard will be set up to cast approximately two complete caissons per day and up to forty concrete armor units per day. The caissons will be constructed in four linear bays with concrete truck access lanes on one side of each bay. The caissons will pre-cast in five to six equal units, approximately 2 m high by 5 m wide by 7 m deep (6.5 ft by

16.4 ft by 23 ft). Once cast, these units will be cured and subsequently transported to barges to be assembled into monolithic units approximately 10 to 12 m (32 to 40 ft) in height.

It is anticipated that the concrete armor units will be unreinforced concrete armor units that will be placed on revetments along three sides of the island. These units will be cast in either 2 or 3 m^3 (2.6 or 3.9 yd^3) sizes. The units are easily manufactured with simple two piece forms. The units will be cured and stacked for placement as needed.

Water to supply the concrete batch plant will be provided by the barge mounted reverse osmosis (RO) unit to be set-up in the support vessel harbor during the initial phases of site construction. The RO unit barge will be moored and the intake and discharge structures for the unit will be placed in order to maximize the distance between the two lines. The intake manifold will be positioned about 1 m (3.2 ft) below the seawater surface. The discharge pipe will be positioned near the sea floor, in a previously dredged area of the Support Vessel Harbor, as described in Section 3.4.2. Temporary piping will be installed on the island to deliver water from the RO barge to the concrete batch plant and to other freshwater uses.

As the amount of on-site workers at Ocean Cay increases, temporary housing will be established using either a quarters barge or a cruise ship. The ship or barge will be moored off the east shore of Ocean Cay and a temporary bridge or floating gangplank will be constructed to shore. The ship will supply its own utilities to support the number of construction personnel housed on the unit.

Temporary construction toilet facilities consisting of incinerating toilets will be placed in several locations on Ocean Cay near the areas of construction to support workers while they are on the island. Comfort stations will also be erected to provide shelter from sun and heat, potable water, and cafeteria facilities in one or more locations on the island. The shelters will be temporary construction buildings or trailers.

2.4.1.2 Dredging

A. Approach Channel and Turning Basin Expansions

As described in Section 2.3.1.1.B, the project includes widening and deepening the existing approach channel and turning basin at Ocean Cay to accommodate the larger ships expected at the LNG/LPG terminal. The approach channel expansions will be performed primarily by use of Cutterhead Suction

Dredge (CSD) technology with some limited areas excavated by backhoe dredge. The limits of the existing approach channel and turning basin, and proposed expansion area, are shown on Figure 2.2.

The CSD is one of the most well-known, efficient and versatile types of dredging equipment available today. Typical CSD vessels are shown on Figure 2.22. CSDs can efficiently dig and pump all types of alluvial material and compacted deposits as well as rock-like formations. The CSDs proposed for this project are expected to be sea-going vessels capable of travelling long distances to mobilize at the project site.

A CSD is a stationary dredge anchored at its stern by two heavy “spud poles”. One of these spuds (the main spud) is always lowered to the seabed in order to keep the dredge in position. The main spud is usually mounted in a central spud carriage that enables the dredge to proceed approximately 6 m (19.7 ft) before retracting and replacing the spud at the next location. Environmental impacts from anchoring are discussed in Section 5.2.4.1.

The “cutterhead” of the CSD is a rotating cutting device that surrounds the intake end of a suction pipe (Figure 2.23). The cutter is usually in the form of an open basket, which may include blades or cutting teeth. As the cutter rotates around a longitudinally mounted shaft, it disintegrates and loosens the seabed material and places it in a velocity stream at the suction intake.

A heavy suction arm (ladder) will be connected to the hull with hinges and can be accurately lowered or hoisted with a heavy gantry and a winch. One or two centrifugal dredge pumps will be installed in a pump room and some dredges may also have a submerged pump on the ladder, located as close as possible to the entrance of the suction pipe. The cutterhead will be connected near the entrance of the suction pipe and will be driven mechanically by an engine and a shaft along the ladder, or directly by a submerged motor. With two side anchors connected on either side of the ladder, the dredge can swing an arc around the spud pole, accurately excavating the desired locations.

The dredged material will be transported to the reclamation site using a floating pipeline. The dredge pumps will provide suction power for the dredged material to be transported from the intake to the reclamation site. Additional booster pumps may be provided along the pipeline, where the pumping distance is greater (e.g. when the CSD is working at the western extent of the approach channel).

The hydraulic pipeline that will be used to carry the dredged material to the reclamation site will likely consist of three different sections. The first section will be a steel pipeline segment. The second section will be a floating or partially submerged synthetic flexible pipeline extending from the steel pipe end to Ocean Cay. The third section, known as the shore pipe, will be located onshore where the slurry will be placed at the reclamation site. Depending on the bathymetry and sea conditions, part of the pipeline may be placed on the seabed; however, the floating pipeline will provide increased mobility for the operations. The pipeline will be inspected prior to each work shift to confirm that it is in good condition and that all pipe connections are secure and not liable to leak or break apart.

The solids content of the slurry will depend on the design of the cutterhead, physical characteristics of the dredged material, and operational factors such as pumping distance. When the dredged material is initially deposited at the reclamation site, it may occupy more than its original volume. The settling process is a function of time, but the material will eventually consolidate. At Ocean Cay, the dredged material will be mainly rock and settlement is likely to occur significantly faster than if it were sand.

Considering the volume of material to be dredged (approximately 6 million cubic meters [8 million cubic yards]) and depending on the finalized construction schedule requirements, one or two CSDs will be employed at Ocean Cay. The CSDs will have at least a 863-mm (34-inch) diameter cutterhead. Due to the nature of the seabed, each CSD will likely have a minimum total power of 20,000 HP with a cutterhead power of 4,000 HP. The normal daily production rate for one CSD of this type is approximately 7,000–16,000 cubic meters (9,000-21,000 cubic yards) per day.

Based on geotechnical information on offshore conditions gathered to date, it is likely that the dredging will be accomplished with very little or no blasting. Blasting is typically required when the compressive strength of rock is above 34,000 kPa (5000 psi). This assumption will be confirmed based on offshore borings and laboratory testing to be conducted August and September 2002. If blasting is required, it will be accomplished by a spud barge using air track or hydraulic percussion or rotary drill rigs to drill vertical holes, which will be 1.8 to 3.0 m (6 to 10 ft) deeper than the desired rock cut depth. The holes will be loaded with explosives from a barge through a sand pipe, or "Kelly Bar," with detonator delays. Following loading of the holes, the barge will be pulled back. A preliminary low energy detonation will be made to deter mobile sea life away from the blast area, followed by detonation of the production blast needed to break up the rock. The blasted rock will then be dredged using the cutterhead suction dredge and pipeline delivery method described above.

B. Caisson Shore Protection Structures

A trench for the caisson shore protection structures proposed at the southern end of Ocean Cay (see Section 2.3.1.1.D) will be constructed using backhoe dredge techniques. A backhoe dredge is a stationary dredge consisting of a hydraulic excavator mounted on a spud barge or a self-elevating platform. A typical backhoe dredge is shown on Figure 2.24. The type and size of the excavator bucket will be dependent on the dredging depth and the type of material to be dredged. A backhoe dredge is a stationary dredge, and requires considerably less space while dredging as compared with other dredging techniques.

The dredged material will be loaded onto a spud barge that will be pushed into location by a tug. The barge will be secured into position using the spuds and, if necessary, by deploying additional anchors. The backhoe will excavate the trench and load the dredge spoils into a barge or a bottom dump scow. The dredged material will be transported to Ocean Cay and off-loaded for placement. The trenching operation will start from the western boundary of the wall and proceed to the east. It is anticipated that the backhoe will be able to excavate any rock encountered during the dredging activities; however, if extremely hard rock layers are encountered blasting may be required prior to excavation.

2.4.1.3 Site Fill & Soils Improvement

As described in Section 2.3.1.1.C, Ocean Cay will be expanded to accommodate the planned project facilities and provide the necessary shore protection. The island size and elevation will be expanded through the use of dredged materials from the approach channel widening and deepening and the turning basin expansion. The reclamation activities will be sequenced in the manner outlined below, and as shown on Figure 2.25. Depending on the number of dredge(s) mobilized, there may be some overlap between these activities.

1. Reclaim and raise the LNG/LPG tank area to its design grade.
2. Reclaim the potential future power generation area (as shown on Figure 1.4) and the western boundary of the island and raise it to the design elevation.
3. Reclaim the northern portion of the island and raise it to its design grade.
4. Construct the cobble beach protecting the western coast of Ocean Cay.
5. Construct the cobble beach to protect the northern coast of Ocean Cay.
6. Stockpile excess dredge material on Ocean Cay and at the Excess Material Shoal.

The construction elements for the expansion of Ocean Cay include the following:

- Construction of dikes and control weirs;
- Fill placement (Reclamation);
- Construction of shore protection; and
- Implementation of ground improvements.

A. Dikes and Control Weirs

To control the discharge of fines and slurry water to the ocean, the entire reclamation area will be surrounded with dikes and control weirs. Dikes will be designed to confine a certain area and protect it against waves or from uncontrolled overflow. The containment dikes will be constructed along the perimeter of the reclamation area using dredged material from CSDs set at a low production rate and a spill barge with a downspout tube. If required, the outer wall of the containment dike will be reinforced using large imported rock. The containment dike will be constructed with one or more gaps to allow installation of weir structure(s). The control weirs will be used to discharge the excess water after settlement of fines occurs within the diked areas. The planned dike and control weir system is shown on Figure 2.26. A turbidity monitoring program will be implemented to prevent unacceptable levels of turbidity from being discharged from the weirs, as described in the Environmental Management Plan (Section 10).

B. Site Filling (Reclamation)

Construction will be staged such that the perimeter boundaries of the reclaimed land will be in place prior to filling of the interior regions of the island. To accomplish this, a series of small settlement basins will be constructed to establish the outer bounds of the area to be filled. Once these perimeter areas have been created by deposition of dredge spoils and stabilized, the larger inner basins will be used as self-contained settlement basins for subsequent filling operations. This method of construction will reduce the need for sediment containment and turbidity control normally required for filling in open waters. It will also result in most dredge spoils being placed and dewatered in their final location, reducing the need for re-handling of these materials. The planned dredge and site filling sequence is shown on Figure 2.25. Following dewatering, ground improvement activities will be conducted as described below.

C. Ground Improvements

Ground improvements will be required to prepare Ocean Cay for the construction of LNG/LPG tank systems and other planned site structures. One or more of the following ground improvement techniques will be used on Ocean Cay.

- Deep dynamic compaction;
- Drilled piles; and,
- Stone columns.

The preferred ground improvement technique(s) will be selected after the completion of the planned additional geotechnical investigations.

Test borings completed on the island indicate that portions of the existing sand deposit forming the island are relatively loose. In addition, dredged materials placed for land reclamation and grade raising will also be loose. These loose materials will not be suitable for support of proposed site facilities such as LNG and LPG tanks. Deep dynamic compaction (DDC) will likely be used to densify the sand that forms the existing island and the dredge spoils placed for land reclamation in order to support structures that will bear on shallow foundations.

DDC consists of repeatedly dropping a large weight, called a pounder, on the ground using a crane. It is anticipated that a pounder weighing approximately 27.2 metric tons (30 tons) may be dropped from a height of approximately 30 m (100 ft) to improve ground density to depths of up to about 13 m (43 ft) below ground surface. The pounder will be dropped at specific points using a grid pattern with an approximate 2.5 to 3 m (8 to 10 ft) spacing between points. The pounder will be dropped at each point until ground subsidence diminishes, which is anticipated to occur after 10 to 15 drops. Upon completing production densification with the heavy pounder, an ironing pass will be performed with a lighter pounder having a larger surface area to densify soils in the upper 2 m (6.6 ft). Test borings will be performed to confirm that adequate densification is achieved.

DDC will be performed over an approximate surface area of 52.5 hectares (130 acres). It is likely that three to four cranes would be mobilized to perform DDC simultaneously over a duration of approximately six months.

All DDC activities will take place on existing or reclaimed land after the dredge material has been placed and adequately drained. DDC will not be performed on cobble beach areas, revetments, or areas that will support the mining operations.

Planned foundations for the tanks, equipment and structures are reinforced concrete shallow type spread footing. If engineering analyses conclude that there is significant potential for large solution cavities in the bedrock, then shallow foundations may not be suitable for support of proposed tanks, equipment, and structures. Consequently, pile foundations will be required.

Although not currently planned, if pile foundations are required it is anticipated that piles would likely consist of 0.3 to 0.6 m (1 to 2 ft) diameter cast-in-place concrete piles. The piles would penetrate overburden and be socketed into bedrock. The piles would be advanced to depths of about 7 m (23 ft) into bedrock, which corresponds to total depths of about 14 to 17 m (46 to 56 ft) below ground surface. A typical spacing between piles will be approximately 1.5 - 2.5 m (5–8 ft). The actual areas covered and number of piles needed will be determined once the geotechnical investigations for final design have been completed.

Boreholes for the drilled piles will be advanced using drilling rigs equipped with augers or air-rotary drilling equipment. Drilling mud (primarily bentonite clay) will likely be required to stabilize boreholes during drilling in overburden. Once bedrock is encountered, a temporary steel casing will likely be advanced to the top of or slightly into bedrock. Casing or drilling mud may be required during drilling in rock to maintain an open borehole at locations where poor quality rock is encountered. Upon completion of the drilling, steel reinforcing will be lowered into the borehole and concrete will be placed through a tremie tube. The temporary steel casing will be removed during concrete placement as the concrete level rises. Casings will be cleaned on-site and reused at subsequent pile locations. Drilling spoils, consisting of soil, rock and drilling mud, will be collected and used as fill on the island. Water displaced by the concrete will be contained, filtered and checked for pH prior to discharge. Concrete for the cast-in-place piles will be generated at a temporary concrete batching plant located on barges adjacent to Ocean Cay.

Although not planned at this time, stone columns, if used, will be installed using a vibrator attached to the bottom of a series of extension tubes which will be suspended from a crane. Jetting water will be pumped to the top of the unit, will pass through the extension tubes and will enter jet pipes attached to the vibrator. The jet pipes will convey the water to the nose of the vibrator, where the water will help the vibrator to penetrate and liquefy the underlying soils. Additional jet pipes may be added to the outside of the extension tubes if necessary to assist in penetration and to ensure that the annulus around the vibrator remains open when using very long vibrators.

Rock for the stone columns may consist of material mined or dredged at the island. If material native to the island does not meet the strength and durability requirements for the stone columns, stone will be imported. Water generated as part of stone column construction will be contained on Ocean Cay and allowed to evaporate and infiltrate into the ground.

D. Shore Protection

As described in Section 2.3.1.1.D, a comprehensive shore protection system will be provided for the perimeter of Ocean Cay. The locations of the shore protection structures including T-groins, cobble beaches and the terminal structures are shown on Figure 1.4. The T-groins and terminal structures will be low-crested rubble mound structures that will be constructed using the conventional three-layer method (core, filter, and armor) on the north, west and northeast coasts of Ocean Cay. Typical cross section views of the shore protection are included on Figure 2.27. Concrete armor units will be used rather than rock armor because of the limited availability, high cost, and unreliable durability of large rock available from local quarries.

E. Excess Material Shoal

A shoal will be constructed to the south of Ocean Cay as shown on Figure 2.2 from the excess dredge materials not utilized during site reclamation. The material placed at this location may be 3,000,000 m^3 (3,902,000 yd^3). The material will be placed within a geotube perimeter as described in Section 2.3.1.1. Typically, geotubes are delivered to the site rolled up on a steel pipe. Inlet and outlets are generally positioned at regular intervals along the length of each geotube. The tube is usually filled with dredged material by directly connecting the end of the dredge pipe to the inlet of the geotube. The dredge material is pumped as a water-soil slurry using the dredge pumps. Geotubes are typically filled to 80% of their capacity. Geotubes will be installed along the perimeter of the excess dredge material stockpiling area, and weir structures will be built at strategic locations to help the dewatering process and minimize sedimentation to surrounding waters. Scour prevention countermeasures may be constructed prior to placement of the geotubes depending on the nature of the seafloor at the location of the shoal. Scour prevention countermeasures may include a scour apron consisting of crushed stone or placement of geotextile fabric.

The geotubes will be filled underwater using the dredged material. The tubes will be placed using a conventional stacking technique or by the continuous position and fill technique (filling a continuous tube on a barge and placing on the seafloor similar to pipeline laying methods). Once the perimeter is placed, remaining excess dredge material will be placed within the geotube frame to an elevation less than the height of the geotube perimeter frame. The geotubes will be removed once the excess dredge material has been harvested as part of the mining operations at Ocean Cay.

2.4.1.4 Support Vessel Harbor

A support vessel harbor (SVH) will include the components as described in Section 2.3.1.1.E. This facility will have the dual purpose of providing a protected berthing area during construction for material delivery barges up to 80 m (262 ft) length, and providing a permanent berthing facility for three large harbor tugs, one smaller mooring launch, and a ferry. The support vessel harbor will be one of the first features of the project completed to support the construction activities and equipment delivery. The sequence of construction will include the following:

- Dredging for adequate depth;
- Erection of shore protection features; and
- Completion of onshore support systems.

The elements of the support vessel harbor construction and the proposed construction techniques are shown on Figure 2.28 and described below.

A. Dredging

The SVH will be dredged to a nominal depth of 6 m (19.7 ft) MLLW using CSD or the backhoe dredge, as described in Section 2.4.1.2. The dredging of the SVH will be performed prior to the dredging of the approach channel and turning basin. Materials removed during the dredging operation will be used for island expansion as described in Section 2.3.1.1.

B. Shore Protection Features

Shore protection features will include caissons (or equivalent) to the southeast within the SVH area as shown on Figure 1.4. Shore protection features at the south side of Ocean Cay will also include a caisson wall as shown in Figure 1.4 (or equivalent).

The concrete caisson system will consist of large pre-cast "U-shaped" reinforced concrete caissons. Each caisson is envisioned to be approximately 5 m (16.4 ft) long, 7 m (23 ft) wide, and 10 m (33 ft) to 11 m (36 ft) high. The final dimension of each unit will be defined during the design process and will depend on selected design criteria as well as constructability considerations. Each unit will weigh approximately 250 metric tons (280 tons).

The caisson units will be placed in a 1.0 m (3.2 ft) deep trench excavated into the bedrock. Prior to the placement of the caisson, a layer of bedding stone will be placed in the trench to achieve a level base. Once several caissons are in place, the trench will be filled with tremie concrete to firmly secure the base of the caissons to the bedrock. The tremie concrete will also seal the voids between the bedding gravel and will reduce the dynamic uplift forces. The caisson units will be back-filled using dredged material. The caissons will be capped using a pre-cast concrete slab with a setback curved parapet wall. To reduce the overtopping rate to manageable levels, the parapet wall is expected to extend 2.0 m to 2.5 m (6.6 to 8.2 ft) above the top of the caisson. The caisson will be designed to withstand the design wave conditions without significant damage.

C. Onshore Support Systems

The SVH berths will be provided with electrical power, diesel fueling capability, and other utilities to service the terminal support vessels. Diesel fueling capability will be provided from aboveground storage tanks with integral secondary containment. The tanks will be installed on a concrete pad placed near the harbor area, as shown on Figure 1.4. These tanks will store fuel oils that will be dispensed to equipment, generators, and other fuel uses during construction. All fuel piping will be aboveground. Fuel handling and transfer procedures are described in the Integrated Spill Control, Response, Pollution Prevention and Storm Water Management Plan (see Section 10).

A building for security/immigration personnel will be constructed near the SVH. This building will be of typical concrete block construction with a foundation slab on grade. Additional information relative to the security building is found in Section 10, Environmental Management Plan.

2.4.2 LNG/LPG Terminal

2.4.2.1 Berthing/Receiving

Marine facilities will include two berths for gas carriers, one for LNG and one for LPG tankers, as described in Section 2.3.1.2. The construction process will include:

- Installation of LNG Berth including;
  - loading platform,
  - three breasting dolphins,
  - six mooring points on the caisson wall,
  - access trestle, and,
  - walkways;
- Installation of LPG Berth including;
  - loading platform,
  - two breasting dolphins,
  - six mooring points on the caisson wall,
  - access trestle, and,
  - walkways.

The planned construction process is described below.

A. LNG Berth

The LNG berth will be designed to accommodate LNG vessels ranging in size from 120,000 to 160,000 m^3 (754,773 to 1,000,000 bbl). As described in Section 2.3.1.2, the LNG berth will consist of a loading platform, three breasting dolphins, six mooring points on the caisson wall, an access trestle for vehicles and a pipeway. The loading platform will include four LNG unloading arms, ship access gangway and piping as required. The LNG berth will also include a walkway from the berthing platform to the breasting dolphins and from one breasting dolphin to the caisson wall to provide two means of egress from the loading platform.

It is anticipated that forty-two steel pipe piles 610 mm (24 in) in diameter will support the platform. Typical offshore pile cross sections are shown on Figure 2.29. All piles will be coated with an epoxy coating to protect against corrosion. In addition, a comprehensive cathodic protection system will be provided.

Each breasting dolphin for the LNG berth will measure approximately 12 m (40 ft) long by 9 m (30 ft) wide in plan with the top elevation at +7.0 m (23 ft) MLLW. The length of the dolphin is arrived at by the choice of foam-filled fender, which is 10.6 m (34.8 ft) long. The dolphin will be supported on eighteen piles arranged in four rows. Typical offshore pile cross sections are shown on Figure 2.29. Most piles will be driven at a batter of 1:4, with the piles battered to the south (towards the ship). The batter is required to develop resistance to the large horizontal forces imposed on the dolphin by berthing, mooring, and seismic loading conditions. The deck of the breasting dolphin will be cast-in-place concrete at a thickness of 2 m (6.6 ft). Reinforcing cages will connect the top of the concrete-filled piles to the deck.

The access trestle will consist of an approximately 10 m (33 ft) wide deck, divided into a 4 m (13 ft) wide roadway and a 6 m (19.7 ft) wide pipeway. It will be a pre-cast/cast-in-place concrete superstructure supported on steel pipe piles.

The piles will be drilled from the deck of a “jack-up” barge that will be floated into location and then raised on legs, approximately one to two meters above the water. Use of a jack-up barge provides a stable and safe working platform, thus reducing the probability of accidents and resultant potential adverse environmental impacts.

All drilling operations for pile installation will use permanent steel casings that will extend from the jack-up barge through the water and into the rock floor of the turning basin. To limit the risk of drilling fluids being discharged, the casing will be seated a distance of about 1 m (3.3 ft) into the top of bedrock to create a secure seal at the bottom of the casing. If the top of bedrock is relatively soft, the casing will be driven to seat it into rock prior to drilling. However, if the rock is too hard to permit driving, the casing will likely be driven through sand overburden to the top of bedrock, and a borehole slightly smaller than the casing diameter will be advanced into the bedrock from within the casing. The casing will then be driven through the rock borehole to the seating depth. Once the casing is seated, the borehole will be advanced further by drilling to the required depth. Drill cuttings will be collected and contained on the barge and disposed of on Ocean Cay.

Drilling fluids will be contained on the deck of the barge within a tank. Drilling fluids will be a non-toxic, biodegradable material, such as Bio-Bore™, or equivalent. Material Safety Data Sheets for Bio-Bore™ are presented in Appendix F. Drilling fluids and spoils pumped into the pile casings will be circulated back to the deck within the sealed casing, and returned to the barge tank. Once the drilling operations are complete the remaining drilling fluids will be placed in a temporary impoundment on Ocean Cay. The water will be allowed to evaporate and infiltrate and then the solids will be incorporated into site fill.

Upon completion of the drilling, a reinforced, epoxy-coated, steel cage or steel H pile will be lowered into the casing and concrete will be pumped and placed through a tremie tube. The top of concrete will extend at least partially into the permanent steel casing, and may extend to the top of casing, depending on the design. Piling caps will be formed and constructed on completed pile groups.

B. LPG Berth

The LPG berth will be designed to accommodate LPG vessels ranging of sizes ranging from 29,000 m^3 to 80,000 cubic meters (182,000 to 500,000 bbl). As described in Section 2.3.1.2, the LPG Berth will consist of a loading platform, two breasting dolphins, six mooring points on the caisson, and an access trestle for vehicles and a pipeway. It will also include a walkway form the berthing platform to the breasting dolphins and from one breasting dolphin to the caisson to provide two means of egress from the loading platform.

It is anticipated that twenty steel pipe piles 610 mm (24 in) in diameter will support the platform. Typical offshore pile cross sections are shown in Figure 2.29. All piles will be coated with an epoxy coating to protect against corrosion. In addition, a comprehensive cathodic protection system will be provided. Each breasting dolphin for the LPG berth will measure approximately 9 m (30 ft) long by 8 m (26.6 ft) wide. The dolphin will be supported on fourteen piles arranged in four rows. Most piles will be driven at a batter of 1:4, with the piles battered to the south (towards the ship). The batter is required to develop resistance to the large horizontal forces imposed on the dolphin by berthing, mooring, and seismic loading conditions. The deck of the breasting dolphin will be cast-in-place concrete at a thickness of approximately 2 m (6.6 ft). Reinforcing cages will connect the top of the concrete-filled piles to the deck.

The access trestle will consist of an approximately 10 m (33 ft) wide deck, divided into a 4 m (13 ft) wide roadway and a 6 m (20 ft) wide pipeway. It will be a pre-cast/cast-in-place concrete superstructure supported on steel pipe piles. Construction methods employed for the LPG berth will be similar to that used to construct the LNG berth, as described above.

2.4.2.2 LNG/LPG Storage

LNG will be stored in two 160,000 m^3 (1,000,000 bbl) tanks situated within secondary containment earth berms in the southwest portion of Ocean Cay. LPG will be stored in a 40,000 m^3 (250,000 bbl) tank also situated within a containment area. The tanks will be designed and constructed according to the requirements of API 620 Appendix Q, as described in Section 2.3.1.2.C. Construction of the tanks will include the following:

- Site Preparation;
- Outer/Inner Tank Construction; and
- Inspection and Corrosion Protection.

A. Tank Construction Overview

The initial site work will concentrate on the soils improvement and foundations for the storage tanks, as described in Section 2.4.1.3. The concrete ring wall sections will be formed and poured, and structural fill will be placed inside the ring wall. The settlement monitoring embedments, foundation-heating conduit, temperature sensing conduit and temporary construction drains will be installed and the sand cushion will be placed inside the ring wall.

After the tank foundations are complete, construction will begin on the steel outer tank bottoms, the outer tanks and the outer tank roofs. After the outer tank roofs have been raised into position, insulation will be installed for the tank bottom and then the inner tank construction will be completed. Once the inner tank has been completed, insulation will be installed into the annular space between the inner and outer tank. Piping on the outside of the tank and the tank roof will be installed during inner tank construction. The tanks will be hydrostatically tested after completion of the inner tanks. Hydrostatic testing procedures are described below.

The “bulk” materials, including piping, insulation, electrical and instrumentation, will be received on-site in order to meet the work schedule. Subassembly (spooling) of pipe will begin as the pipe and fittings are received. Mechanical, electrical and instrumentation work will be concurrent with or closely follow pipe erection. Following the completion of pipe testing, pipe painting and insulation will be conducted concurrent with electrical and instrument installation.

The exteriors of the tanks will be provided with corrosion protection by painting or galvanizing all metal structures as follows:

- Shop blasting and priming will be performed on all exterior surfaces of the tank steel except the LNG inner tank 9% nickel material.
- The LNG/LPG storage tank structural steel will be painted with the exception of the galvanized items.
- Anchor bolts for LNG/LPG tank foundations will be galvanized.

As the process, mechanical, electrical and instrumentation work is completed, pre-commissioning activities will begin. Instruments will be calibrated before loop checks of the electrical and instrumentation circuits are completed. When the pre-commissioning activities are completed, the tanks and systems piping will be cleaned, hydrostatically tested (as described below), and then undergo a nitrogen purge. A temporary nitrogen generator will be brought to Ocean Cay for this application. When the facility is ready for the first shipment of fuel the tank will be purged of nitrogen gas and then cooled down using LNG or LPG as applicable. This will require a loaded LNG or LPG ship, as applicable, with onboard regasification equipment to be furnished for approximately five days for the cool down and subsequent filling of the tank.

Equipment required for construction of the LNG/LPG terminal will include 4 cranes ranging in size from 30-ton to 200-ton capacity, multiple portable welding units, scaffolding, equipment trailers and nondestructive test equipment. It is estimated that a maximum labor force of approximately 330 on-site personnel will be required for the tank and LNG/LPG systems construction. Site improvements, construction of the tanks and associated processing and delivery systems will take approximately 35 months.

B. Hydrotest Procedure

The LNG and LPG tanks and piping will be hydrostatically and pneumatically tested in compliance with the applicable codes that govern the pipe and/or tank design. Desalinated water from the temporary or permanent RO units and distribution system will be used for the pipe hydrostatic testing. Because sufficient quantities of desalinated water will not be available for hydrostatically testing the LNG and LPG tanks, the tests will be performed using seawater. Seawater will be obtained through the cooling water intake pipe installed west of Ocean Cay. The tanks will be cleaned of dirt and debris prior to the hydrotest. Each LNG tank hydrotest is expected to require 95,000 m^3 (25 million gal) of water; the LPG tank hydrotest is expected to require 40,000 m^3 (10.5 million gal) of water. Hydrotest waters will be filtered and discharged through Outfall 001. Following the hydrotest a potable water spray rinse (of approximately 380 m^3 (100,000 gal) per tank) will be conducted following the hydrotest. The rinse water will be filtered and disposed of through the wastewater discharge structure (Outfall 001). Flow rates during testing and discharge will be approximately 19,000 to 38,000 liters/min (5,000 to 10,000 gpm).

C. Tank Painting and Corrosion Protection

The exteriors of the tanks will be provided with corrosion protection by painting or galvanizing all metal structures. MSDS sheets for the coating materials are provided in Appendix F. Shop blasting and priming will be performed on all exterior surfaces of the tank steel except the inner tank 9% nickel material. The LNG/LPG storage tank structural steel will be painted with the exception of the galvanized items. Anchor bolts for LNG/LPG tank foundations will be galvanized.

2.4.2.3 Regasification/Sendout System and Ancillary Structures

The following discussion provides the general procedures in the construction of the LNG/LPG process system and ancillary structures.

A. Buildings

The structures associated with this segment of the project include the Auxiliary Equipment Building, the Administration and Warehouse Building, and the Compressor Building, as shown on Figure 1.4. The buildings will be constructed on concrete slabs and primarily composed of concrete block with a sloped concrete slab for the roof. Construction of buildings having block walls will begin as the foundation slabs are completed. Roof installation will begin as soon as the walls are completed. Interior walls, windows and doors, interior wiring, utilities, etc. will be added to the buildings as the exterior is completed.

B. Process Equipment

The techniques used to construct the foundations for the associated structures will depend on the soils bearing capacity of the selected site. Options for the foundations include the use of pile supports, spread footings, or strip foundations. Foundations will be constructed of reinforced concrete and designed according to standard engineering practices. Foundations for all process equipment and large machinery will be completed before the units arrive on-site.

This scheduling prevents temporary storage, extra movement and lifting all of which can damage the equipment. After the machinery is set on its foundation it is leveled and shimmed before securing the anchor bolts, with grouting being installed when the equipment manufacturer requires. Final alignment of rotating equipment will be performed after the final attachment of the pipe. As soon as possible after final alignment, pre-commissioning will begin with lubricant filling and initial electrical energizing for motor "directional rotation". The systems will then be placed in service to support the balance of plant start up activities.

C. Piping

Typically, pipe is pre-fabricated in segments (spools), which allows complicated pipe segments to be completed more easily and within weather protected structures. AES expects to have some pipe spools fabricated by a vendor off-site and will also produce some pipe spools on-site. Piping will be fabricated and installed according to ASME standards. Installation will conform to the final design plans and specifications. Welders will be qualified according to ASME Section IX.

Shortly after any process equipment is set and secured to its foundation, pipe attachment will begin. If the pipe is pre-fabricated, the final closure welds will not be completed until the equipment is set, to prevent pipe connection misalignment.

Long lengths of pipe that are installed on a pipe rack and/or structural supports often are installed “in position”. The pipe is laid on the pipe rack, after which temporary support rolls are installed so that the pipe lengths can be “rolled” during jointing or welding. When the jointing work on the long pipe rack lengths is completed the temporary support rolls are removed. Hydrostatic or pneumatic testing of the pipe is conducted as soon as valves and/or flanges are attached. All the cryogenic piping will be pneumatic tested.

Some process equipment is not included in the pipe hydrostatic testing for various manufacture’s reasons. When a pipe between two points is ready for hydrostatic testing, the pipe to equipment flange connections are loosened and test flanges installed. After the pipe test is successfully completed, the test flanges are removed and the pipe is reconnected to the equipment. Instrumentation that cannot withstand the hydrostatic test pressures is installed in the various pipes after they have been hydrostatically tested.

The pipe and mechanical installation work is expected to be performed at many locations within the terminal at the same time. Scheduling of the pipe work in an area is often determined by the deliveries of the major process equipment. The pipe that is installed from grade to the tank top platform will not be installed until after completing the platform. Pipe and plumbing work inside the buildings will be included as part of the building construction or will be scheduled for installation concurrent with the building interior work.

D. Systems Painting and Corrosion Protection

Piping will be delivered to either the job site or subcontractor for blasting and priming prior to erection on-site. Purchased items that will be installed within a building will use manufacturer's standard coating systems. The equipment to be located outside will have a coating system that is compatible with the project coating system and operating environment.

E. Electrical and Instrumentation

Electrical work inside the terminal will, in general, follow the pipe and mechanical installation. As the pipe racks are completed, and the majority of the equipment is set, power and instrument raceway is installed. Concurrently the Motor Control Center (MCC) equipment and the instrument marshaling cabinets are installed in the MCC.

With the raceway installation complete and the equipment set, the bulk control and power wiring installation will be completed. After all the equipment is placed in the MCC, the primary feeds from the main step-down transformers to the MCC and the feeds from the stand-by generator are installed and tested. As the bulk wiring installation is completed the testing and termination of the power wire is started. The electrical "roughing in" of various buildings is accomplished as part of the building construction and the building power panels are terminated as part of the power feed terminations.

Instrumentation work primarily involves installation of field mounted devices and wiring them to the terminals in the control panels in the control room. The field instruments consist of level gages, flow, pressure, and temperature measuring devices and transmitters, valve positioners, and gas/fire detectors. Instruments will be installed as permitted by the progress of piping and vessels. Instrument cables will be run in cable trays and separate trays will be required for electric power and instrumentation cables.

Instrument wiring is usually the last type of wiring to be installed. In addition to this wire being the most fragile, the locations of installation are usually the most complicated. Wiring "loop checks" and calibration of instruments are part of the pre-commissioning activities..

2.4.2.4 LPG Removal System

The LPG removal system described in Section 2.3.1.1.E will be constructed utilizing the same general construction methods as for the LNG systems. The LPG removal equipment will be located in a separate building of concrete block structure. As the process, mechanical, electrical and instrumentation work is completed, pre-commissioning activities will begin. Instruments will be calibrated before loop checks of the electrical and instrumentation circuits are completed. Piping systems will be tested pneumatically.

The LPG removal system will include a hot oil heater sized for a maximum capacity of 80 MMBtu/hr. The hot oil heater will be installed as part of the LPG removal system and will arrive on-site as a packaged unit. The unit will be installed on a shallow concrete spread footing.

2.4.3 LNG Ancillaries

2.4.3.1 Water Intake and Discharge System

As described in Section 2.3.1.3.A, the water intake and discharge system will consist of the offshore intake structure, the intake pipeline, the onshore pumphouse equipment, the discharge outfall pipe to the south side of Ocean Cay, and connecting piping. The construction techniques used to install these elements of the project will include the following:

- Offshore excavation and filling for anchoring the intake structure;
- Trenching (offshore and onshore) to install the intake line;
- Onshore trenching and near shore dredging at the turning basin to install the discharge outfall pipe;
- Construction of a concrete building to house pumps and screen systems; and
- Mechanical and electrical system installation for pumps and automated controls.

Offshore excavation for the intake structure and pipeline installation will be accomplished using a barge-mounted crane or a backhoe dredge. Excavation will be performed to accommodate the anchoring of the velocity cap structure, as shown on Figure 2.12. After the excavation is completed, the velocity cap will be lowered into place and anchored using piles prior to installation of the offshore pipeline. The bottom of the velocity cap structure will be 0.6 m (2 ft) below the intake pipe invert level. Fill materials (gravel) will be placed around the structure to keep it secured. To keep the fill materials in place, concrete mats will be placed over the fill and around the structure. Spoils from the excavation will be placed next to the excavation and used for fill during pipeline installation. Excess spoils will be directed to the island for reclamation purposes, or placed in the Excess Material Shoal. Potential impacts associated with the intake and discharge structure are discussed in Section 5.

Offshore trenching for the intake pipeline installation will be conducted using the same equipment used for dredging the approach channel, in addition a backhoe dredge will be used for near shore locations (less than 5 m (16.4 ft) water depth). The water intake pipeline system will consist of a 1.8 m (6 ft) diameter reinforced concrete pipe extending west from the pumphouse structure approximately 280 m (920 ft) to approximately 7.3 m (24 ft) of water depth. The undersea portion of the pipeline will be buried approximately 1 m (3.2 ft) below the seabed and will be covered with native material and concrete mats, where required, to prevent movement by currents and waves as shown on Figure 2.12. Excavation for the onshore portion of the pipe installation will be performed by conventional backhoe and clamshell crane. A temporary sheet piled embankment will be constructed along the pipeline route to the pump house. The intake pipe will then be laid over bedding material in standard lengths starting from the seaward end, aligning with the pump house at the other end. After the pipeline is in place, granular fill material will be placed around and over the pipe, followed by standard fill material, where required, and a concrete mat to secure the pipe in position. Shallow onshore trenching will be conducted using an excavator for purposes of installing the trash trough that will direct the material washed from the traveling screens to Outfall 002. The trough will be constructed with a slope to allow gravity drainage.

Excavation for purposes of installing the 5.5 m (18 ft) diameter discharge pipe Outfall 001 will be accomplished by using the cutterhead suction dredge (CSD). Trenching for the discharge pipe installation will be performed in a north-south orientation and will extend to a position located behind the caisson structure, as shown on Figure 2.14. Onshore, the discharge line will continue north from the caisson wall, and will be installed in an excavated trench. Excavation onshore will be performed by conventional backhoe techniques.

The reinforced concrete building and screen structures, as well as the mechanical and electrical system installations, will be constructed using commonly accepted construction techniques. All mechanical, electrical and instrumentation systems will be tested and commissioned in accordance with good engineering practices prior to being placed in operation..

2.4.3.2 Desalination Plant

The desalination plant, consisting of the seawater pretreatment, two 2-stage Reverse Osmosis units and associated storage tanks for potable, service and demineralized water will be constructed in the area shown on Figure 1.4. A concrete block building (or equivalent) will be constructed to contain the pretreatment systems and the RO units. It is anticipated that the RO equipment will be delivered as skid-mounted package units, which will be placed within the building. Piping and pumping systems will be installed according to commonly accepted construction methods and tested prior to commissioning. Instrumentation and electrical work will be completed within the building and tested prior to commissioning. Containment areas with chemically impervious floors will be constructed for storage of the acids and bases required to operate the RO unit.

Potable, service water, and demineralized water tanks will be constructed as described in Section 2.3.1.3.B. The tanks will be of standard steel construction on foundations suitable for the weight and dimensions of the tanks. Corrosion protection paint will be applied to the outside and inside surfaces, as applicable using spray application. The level controls and other instrumentation required for the operation of the RO system and associated tankage will be installed and checked prior to start-up, commissioning, and operation.

2.4.3.3 Electrical Generation

The on-site power generation plant will be installed to the north of the LNG tanks at the location shown on Figure 1.4. Concrete pad foundations will be prepared for the turbines. The three simple cycle gas turbines will be installed in parallel basis, with the shafts oriented south to north and the generators facing south with the stacks on the north side. Major erection work related to the power generation plant will proceed as follows:

- Gas turbine generator unit
- Inlet manifold and coupling cover
- Exhaust manifold and expansion joint
- Pipe rack assembly
- Mechanical package
- Electrical package
- Turbine enclosure
- Lube oil coolers
- Inlet air systems
- Interconnect piping
- Electrical conduit
- ISO-phase/DC bus assemblies
- Fuel gas system
- Miscellaneous systems

The turbines are expected to arrive at Ocean Cay as skid mounted installations, which will be placed on the concrete pads by a crane. The discharge stack for each of the turbines will be a self-supporting steel stack. The stacks will be equipped with sampling ports, ladders, platforms and electrical grounding. Construction will be consistent with the recommendations of the manufacturer.

Field-erected tanks include water storage tanks, and a fuel oil bulk storage tank. Each storage tank is a vertical cylindrical, field-erected steel tank supported on a foundation consisting of either reinforced concrete mat or a reinforced concrete ring wall supporting the tank bottom.

Piping for delivery of natural gas, fuel oil, and water for cooling will be installed using commonly accepted construction methods. Electrical cable to transformers and for distribution of electrical power on Ocean Cay will be installed at aboveground pole mounted locations throughout the facility. Instrumentation and system controls will be installed and checked prior to the commissioning of the turbine system. Prior to the gas turbine start-up, oil will be flushed through the lube oil system to remove scale and particulate from the piping. The flushed oil will return back to the oil reservoir where it will be filtered for reuse.

The performance test program will be conducted in accordance with the ASME PTC 22 (Performance Test Code). The test will be performed at base load and part load conditions for power output, plant heat rate, and plant air and noise emissions. The exhaust emissions will be tested in accordance with 40 CFR Part 60 for nitrogen oxides, sulfur dioxide and carbon monoxide. The testing for nitrogen oxides would be conducted at four different operating loads in accordance with 40 CFR Part 60 Subpart GG requirements. A stack test will be conducted during the first quarter of full power operation to certify the equipment manufacturer's performance specification. All instruments for the performance test will be calibrated before the tests. Accuracy requirements for all instrumentation and measurement systems will be in accordance with ASME PTC 22.

2.4.3.4 Stormwater Management System

The stormwater management system components and operation are described in Section 2.3.1.3.D. The primary features of the stormwater management system include three outfall locations, a storm sewer collection system (storm drains, catch basins, downspouts, underground piping) and oil/water separators. Construction of Outfall 001, also the location of the cooling water discharge, is described in Section 2.4.3.1.

The construction of Outfall 002 and 003 will be performed using construction techniques similar to those used for the onshore portion of the Outfall 001. Outfalls 002 and 003 will consist of concrete-lined ditches. The ditches for Outfall 002 and 003 will be excavated and sized to accommodate surface water from storm events, as described in Section 3. Each Outfall will have a sluice gate installed with manual controls and a flapper valve to prevent backflow during high sea conditions.

The oil/water separators will be installed using conventional installation techniques, at locations where stormwater has the potential to be contaminated with oils. The discharge from the oil/water separators will be directed to Outfall 001 only. Discharges will be monitored and tested according the Integrated Spill Control, Response, Pollution Prevention and Storm Water Management Plan (see Section 10).

2.4.3.5 Roads, Curbs and Sidewalks

Road work is typically the last item to be completed. This work will be scheduled after the heavy equipment (cranes, heavy haul trucks, etc.) have completed their work so as to minimize damage to the roadways by heavy equipment. The roadways will be of gravel construction.

2.4.3.6 Airstrip

The proposed airstrip will be designed based on C-130 aircraft loading. The airstrip will be built on reclaimed land that has been densified by DDC. The pavement section will likely consist of reinforced concrete over a compacted granular subbase. Details of the pavement section will be developed as project design proceeds.

2.4.4 Pipelines

2.4.4.1 610 mm (24 in) Gas Pipeline to Florida

The project will include construction of an offshore 610 mm (24 in) natural gas pipeline that will extend from Ocean Cay, The Bahamas, approximately 65 km (40 mi) west to the Exclusive Economic Zone boundary (EEZ) as described in section 2.3.1.4 of this EIA, and shown on Figure 2.17. The project will utilize pipe and materials manufactured in accordance with American Petroleum Institute (API) Standard 5L, with a factory applied coating. The project will be constructed in accordance with applicable regulations and standards for design, permitting, construction, testing, operation and maintenance.

Construction of the pipeline will include the following:

- Shore Approach and Shallow Water Construction;
  - Trenching,
  - Lowering,
  - Shorepull;
- Jetting
- Offshore Tie-In;
- Deepwater Construction
- Work Vessels
- Crossing of Third Party Cables; and,
- Hydrostatic Testing.

Due to the large variations in water depth encountered from Ocean Cay to the Straits of Florida, two different construction techniques will be required. A shallow water construction spread will be required to carry out the pipeline installation from the Ocean Cay shore approach to the beginning of the Bahamas slope, a length of 4.1 km (2.5 miles), in water depth up to approximately 30 m (100 ft). A deep water construction spread, employing a dynamically positioned vessel will be utilized to install the pipeline westward in the deeper waters. The proposed construction techniques are further described below.

A. Shore Approach and Shallow Water Construction Procedures

The shallow water installation and shore crossing will be carried out by an S-lay barge (Figure 2.30). The barge will be moved by anchors and may have spuds (pole anchors) for use in shallower sections. At the shore approach, the pipeline will be buried to a depth of 1 m (3.2 ft) by constructing a trench into which the pipeline is pulled and subsequently buried to the degree possible and will be covered with a double layer of articulated concrete mats as shown on Figure 2.31.

The procedure for the shore approach includes the following steps:

- Prepare a short trench in the rock at the island water line to ensure a smooth transition of the pipeline onto Ocean Cay.
- Install a winch onshore, anchored to a deadman, with a messenger line run from the barge to the winch using a workboat. The winch cable will then be pulled to the lay barge and connected to the pipeline pull head. The pulling operation will be controlled from the land-

based winch.

- As each pipe joint is welded together on the lay barge, the onshore winch (or barge winch) will pull the pipeline to shore along the trench bottom. Temporary floatation buoys may be added to the pipeline, thereby reducing submerged weight and resulting frictional resistance, in order to reduce pulling forces.
- The pipeline placed on the bedrock near shore will be covered by a double layer of articulated concrete mats (6.1 m x 2.4 m x 22.9 cm [20 ft x 8 ft x 9 in] thick) up to where the sand cover over the pipeline is 1 m (3.2 ft). The length proposed to be covered with concrete mats is approximately 400 m (1300 ft), thus requiring approximately 300 mats.

The pipeline extending west of the near shore area will be buried with low sand cover, using the jetting method. In areas where the depth of burial cannot be achieved due to the bedrock, articulated concrete mats will be utilized for cover as shown on Figure 2.31.

The 610 mm (24 in) pipeline will be buried to a minimum cover depth of 1 m (3.2 ft) in water depths up to approximately 30 m (100 ft). Trenching will occur between the near shore section described above and the beginning of the Bahamas Shelf. The trench will be constructed by jetting, as described below, and will have a depth of 1.7 m (5.6feet) with respect to the surrounding seabed. Typically in sand, the trench will be triangular in cross section with side wall slopes will be 1:4 and a top width of 14 m (46 ft), depending on the type of sand. Burial will be achieved by natural backfill with natural currents redepositing jetted materials in the trench over a short period of time.

B. Jetting

The method of trenching for installation of the pipeline out to water depths of 30 m (100 ft) will be jetting. Jetting will cause soils at the seabed to be fluidized by water jets and the soil-water medium will be removed by suction pump. The fluidized soil will be jetted clear of the trench. Jetting is appropriate where sand is the principal jetting material. Jetting equipment will consist of two main components: a floating work barge and a submerged jetting machine. The work barge will supply power, control and pressurized water to the jetting machine on the seabed. Water for fluidizing the soils will be provided by high-pressure pumps. A typical jetting equipment arrangement is shown on Figure 2.32.

The jetting machine will either ride on the seabed (a jet sled) or will ride on the pipeline guided by rollers. In either case, the work barge will provide the pull force for forward motion. The jetting machine will lift the pipeline upwards as it moves. Material will be removed from underneath and from the sides of the pipeline by the water jets and pumps, as described above. Multiple passes will be required to achieve trenching depths greater than 1 m (3.2 ft). The jets will usually be located facing to the front on the leading edge of the machine, also extending under the pipeline. The water will be emitted from nozzles typically 1.3 cm to 2.2 cm (1/2 in to 7/8 in) in diameter. Discharge pipes will have inlets under the pipeline. The outlets will be elevated above the pipeline and will be pointed upward and sideways, to cast the soils away from the trench on both sides. The discharge pipe will also be directed back into the trench, thus providing some backfill. A typical jet sled is shown on Figures 2.32 and 2.33. Potential impacts associated with jetting are discussed in Section 5.

C. Offshore Tie-In

The shallow section installation will end at the Bahamas Bank, and a point will be designated for the tie-in with the pipeline to be installed by the deep water methods. The tie-in point will occur in water depths of between 30 and 40 m (100 and 130 ft) to the west of Ocean Cay.

The shallow water lay barge will install the pipeline up to the tie-in point, where the pipe will be fitted with an end cap (with buoyed cable for retrieval) and will be laid on the sea bed. The deep water lay vessel will pick-up the end of the pipeline and position it on the assembly ramp. The end cap will be cut-off and the tie-in weld will be performed. The deepwater vessel will then lay the pipeline as described below.

D. Deep Water Construction

The deepwater installation of the pipeline will be carried out by a dynamically positioned vessel as shown in Figure 2.34. The deepwater installation operations will start at the Bahamas Shelf tie-in point and will be a continuous operation up to the tie-in point in the vicinity of the EEZ boundary.

The pipeline will be installed by a lay barge designed especially for this type of marine construction. The lay barge will be a floating work platform. The lay barge will be supplied with 12.2 m (40 ft) joints of pipe that have been corrosion and concrete coated as designed for the bottom conditions. The pipe will be transported from an onshore facility directly to the lay barge by marine pipe haul vessels. The pipe joints will be moved onto assembly-line conveyors and welded together to make one continuous pipeline. Each pipeline weld will be inspected to verify its integrity.

At welds, corrosion coating will be added and the gap in the concrete coating at welded field joints will be filled with quick-setting concrete or other suitable material. The purpose of the filler will be to replace weight lost by the gap in the concrete and to provide a continuous protective coating around the pipeline.

At designated intervals, a pipe joint with a pre-installed sacrificial anode will be inserted into the pipeline. The anodes will be nearly flush with the outside diameter of the concrete coating. The anodes will provide cathodic protection that will protect the pipeline against corrosion.

When each station in the assembly line has completed its task, the lay barge will advance, a new pipe joint will be added to the line, and the assembly process will be repeated. The lay barge will advance by pulling on mooring anchors. Bow anchors will usually extend several thousand feet ahead of the lay barge. These bow anchors will provide the majority of the traction for pulling the barge forward. In addition, breast anchors and stern anchors will provide lateral stabilization and holdback, respectively. The deepwater lay barge will advance using its thrusters.

During Installation, the pipeline will have a controlled, unsupported span from the barge stern to seabed. This span will be maintained in an appropriate configuration by use of a “stinger” connected to the lay barge stern and tension applied to the pipeline by equipment on the lay barge, as shown in Figure 2.35.

If necessary, in congested areas, an escort vessel may accompany the lay barge. Its purpose will be to ensure pleasure craft and commercial vessels sharing the site will be kept fully aware of the construction work and any temporary access restrictions.

E. Work Vessels

As discussed above, the pipeline will be installed in deep water by a lay barge designed especially for marine work. The lay barge and its support vessels are termed the pipeline spread, which will include:

- Lay barge;
- Survey vessel;
- Two or more anchor handling tugs;
- Two or more pipe supply barges;
- Escort boats (if required);

- Personnel carriers; and,
- Utility launches and other marine support equipment as required.

Lay Barge

The lay barge has a wide range of highly specialized marine construction equipment. The principal equipment typically includes (see Figures 2.30 and 2.34):

- Heavy-duty derrick (crane);
- Pipe storage racks;
- Pipe conveyor system;
- Welding and non-destructive testing stations;
- Hydraulic pipe tensioner(s);
- Hinged support ramp for lowering pipeline off the stern (the stinger);
- High-capacity pulling winch;
- Pipe lifting davits;
- Diving support facilities; and,
- Heavy-duty mooring winches.

The vessel is highly autonomous and can work offshore for months without port calls. It will be equipped with sleeping quarters, messing, medical, recreation and other facilities necessary to support continuous work offshore. The vessel will work around-the-clock, usually alternating in two 12-hour shifts. Fuel will be provided by tender barges.

The core operating crew specializes in offshore pipeline construction and typically has performed similar work in many U.S. and overseas locations. The majority of the crew will live aboard. Personnel and materials will be brought to the lay barge by support vessels or by helicopter.

Survey Vessel

The survey vessel is anticipated to be in the 38 m (125 ft) class or smaller. Survey vessels of this type will typically be equipped with the following basic survey instruments:

- High-accuracy radio positioning;
- Echosounder;
- Sidescan sonar;
- Magnetometer;

- Pipeline and cable locator; and,
- Navigation and positioning equipment and other survey support equipment.

Anchor Handling Tug

The tug's main function will be to deploy and pick up mooring anchors, but it also will be used to tow material barges, for emergencies and other tasks. The tugs typically will have the following equipment:

- Navigation and positioning equipment;
- Heavy-duty winch capable of lifting mooring anchors; and,
- Heavy-duty wire rope and shackling and other support equipment.

Pipe Supply Barge

The supply barges are simple flat-top barges. They typically will not have propulsion, but will be hauled by the anchor handling tugs. Line pipe and other materials will be loaded onto the barges at a suitable port, hauled offshore to the lay barge and offloaded by the barge's derrick.

Escort Boat

The escort boat will likely be a vessel in the class of a harbor pilot boat. It will accompany the pipelay vessel, if deemed necessary, to keep other vessels fully aware of the barge's movements. Should any vessel (such as a pleasure yacht) inadvertently enter the construction area, the escort boat will sail out to that craft and advise them of safety procedures.

Personnel Carriers and Utility Launches

These are common utility vessels of small class capable of transporting personnel and light materials to and from shore. They typically will be chartered from local areas.

F. Crossing of Third Party Lines

A hazard survey was conducted to identify potential cables or pipelines that will be crossed by the pipeline. The following table lists the cables that will be crossed by the project.

Table 2-6

Hazard Survey Identified Foreign Lines

Name	Type	Status	Easting (feet)	Northing (feet)	Water Depth (feet)	Crossing Angle (degrees)	Seabed Type
US – Cuba – 7	Telecom Cable	Active	2,111,664	9,272,783	2,788	50	Sand Over Rock
SAM-1 Seg I	Telecom Cable	Active	2,080,110	9,307,538	2,624	85	Sand

The owners of confirmed foreign lines will be contacted, as will the authorities having regulatory jurisdiction. After initial fact-finding sessions, AES will propose detailed crossing methods to the appropriate foreign line owner/operator or regulatory authority. Normally, crossing will be achieved by placing concrete mats over the cable as shown in Figure 2.36.

G. Pipeline Hydrostatic Testing

Testing of newly constructed natural gas pipelines is required and will be conducted in accordance to ANSI B31.8 – Gas Transmission and Distribution Piping Systems. The proposed testing medium will be fresh water from the desalination plant on Ocean Cay, as described in section 2.3.1.3.B. Testing of the pipeline will be carried out once the complete line from Ocean Cay to Dania Beach, Florida has been installed. The proposed testing sequence will be the following:

- The ends of the test section will be fitted with hydrotest heads. These allow insertion and removal of pigs, for filling with test water, emptying, measurement of pressure and temperature, and other tasks.
- A filter and pumping unit will be staged at the Ocean Cay end of the pipeline.
- A temporary pig receiver, drain line and vents will be staged at the Dania Beach, Florida terminus. A portable compression station (containerized units and portable offices will also be installed temporarily at this location).

A pig is a device that can attain a sufficient seal inside the pipeline such that pressure behind the pig will propel it forward in the pipeline. Prior to hydrostatic testing, a gauging plate or similar device will be installed on a pig and pushed through the pipeline. The diameter of the pig's sizing plate will normally be a small percentage less than the inside diameter of the pipeline. This plate will verify that the pipeline did not sustain any unforeseen damage during the installation process. Water will be used to propel the gauging plate pig and to fill the pipeline for the hydrostatic test. The pipeline will be hydrotested for 24 hours at 1.25 times the design pressure.

The following additives may be used for the purposes indicated:

- Corrosion inhibitor: coats inside steel surface to inhibit normal corrosion process;
- Oxygen scavenger: removes oxygen from test water, greatly reducing corrosion rate; and/or,
- Micro-biocide: removes bacteria that might pose a corrosion hazard from substances secreted.

The additive types, concentrations and management procedures for discharge of the hydrotest water will be determined during the final design process. After the testing is complete, the water in the pipeline will be filtered, treated (as necessary) and discharged at the Ocean Cay discharge point (Outfall 001). The pipeline will be dried using several dewatering pigs.

H. Construction Schedule and Manpower

After receiving all regulatory permits and approvals, AES plans to start construction on the natural gas pipeline to Florida in the third quarter of 2003. The total anticipated offshore work force will be approximately 385 workers on the marine lay barge spread including client representatives, which may include up to 10 inspection and management personnel. The total number of personnel required on land for the shore pull is anticipated to be approximately 15 workers.

2.4.4.2 60 mm (2 in) Gas Pipeline and 219 mm (8 in) Potable Water Pipeline to Bimini

Up to 76,700 standard cubic meters per day (scmd) (2.71 million standard cubic feet per day [scfd]) of pipeline quality natural gas and 1,893 m^3/day (500,000 gallons per day) of potable water will be transported from Ocean Cay to North Bimini via a 60 mm (2 in) natural gas pipeline and a 219 mm (8 in) potable water pipeline. A single shallow water construction spread will be required to carry out the pipeline installation from the Ocean Cay shore approach to North Bimini Island, a length of 38.4 km (23.9 mi) as shown on Figure 2.18. Most of the route length lies in water depth of approximately 5 m (16 ft) or less, with one location reaching a depth of 12 m (40 ft). Due to the shallow waters, the lay barge will be equipped with spuds. The pipeline will be designed, constructed and operated in accordance with applicable international and local codes and standards.

Construction of the pipelines will include the following phases:

- Shore Approach at Ocean Cay;
- Pipeline Installation;
- Offshore Tie-In;
- Shore Approach at North Bimini;
- Onshore portion at Bimini; and
- Hydrostatic Testing.

The offshore pipelines will extend from Ocean Cay to North Bimini Island, following an approximately south-north route and keeping to the east of the Cays, on the Bahamas Bank as shown on Figure 2.18.

A. Shore Approach At Ocean Cay

The shallow water installation and shore crossing will be carried out by an S-lay barge. The shallow water installation and shore approach of the natural gas and water lines to Bimini will be very similar to the construction activities associated with the shore approach for the 610 mm (24 in) pipeline.

The route survey shows that the approach to the west of the island is sand up to approximately 400 m (1300 ft) from the shore, in water depths of about 5 m (16.4 ft), but with bedrock at approximately 1.5 m (4.9 ft) below the sand. For the final 300 to 400 m (1000 to 1300 ft) to the Ocean Cay shoreline, the bedrock is exposed with no sand cover. Due to the shallow exposed rock, a trench will not be made and the following shore approach is proposed:

- Prepare a short trench in the rock at the Ocean Cay water line to ensure a smooth transition of the pipeline onto the island.
- The shallow water lay barge will be positioned in line with, and stern to, the trench and as close to shore as its draft and tidal conditions allow.
- A winch is installed onshore, anchored to a deadman, with a messenger line run from the barge to the winch using a workboat. The winch cable will then be pulled to the lay barge and connected to the pipeline pull head. The pulling operation will be controlled from the land-based winch.
- The pipeline on the bedrock near shore is to be covered by a layer of articulated concrete mats (6 m x 2.4 m x 23 cm thick [20 ft x 8 ft x 9 in]) out to the point where the sand cover is at least 1 m (3.2 ft). This length is approximately 400 to 500 m (1300 to 1600 ft), thus requiring approximately 65 to 80 mats (laid length-wise).

- The pipeline west and north of this area will be buried with sand cover. The burial will be carried out by jetting.

As each pipe joint is welded together on the lay barge, the onshore winch (or barge winch) will pull the pipeline to shore along the trench bottom. Temporary floatation buoys may be added to the pipeline, thereby reducing submerged weight and resulting frictional resistance in order to reduce pulling forces.

After the pipeline has been pulled ashore, the lay barge will begin normal pipe lay, moving away from Ocean Cay along the pipeline route to North Bimini. The pipeline will then be post-lay trenched along the entire route, as described in Section 2.4.4.2. In areas where the depth of burial is not possible to achieve due to the bedrock, articulated concrete mats will be used for cover.

B. Pipeline Installation

The pipelines to North Bimini will be installed by a lay barge designed especially for this type of marine construction. The lay barge will be a floating work platform. The trench to place the pipelines will be created by the jetting process described in detail previously with respect to the construction of the 610 mm (24 in) pipeline. The lay barge will be supplied with 12.2 m (40 ft) joints of pipe that have been corrosion coated as designed for the bottom conditions. The pipe will be transported from an onshore facility directly to the lay barge by marine pipe haul vessels. The two pipelines, the 51 mm (2 in) gas line and the 203 mm (8 in) water line, will be fabricated in parallel. The pipe joints will be moved onto assembly-line conveyors and welded together to make one continuous pipeline. Each pipeline weld will be inspected to verify its integrity. Then, corrosion coating will be added at each weld and the gap in the coating protection at welded field joints will be filled.

At designated intervals, a pipe joint with a pre-installed sacrificial anode will be inserted into the pipeline. The anodes will provide cathodic protection for pipeline against corrosion.

When each station in the assembly line has completed its task, the lay barge will advance, a new pipe joint will be added to the line and the assembly process will be repeated. The lay barge will advance by pulling on mooring anchors, positioned in pre-established locations by anchor-handling tugs. Bow anchors will usually extend some hundred meters ahead of the lay barge. These will provide most of the traction for pulling the barge forward. In addition, breast anchors and stern anchors will provide lateral stabilization and holdback, respectively. In the shallower waters (2 to 3 m depth [6 to 10 ft]), spuds will be used to stabilize the barge.

During installation the pipeline will have a controlled, unsupported span from the barge stern to seabed. This span will be maintained in an appropriate configuration by use of a "stinger" connected to the lay barge stern and tension applied to the pipeline by tension equipment on the lay barge. Due to the shallow water, the stinger may be a short fixed ramp. In areas of established marine traffic, an escort vessel may accompany the lay barge similar to the 610 mm (24 in) pipeline operations.

The pipeline will be installed by jetting using the venturi method. The venturi excavator is a simple reverse jet pump, which uses a high-pressure nozzle to generate a localized and rapid high-volume blowing device.

The excavation tool will be deployed from the vessel crane, or a dedicated launch and recovery system, to just above the pipeline. The column of water from the tool excavates the seabed without any physical contact with either the seabed or any structures such as pipelines, which makes this method of excavation very low risk to the pipeline. The jet uses seawater pumped from equipment placed on the support vessel. Monitoring and control of the excavation will be achieved using a Seabat 9001 multibeam sonar (or similar instrument) mounted on the tool. This device will be able to show the workface beneath the tool during excavation, and provides the operator on the surface with a real-time image of the seabed.

The excavation will be about 1.4 m (4.6 ft) in depth to provide 1.2 m (4 ft) cover on the gas pipeline. In sand, the trench would be triangular in cross section with side slopes of 1:4 and a top width of 10 m (32 ft). The venturi excavator will have a 152 mm (6-inch) diameter outlet and a normal water velocity of 14 m/s (50 ft/s). The tool excavates by dispersing the soil laterally across the seabed. The plume of soil in the water column will depend on the soil type, and the prevailing current. As the soil is not lifted up to surface and then discharged, the soil plume never reaches the surface. With sand materials, it is expected that the material will drop out of suspension in the close vicinity to the excavation area. As the sand is suspended by the water jet, the pipelines will be placed at the bottom of the excavation. The pipe will be backfilled by the natural movement of sands on the ocean floor due to currents. Potential impacts associated with the pipeline installation are discussed in Section 5.

C. Offshore Tie-In

The lay barge will start the pipeline installation at Ocean Cay and proceed to North Bimini. Once the lay barge reaches the near shore location of North Bimini, approximately 700 to 800 m (2300 to 2600 ft) from shore, the pipelines will be capped and laid on the sea floor. This will be necessary because the same lay barge will carry out the shore approach at North Bimini.

When the lay barge from the shore approach operation at North Bimini (traveling west) reaches the location of the tie-in point, it will pick up the pipeline and maneuver the two ends together. When the two sections of pipeline are lined up, the end cap will be cut off and the tie-in weld will be performed. The weld will be tested, the joint will be coated, and the completed line will be layed within the trench.

D. Shore Approach At North Bimini

The shore approach at North Bimini will employ a similar procedure used for the shore approach at Ocean Cay. The predominant difference between the two installations is that the final 300 m (984.3 ft) to the North Bimini shore is sand. Two alternative shore approach procedures are proposed, each equally effective, and will be selected based upon equipment availability at the time of execution.

Shore Approach by Trench and Pull

The following steps describe the Trench and Pull pipeline installation procedure.

- Set up the pull-in winch on the shore.
- Construct a trench at least 1.5 m (4.9 ft) deep using sheet piling to keep the 2.5 m (8 ft) wide trench open. Excavated spoils will be placed on a barge for use as backfill. The trench will extend up to 300 m (1000 ft) offshore to where the bedrock appears. Shore based equipment (backhoes) will be used for trenching on the near shore and barge mounted hoes will be used for the deeper section. The roughness of the exposed rock may have to be smoothed out using the backhoes to avoid damaging the pipe.
- The lay barge will be positioned just offshore. The pipeline will be made up on the barge and will be pulled in to shore by the winch.
- Once the pull is completed, the barge will lay the rest of the pipeline to the point where the section from Ocean Cay was terminated and tied-in.
- The shore trench will be backfilled and the sheet piles removed. The pipeline laying on the bed rock (approximately 300 m (984.3 ft) length in 5 m (16 ft) water depth) will be covered by

articulated concrete mats for protection. Hand jetting may be required for the final cover of areas near the rock.

Shore Approach by Plow Pull

This method will use a specifically designed plow (available in the pipeline and cable industry) to make the trench for the pipeline (Figure 2.37). This plow will be pulled to shore by a winch with the pipeline attached to it. Thus, the pipeline will be pulled directly into the trench from offshore up to the onshore point. The procedures are the following:

- Set up the pull-in winch on the shore. The winch will have the pull force determined by the plow technicians (approximately 200 to 300 tons).
- Position the lay barge just offshore, ready to make up the pipeline. Position the plow in the sandy area east of the bedrock.
- The pipeline will be made up with an end cap and pad eye and will be attached to the plow end, just behind the plowshare.
- As more pipeline is made up, the plow will be pulled to shore by the winch. As the plow advances, it will make the trench in which the pipeline is positioned. The trench will have a depth of at least 1.5 m (4.9 ft).
- Once completed, the near shore trench will be backfilled using backhoes.
- Once the pull is completed, the barge will lay the remainder of the pipeline to the point where the section from Ocean Cay will be tied in.
- The pipeline laying on the bedrock (approximately 300 m (1000 ft) length in 5 m (16.4ft) water depth) will be covered by articulated concrete mats for protection. Hand jetting may be required for the final cover of areas near the rock.

E. Onshore Installation – North Bimini

The 60 mm (2 in) natural gas and 219 mm (8 in) potable water pipelines will be routed from the landfall across the beach to an intersection point with the Queen’s Highway. Normal trenching and backfill procedures will be used to bury the pipeline in accordance with U.S. Department of Transportation requirements (49 CFR 192), as shown on Figure 2.18.

The construction right-of-way (ROW) will be cleared and graded to remove brush, trees, roots and other obstructions as necessary. Permission will be obtained from landowners for use of access roads across their property to the ROW and for cutting trees and erecting temporary gates along access roads where necessary. Small backhoes or trenching machines will be used to excavate a 1 m (3.2 ft) deep trench where the pipelines will be laid. Trucks or other small tractor/trailer vehicles will travel along the ROW and lay or string the individual joints parallel to the centerline of the trench so they are easily accessible to welding and construction personnel. The pipeline will be welded in accordance with API specifications by approved welders and approved welding procedures. The welding will be completed manually, using shielded-metal-arc welding or similar. Each weld will be tested using radiographic techniques (x-ray or similar).

The pipe will be protected with an external coating designed to protect the pipe from corrosion. Small tractors fitted with side lift frames, small cranes, or small backhoes with the capacity to lift will be used to lower the pipelines into the trench. If the bottom of the trench is rocky, methods to protect the pipe will be used including sandbags or support pillows at designated intervals along the trench. After lowering the pipe in the trench and testing of the pipeline, the trench will be backfilled using a small bulldozer, backhoe or other suitable equipment. Where the trench has been excavated through paved areas, the original pavement will be restored in kind. The final tie-in between the offshore pipeline and the onshore pipeline will be made at the block valve located just onshore.

After the completion of backfilling, disturbed areas will be finish graded and any remaining trash and debris removed. The onshore section of the pipelines will be tested, dewatered, and precommissioned together with the offshore section of the pipelines.

F. Hydrostatic Testing

Testing of newly constructed natural gas pipelines is required and will be carried out on the gas pipeline in accordance with ANSI B31.8 – Gas Transmission and Distribution Piping Systems. The water pipeline will be tested according to the American Water Works Association (AWWA) M-11 – Steel pipes, Design and Installation standards. The proposed testing medium will be fresh water obtained from the desalination plant on Ocean Cay.

The proposed testing sequence will be as follows:

- The ends of the test section will be fitted with hydrotest heads. These will allow insertion and removal of pigs, for filling with test water, emptying, measurement of pressure and temperature and other tasks.
- A temporary pumping unit will be installed at the Ocean Cay end of the pipeline.

- At the North Bimini pipeline terminus, a temporary pig receiver, drain line and vents will be installed. A portable compression station (containerized units and portable offices) will also be set up at this location.

Prior to hydrostatic testing, a gauging plate or similar device will be installed on a pig and pushed through the pipeline as described with respect to the 610 mm (24 in) pipeline hydrotest procedure described above.

Filling the line will take place from Ocean Cay while venting to the atmosphere will occur at North Bimini. Test water discharge will be in accordance with Bahamian discharge regulations. Approximately 710 m^3 (190,000 gal) of test water will be required for the water pipeline and 80 m^3 (22,000 gal) of test water will be required for the gas pipeline. Additives similar to those proposed for the 610 mm (24 in) pipeline may be used.

Individual tests will be performed for each pipeline. The gas pipeline will be hydrotested for 24 hours at 1.25 times the design pressure, and the water pipeline will be hydrotested for 24 hours at 1.5 times the design pressure. After the pipeline has been pressure tested, the line will be depressurized and test water will be filtered and treated, as necessary, then discharged at Ocean Cay through the discharge structure at Outfall 001. The emptying will take place by pushing several dewatering pigs through the pipeline with compressed air from North Bimini.

2.4.4.3 Construction Schedule and Manpower

After receiving all regulatory permits and approvals, AES plans to start construction of the pipelines in the third quarter of 2003. The total anticipated offshore work force would be approximately 182 workers on the marine lay barge spread including client representatives, which may include up to 5 inspection and management personnel. The total number of personnel required on land for the shore pull and onshore construction is anticipated to be approximately 20 workers.

2.4.5 Housing

2.4.5.1 Permanent Housing

Housing development will be constructed on a plot of land, approximately 4 hectares (10 acres) in size, located on South Bimini as shown on Figure 2.19 and described in Section 2.3.1.5. The permanent housing will be used by the employees of AES Ocean LNG Ltd. when the facilities becomes operational.

A. Housing Units

The parcel of land targeted for this development will not require ground improvements (i.e., compacting) for development of the housing units. The foundation for the buildings will conform to Bahamas Building Code (standard 91.4 cm (36 in) wide x 25.4 cm (10 in) deep foundation footings placed 15.2 cm (6 in) into rock). These footings will be reinforced by #5 continuous bars and #3 ties which will be specified during final design. The houses will be constructed of 20.3 cm (8 in) exterior concrete block with plaster finish. Roofing materials will be of wood construction with finishes to be established upon final design. Roofing alternatives include either roofing tiles or cedar roofing. Interior walls will be stud work with masonry board and/or sheet rock finish and will be insulated. Typical floor plans and finished elevation views are shown on Figure 2.20.

B. Recreational Facilities

The parcel may require minimal land improvement for recreational facilities such as basketball or tennis courts, as well as for road improvements and beautification of the property. Although the parcel of land is a waterfront property, it will not be accessible by boat. No docking or marine facilities are planned for the site.

C. Utilities

It is expected that the existing water system on South Bimini will be used to supply water to the housing development. The details of the water system for the housing development will be determined during the final design phase of the project. Required upgrades to the existing system will be identified and installed as necessary. The water supply on Bimini will be augmented by transmission of clean fresh water from the Ocean Cay desalination plant. The fresh water will be conveyed via the pipeline to be installed as part of the project. The sewer system will consist of an approved septic tank and leaching system constructed according to The Bahamas Building Code. The location and sizing of the septic tank and leaching system will be completed during final design of the project. No other sewer system or solid waste management system will be necessary. The development will be connected to local electrical supply system managed by The Bahamas Electricity Corporation (BEC). Additional transformers or other system upgrades may be required to supply power to the development. AES will work with BEC to facilitate the required upgrades.

Debris from construction of the housing units will be removed from the island by barge and disposed according to applicable regulations. Currently an incinerator is not anticipated; however, if an incinerator becomes necessary, government approval will be obtained prior to its purchase and installation. Following construction of the housing, household trash removal is expected to be performed by existing services, as controlled by the Government's Ministry of Environmental Health Services.

2.5 Description of Alternatives

Alternatives were evaluated during development of the selected project to best balance the needs and diverse interests affected by construction of the proposed facilities, while minimizing environmental and socioeconomic impacts resulting from the project. Refer to Section 8 for the detailed evaluation of the benefits, detractions and impacts of the various alternatives, as well as evaluations of alternative fuel sources and technologies evaluated.

3.0 PROJECT BOUNDARIES AND OPERATIONAL CHARACTERISTICS

This section provides a summary of the boundaries and operational characteristics for the planned AES Ocean LNG, Ltd. project, by discussing the following topics:

- Project Boundaries;
- Areas of Potential Influence;
- Air Emissions;
- Seawater Withdrawal and Wastewater Discharge;
- Stormwater Management
- Petroleum and Chemical Storage and Use; and
- Solid and Chemical Waste Management.

These areas are discussed below.

3.1 Project Boundaries

The boundaries of this project include those areas where construction and operational activities will take place, where structures will be sited (including tanks, piers, buildings, and pipelines), or where potential impacts to the environment may occur. The project boundaries are shown on Figure 3.1. The project will be conducted in the four areas summarized below:

- Ocean Cay and the surrounding waters;
- The natural gas pipeline route from Ocean Cay to the EEZ boundary;
- The natural gas and potable water pipelines route from Ocean Cay to North Bimini; and
- The Bimini Islands.

3.1.1 Ocean Cay

As described in Section 2.1, Ocean Cay and the surrounding waters are the proposed site for the structural project elements with the exception of the pipelines and permanent staff housing at South Bimini. Expansion of Ocean Cay will increase the size of the island by approximately 74 hectares (181 acres), as shown on Figure 2.2. For flood protection purposes, the western and northern portions of the island grade will be raised utilizing dredged materials, as described in Section 2.3.1.1. Shore protection will be constructed to protect the island grade from erosion due to storm events. The total expansion will increase the areal extent of the island to 112 hectares (276 acres). The usable portion of the island will constitute 77 hectares (190 acres) while the shore protection and sacrificial beaches will account for the additional 35 hectares (87 acres).

Installation of new docking and harbor facilities on the southern and eastern sides of Ocean Cay, as well as breakwaters and other shore protection devices at the western and northern shores of Ocean Cay, will require additional expansion or reconfiguration of Ocean Cay's existing boundaries. Additionally, the existing approach channel and turning basin along the southern boundary of Ocean Cay will be expanded as described in Section 2.3.1.1.B. and 2.4.1.2. to accommodate the LNG and LPG ships, as shown on Figure 2.2.

The majority of the proposed project elements will occupy the western half of Ocean Cay, while the existing mining operation will be confined to the eastern portion of the island. Additionally, the airstrip will occupy the extreme northern end of Ocean Cay and a support vessel harbor (SVH) will be sited on the southeastern coast of the island.

Construction activities that will occur outside of the project boundaries will consist of barge and other marine vessel traffic bringing equipment, supplies, and workers in support of the construction process. Temporary housing during the construction phase will consist primarily of quarter barges or a cruise ship anchored off the eastside of Ocean Cay.

A shoal will be constructed utilizing excess dredged material to the south of the turning basin, as shown on Figure 2.2. The shoal will be constructed utilizing approximately 3,000,000 m^3 (3,902,000 yd^3) of excess dredged material.

3.1.2 Natural Gas Pipeline to the EEZ Boundary

The proposed 610 mm (24 in) natural gas pipeline will extend from the western shore of Ocean Cay to the EEZ boundary through the corridor shown on Figure 1.1. The construction corridor will be 200 m (656 ft) wide to a water depth of 30 m (100 ft) at KP 5.27, from a water depth of 30 m (100 ft) to the EEZ boundary the construction right-of-way (ROW) will be 60 m (200 ft) wide. The pipeline will be 64.7 km (40.2 mi) in length from Ocean Cay to the EEZ boundary. The permanent right-of-way at the pipeline will be 60 m (200 ft) wide and 64.7 km (40.2 mi) long. The total construction ROW will be approximately 4.6 km^2 (1.8 mi^2), and the permanent ROW corridor area will be 3.9 km^2 (1.5 mi^2). Baseline conditions along the pipeline corridor are described in Section 4, and potential impacts are discussed in Section 5.

3.1.3 Natural Gas Pipeline and Potable Water Pipeline to North Bimini

The proposed 60 mm (2 in) diameter natural gas pipeline and 219 mm (8 in) potable water pipeline will extend from the northwestern shore of Ocean Cay to North Bimini through the corridor shown on Figure 1.5. The off shore construction corridor will be 100 m (328 ft) wide and 37.8 km (23.5 mi) in length. The off shore permanent pipeline rights-of-way will be 40 m (131 ft) wide by 37.8 km (23.5 mi) long. The total area occupied by the submerged portions of the construction corridor will be 3.78 km^2 (1.46 mi^2). The permanent ROW corridor area will be 1.5 km^2 (0.6 mi^2). During construction of the pipelines, additional small areas will be used as temporarily anchorage areas for lay barges.

3.1.4 Bimini Islands

Project activities on North Bimini will be restricted to landfall and onshore installation of the 60 mm (2 in) natural gas and 219 mm (8 in) potable water pipelines. At the North Bimini landfall a work area approximately 23 m (75 ft) wide along the pipeline route will be required. After the pipeline crosses the beach, the work area and the permanent ROW will be restricted to the ROW of the existing power lines and the roadway (Queen's Highway).

The work area for the proposed housing unit on South Bimini will be restricted to property that will be acquired by AES (approximately 4 hectares (10 acres). Additional potential housing locations on South Bimini are currently being investigated. When and if, additional permanent housing locations are finalized and purchases of land are complete, an addendum to this EIA will be submitted.

3.2 Areas of Potential Influence

Physical activities during construction and operation of the project will be confined to the project boundaries described above in Section 3.1 (with the exception of marine vessel traffic to and from Ocean Cay and The Biminis), although, it is possible that direct and indirect impacts as a result of the project could involve additional areas outside the defined project boundaries. Since the proposed project is located on small islands in the open sea, several miles away from the nearest population centers, additional areas of potential influence will include the waters and sea floor in the vicinity of Ocean Cay and along the pipeline corridors. Specifically, these include the areas near the seawater intake and the water discharge structures on Ocean Cay, the areas to be dredged (approach channel, turning basin, support vessel harbor), and the pipeline corridors.

Geophysical, geologic and biological information was collected in the vicinity of Ocean Cay and along the proposed pipeline routes to help define those areas that could potentially be influenced by the project. The current conditions of these areas are discussed in detail in the description of baseline conditions in Section 4, and the potential impacts from the proposed construction and operational activities are described in Section 5.

Archeological assessments performed for the project indicate that the sea floor around Ocean Cay and along the proposed pipeline routes is free of historic shipwreck resources or other resources of a potential cultural interest. Archeological remains of terrestrial origin are almost non-existent on the Florida and Bahamas Shelves because the late Pleistocene and Early Holocene environments of the Florida/Bahamas Platform were not optimal for the preservation of terrestrial-archaeological sites as sea levels rose to their modern elevations. Since Ocean Cay is a man made island constructed in approximately 1970, no historic resources or items of cultural interest are located on Ocean Cay. Based on preliminary research, no evidence of significant cultural or archeological resources was found at the North Bimini landfall or terrestrial pipeline route for the 60 mm (2 in) diameter natural gas pipeline and the 219 mm (8 in) diameter potable water pipeline. An archeological assessment of the proposed permanent housing site on South Bimini has not yet been completed. Upon completion of the survey, the results will be submitted as an addendum to this EIA. A detailed description of the cultural and archeological resources in the vicinity of the project area is included in Section 4.

The following sections describe the operations of the proposed project with respect to the generation of air emissions, wastewater and stormwater discharges, oil and chemical storage, and the management of solid and chemical wastes. The potential impacts of these operations on the areas of potential project influence are discussed in Section 5. Operational aspects described below have been designed and selected to avoid and reduce the potential area of project influence.

3.3 Air Emissions

The gas turbine generators and LPG separation oil heater are the primary operating phase components of the project with the potential to impact air quality in the vicinity of Ocean Cay. The results of the air quality impact analysis indicate that the proposed project will have an insignificant impact on the surrounding air quality, as defined by Florida State and US EPA air quality impact analysis guidelines and procedures. Additionally, plume visibility analysis demonstrated that the impacts on surrounding visibility will also be insignificant. A full discussion of potential impacts associated with air emissions is presented in Section 5.5. As described in Section 2.3.1.3.C., two gas turbine generators will supply the power required to operate the LNG and LPG facilities and will operate continuously, one gas turbine generator will be used as a standby. The natural gas fired oil heater used for the LPG separation hot oil system may also operate continuously and therefore, was included in the air quality modeling analysis. Other minor and intermittent emission sources, which will only operate in the event of an emergency or outage of the gas turbine facility, include several small diesel reciprocating engines used for emergency firewater pumping and standby electricity generation. A flare system will also be constructed, and will be used to combust natural gas from the LNG and LPG facilities if a power failure renders the vapor handling systems inoperable.

Each of the proposed air emissions sources is classified as combustion equipment and, as such, will emit combustion-related pollutants. The combustion of the primary fuel (natural gas) and the backup fuel (diesel fuel) in the gas turbines, diesel in the reciprocating engines and natural gas in the LPG separation hot oil and flare will result in the formation of combustion byproducts, primarily consisting of typically unregulated carbon dioxide (CO_2) and water vapor (H_2O). The balance of the combustion products and exhaust gases will consist of the regulated pollutants nitrogen oxides (NO_X), carbon monoxide (CO), volatile organic compounds (VOC), sulfur dioxide (SO_2) and particulate matter (TSP/PM_{10}). With the proposed fuels, combustor designs and emission controls, NO_X, VOC and CO will be emitted in low part per million levels. SO_X and TSP/PM_{10} will be emitted in negligible amounts, primarily formed from the trace amounts of sulfur and noncombustible ash in natural gas and diesel fuel. Baseline conditions of air resources in the project area are discussed in Section 4. Potential impacts to air resources in the vicinity of the project area are discussed in Section 5.

Operating parameters and scenarios for each of the proposed sources referenced above are described in more detail below.

3.3.1 Gas Turbine Generators

AES is currently evaluating two different gas turbine configurations and several different vendors for each configuration. In order to provide AES the flexibility to develop either configuration, the maximum air quality impacts representative of both configurations have been evaluated in Section 5.5.

One configuration (the preferred alternative) would consist of a maximum of three simple cycle gas turbine generators, each sized at approximately 15 MW generating capacity to support the LNG and

LPG facilities. Two gas turbine generators operating simultaneously would be sized to handle 100 percent of the operating load of the LNG/LPG facilities and one gas turbine would be used for standby capacity as a spare. Furthermore, two of the gas turbines will operate exclusively with natural gas and one would have dual-fuel capability to operate firing either natural gas or diesel fuel. It is anticipated that the gas turbines would operate primarily on natural gas and that diesel fuel would only be used as a backup fuel.

The alternative gas turbine configuration would consist of two simple cycle gas turbine generators each sized at approximately 30 MW generating capacity. In this configuration, one gas turbine would be sized to handle 100 percent of the operating load and one would be used for standby capacity. One gas turbine would be designed for exclusive natural gas combustion and the other would have dual-fuel capability.

For the purposes of evaluating air quality impacts from operation of the gas turbines, two sets of operating scenarios were developed, one for each gas turbine configuration. For the three gas turbine configuration, the worst-case operating scenario assumes two gas turbines operating simultaneously, one firing natural gas and one firing diesel fuel. For the two gas turbine configuration, the worst-case operating scenario assumes one gas turbine operating on diesel fuel. Although both operating scenarios likely overstate the anticipated operations and emissions from the gas turbines, they were used in the air impact dispersion modeling analysis, discussed in Section 5.5, to provide for maximum operating flexibility and to conservatively evaluate the maximum ambient impacts from the facility.

The maximum estimated emission rates and worst-case stack parameters used in the dispersion modeling analysis, discussed in Section 5.5, were developed using gas turbine manufacturers' information for the equipment proposed for the project. For the purpose of determining air emissions, the gas turbines selected are ABB GT35, or equivalent for the 15 MW case and GE LM2500, or equivalent for the 30 MW case. Because final selection of specific gas turbine suppliers has not been made at this time, worst-case composite emissions and other stack parameters were developed so that the air quality impact dispersion modeling analysis could be conducted in a manner designed to conservatively estimate the impacts. For example, for the range of potential manufacturers, the highest emission rate for each pollutant was selected along with the lowest stack temperature and exhaust volume rate. The same modeling input data was developed for three operating loads varying between 50 and 100 percent and for three combustion air inlet temperatures ranging between 8.9 and 37.8 °C (48 and 100 °F). The estimated maximum hourly emission rates and stack parameters for each gas turbine (1 gas turbine at 100 percent of required plant load and 2 gas turbines at 50 percent of load) and each fuel are summarized in Table 3-1 and Table 3-2, respectively, for each operating load condition. Estimated expected and maximum short-term and annual emissions representative of the gas turbines are summarized in Table 3-3. The data used to develop these estimates is provided in Appendix G.

Table 3-1
Summary of Gas Turbine Emissions and Stack Parameters

1 Gas Turbine @ 100% Capacity											
Fuel		**Gas**	**Gas**	**Gas**	**Oil**	**Oil**	**Oil**	**Gas**	**Gas**	**Oil**	**Oil**
Case Number		**1**	**2**	**3**	**4**	**5**	**6**	**13**	**14**	**15**	**16**
Input Data											
Ambient temperature	°F	**48°F**	**75°F**	**100°F**	**48°F**	**75°F**	**100°F**	**48**	**48**	**48**	**48**
GT power as % of site rating	**-**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**75%**	**50%**	**75%**	**50%**
Performance Data											
Plant Summary											
Plant gross output	kWe	31,362	27,529	22,477	32,596	26,886	22,509	23,626	15,826	22,847	15,299
Stack Summary											
Stack temperature	°F	958.10	975.70	994.30	931.90	986.80	1012.00	883.90	837.90	894.00	848.20
Stack height above grade	m	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24
Stack internal diameter, each	m	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44
Stack gas velocity	m/s	43.14	40.20	36.18	43.85	39.50	36.14	36.14	29.22	35.40	28.69
Emissions Data											
NO_x	lbs/hr	27.8	25.08	21.58	52.67	42.49	37.43	21.88	16.25	70.38	52.36
CO	lbs/hr	46.0	41.51	35.72	38.11	30.78	27.12	61.23	67.24	42.83	31.79
PM-10	lbs/hr	8.4	8.40	8.40	16.70	16.70	16.70	7.55	6.60	14.81	13.11
SO_2	lbs/hr	0.7	0.59	0.51	83.02	67.12	59.09	0.52	0.38	58.30	43.43
Pb (based on AP-42 emission factor)	lbs/hr	-	-	-	4.4E-03	3.6E-03	3.2E-03	-	-	3.1E-03	2.3E-03

Table 3-2
Summary of Gas Turbine Emissions and Stack Parameters

2 Gas Turbines at 50% Site Rating Each											
Fuel		**(2) Gas**	**(2) Gas**	**(2) Gas**	**(1) Gas + (1) Oil**	**(1) Gas + (1) Oil**	**(1) Gas + (1) Oil**	**(2) Gas**	**(2) Gas**	**(1) Gas + (1) Oil**	**(1) Gas + (1) Oil**
Case Number		**7**	**8**	**9**	**10**	**11**	**12**	**17**	**18**	**19**	**20**
Input Data											
Ambient temperature	°F	**48°F**	**75°F**	**100°F**	**48°F**	**75°F**	**100°F**	**48**	**48**	**48**	**48**
GT power as % of site rating		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**75%**	**50%**	**75%**	**50%**
Performance Data											
Plant Summary											
Plant gross output	kWe	35,033	30,042	25,913	34,638	29,692	25,597	26,437	17,687	26,115	17,501
Stack Summary		0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stack temperature	°F	702	727	753	702	727	753	646	585	646	585
Stack height above grade	m	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24	15.24
Stack internal diameter, each	m	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44
Stack gas velocity	m/s	37.98	35.53	33.53	37.70	35.27	33.29	32.23	26.63	31.96	26.48
Emissions Data											
Nox	lbs/hr	37.6	33.9	30.9	64.5	58.1	52.9	35.9	26.9	66.3	49.8
CO	lbs/hr	22.9	20.6	18.8	34.6	31.2	28.4	58.2	43.6	58.5	43.9
PM-10	lbs/hr	14.1	13.2	12.4	18.2	17.0	16.1	11.9	9.9	15.4	12.8
SO2	lbs/hr	0.9	0.8	0.8	51.2	46.1	42.0	0.7	0.6	40.7	30.6
Pb (based on AP-42 emission factor)	lbs/hr	-	-	-	2.7E-03	2.4E-03	2.2E-03	-	-	2.2E-03	1.6E-03

Table 3-3
Summary of Estimated Expected and Maximum Gas Turbine Emissions

Pollutant	Natural Gas Firing Short-Term Emissions, lb/hr[1]	Maximum Potential Short-Term Emissions, lb/hr[2]	Exclusive Natural Gas Firing Annual Emissions, Tons/yr[3]	Estimated Actual Annual Emissions, Tons/yr[4]	Maximum Potential Annual Emissions, Tons/yr[5]
NO_2	37.6	64.5	164.8	200.1	282.5
CO	22.9	34.6	100.3	115.7	151.6
PM-10	14.1	18.2	61.6	67.1	79.8
VOC	1.0	2.1	4.6	6.0	9.3
SO_2	0.9	51.2	4.1	70.2	224.4
Pb	-	2.7E-03	-	3.6E-03	1.2E-02

AES is evaluating an variety of gas turbine configurations and vendors. The emissions summarized above are representative of the configuration and operating scenarios that result in the highest ambient air quality impacts as determined from the screening modeling.

1 Three gas turbine configuration, two gas turbines operating at 100% rated capacity, both firing natural gas.
2 Three gas turbine configuration, two gas turbines operating at 100% rated capacity, one firing natural gas and one firing No. 2 fuel oil.
3 Three gas turbine configuration, two gas turbines operating at 100% capacity for 100% of the year firing natural gas.
4 Three gas turbine configuration, two gas turbines operating at 100% rated capacity, one firing natural gas for 100% of the year, one firing natural gas for 70% of the year and No. 2 fuel oil for 30% of the year.
5 Three gas turbine configuration, two gas turbines operating at 100% rated capacity, one firing natural gas for 100% of the year, one firing No. 2 fuel oil for 100% of the year.

The exhaust gases from each gas turbine will exit through individual unit stacks. Each stack will have a height above grade of approximately 15 m (39 ft) and a diameter of 2.4 m (7.0 ft).

Air emissions from the gas turbines will be minimized using combustion control and state-of-the-art combustor design to minimize formation of NO_X, CO and VOC. Either dry low-NO_X combustor design or water injection, depending on the selected manufacturer, will be used to minimize NO_X emissions. Combustor design and high-efficiency combustion will minimize formation of CO and VOC. SO_2 and particulate emissions will be minimized by the use of natural gas and low-sulfur diesel fuel.

3.3.2 LPG Removal Hot Oil Heater

The hot oil heater included in the LPG removal system will be exclusively natural gas fired and sized for a maximum capacity of 80 MMBtu/hr. The heater may operate continuously when performing LPG stripping operations and, therefore, the potential emissions have been included in the air quality impact analysis dispersion modeling described in Section 5.5. Potential emission rates were estimated using US EPA emission factors for natural gas external combustion devices and are summarized in Table 3-4.

Table 3-4
LPG Hot Oil System Heater (Reboiler)
Modeling Input Data and Emission Calculations

	100% Natural Gas Firing				
Pollutant	**Emission Factor lb/MMSCF[1]**	**Emission Factor lb/MMBtu**	**lb/hr**	**Potential TPY**	**Emission Factor Source**
TSP	1.9	0.0019	0.15	0.67	AP-42 T 1.4-2
PM-10	1.9	0.0019	0.15	0.67	AP-42 T 1.4-2
SO_X	0.6	0.0006	0.05	0.21	AP-42 T 1.4-2
NO_X	50	0.05	4.00	17.52	AP-42 T 1.4-1
VOC	5.5	0.0055	0.44	1.93	AP-42 T 1.4-2
CO	84	0.084	6.72	29.43	AP-42 T 1.4-1

Note:
1. Emission factors based on EPA AP-42, Section 1.4 (nat. gas combustion).
2. TSP and PM-10 emissions are total filterable particulate matter and assumed to all be less than 10 microns.

Fuel	Nat. Gas
MMBtu/hr	80
Btu/CF	1,000
CF/hr Nat. Gas	80,000
CF/yr Nat. Gas	700.8E+6
Equiv. hrs/yr	8,760
MMBtu/yr	700,800
Stack Temp., deg. F	600
Flue gas rate, lb/hr	94,000
Flue gas rate, ACFM (@ 0.072 lb/cf)	43,683
Stack Height, ft	119.7
Stack diameter, ft	8.75
Stack exit velocity, ft/s	12.1

3.3.3 Diesel Engine Fire Pump and Emergency Generator

The diesel reciprocating engine-powered fire pump and backup generator will only be used in emergency situations and/or during an electrical power failure. The fire pump engine will be sized at approximately 400 HP and the diesel engine generator will also have an approximate 400 HP generating capacity. Both will be fueled exclusively with diesel fuel. It is estimated that each will operate typically only for 50 to 100 hours per year for engine exercising purposes and at most for several hundred hours annually in the event of an emergency or power outage. Because these emission sources are not part of the normal operating scenario, they are not included in the air quality impact assessment dispersion modeling analysis discussed in Section 5.5. However, emission rates have been estimated and summarized in Table 3-5, based on US EPA emission factors for diesel reciprocating engines.

Table 3-5
Emission Calculations
Emergency Generator and Firepump Engines

Estimated Emissions					
Pollutant	Emission Factor (lb/MMBtu)	Potential Emissions (lb/hr)	Potential Emissions (8760 hrs) (tons/yr)	Actual Emissions (500 hrs) (tons/yr)	Emission Factor Source
PM-10	0.31	1.74	7.60	0.43	AP-42 T 3.3-1 (10/96)
SO_X	0.303	1.70	7.43	0.42	AP-42 T 3.3-1 (10/96)
NO_X	4.41	24.70	108.17	6.17	AP-42 T 3.3-1 (10/96)
VOC	0.35	1.96	8.58	0.49	AP-42 T 3.3-1 (10/96)
CO	0.95	5.32	23.30	1.33	AP-42 T 3.3-1 (10/96)
Lead	9.0E-06	5.0E-05	2.2E-04	1.3E-05	AP-42 T 3.3-1 (10/96)

Note:

Fuel Burned	Diesel Oil
Fuel Heat Content, Btu/gal	137,000
% Sulfur in Fuel	0.30%
Max. Rating, Bhp	800 (2 @ 400 hp each)
Max Fuel, MMBtu/hr	5.60 (@ 7,000 Btu/hp-hr)
Max Fuel, Gal/hr	40.9
Max. Annual Operating Hours	500 (estimated equiv. full load operating hours)
Annual Fuel Use, Gal/yr	20,438

3.3.4 Flare

An emergency flare system will be operated in the event that the boil-off gas compression system, is inoperative due to equipment malfunction, power failure or other emergency. In that event, the boil-off vapors will be directed to the flare, as described in Section 2.3.1.2.C. The flare will also be used to provide LNG/LPG storage tank overpressure protection. If the tank pressure exceeds the maximum operating limit, a pressure control valve will automatically relieve excess vapor from the vapor headers to the flare. The flare will be approximately 15.25 m (50 ft) high and will be sized to burn up to 20,412 kg/hr (45,000 lb/hr) of fuel gas. Because the flare is not part of the normal operating scenario, potential emissions during an emergency condition are not included in the air quality impact assessment.

3.4 Water Withdrawal and Wastewater Discharge

3.4.1 Seawater Intake System

The seawater intake system will withdraw seawater from the ocean and direct it to several water systems on Ocean Cay. Primarily this water will be directed to LNG vaporizing, the desalination plant, auxiliary cooling system, the sodium hypochlorite generator and the backup firewater supply system, as described in the sections below. The primary components of the intake system include the intake structure with a velocity cap, the intake pipe, and onshore pump house. The intake structure is designed to minimize entrainment of marine organisms through the use of a low velocity suction intake (i.e., a pipeline inlet equipped with a velocity cap). The purposes and design of the intake structure are described in detail in Section 2.3.1.3.A. Construction techniques and methods proposed for installation of the seawater intake structure are described in Section 2.4.3.1.

The project water balance in Figure 2.15 provides a summary of the seawater uses and estimates of the maximum and average flows for each use. These uses are further described below.

3.4.1.1 RO Desalination

The desalination plant will provide water for service water, firewater, and potable water systems, as well as makeup water to the electro-deionization (EDI) system as described in Section 2.3.1.3.

- Service Water

  The plant service water will be a mixture of the product water from the First Stage Reverse Osmosis (FSRO) and Second Stage Reverse Osmosis (SSRO) modules and the brine stream from the EDI system. The FSRO product water and EDI brine stream will be routed to the service/firewater tank. The tank will provide storage for the service water and firewater reserve needs of the plant. The tank will also supply makeup water to the potable water supply system and the SSRO module.

  Two full capacity service water pumps will supply a distribution piping system consisting of utility stations throughout the facility and in plant areas where wash down is required. The resulting wastewater from the use of service water in the plant will be collected in floor drains and equipment drain sumps. The sump water will be pumped to the corresponding wastewater collection systems for treatment using oil/water separators and subsequent discharge to the facility discharge Outfall 001.

- Potable Water

  Water for potable uses will be taken from the service water system. The potable water system will supply drinking quality water to both Ocean Cay and the pipeline to North Bimini. The potable water will be disinfected by chlorination with sodium hypolorite prior to distribution. The wastewater generated from the domestic water usage on Ocean Cay will be routed to the sanitary wastewater system.

- Demineralized Water

  An EDI process will be used to produce deionized water from product water from the SSRO. Deionized water will be used for filling and makeup of the gas turbine generator (GTG) closed loop cooling system, GTG water injection for emissions control, and GTG washing. The GTG wash water will be used as needed on an intermittent basis for GTG compressor cleaning. The deionized water will be stored in a demineralized water tank for distribution to plant users. The waste brine stream from the EDI will be directed to the service water tank to mix with product water from FSRO. The deionized water used for GTG water injection will be exhausted through the GTG stack as water vapor.

3.4.1.2 LNG Vaporizer

The main LNG vaporizer system will receive seawater from vertical wet pit pumps arranged to take suction from the intake structure. The seawater will then be routed to LNG vaporizers. Cooled seawater from the vaporizers will be sent back to the seawater discharge line and then discharged back to the sea at the facility discharge Outfall 001. A process flow diagram showing the LNG regasification system is presented on Figure 2.10.

An ethylene glycol system will also be included to provide cooling for the gas turbine inlet air, cooling for machinery and miscellaneous heat exchangers. An MSDS sheet for ethylene glycol is provided in Appendix F. The ethylene glycol mixture will be cooled by heat exchange with LNG through use of a shell and tube heat exchanger. For startup and backup purposes, the ethylene glycol mixture could also be cooled by heat exchange with seawater in a plate and frame exchanger.

The ethylene glycol system will contain approximately 57 m^3 (15,000 gal.) of a 50 percent solution of water and ethylene glycol. The ethylene glycol system will be a closed loop system, therefore, only small amounts (less than 0.76 m^3 (200 gal) per year) of the ethylene glycol/water mixture will need to be added to the system, as shown on Figure 3.2. If maintenance is required on the ethylene glycol system, the mixture will be drained from the affected portion of the system, containerized and reused or disposed of at a licensed disposal or recycling location.

3.4.1.3 Auxiliary Cooling System

The auxiliary cooling system will use seawater for cooling the various equipment and heat exchangers in the plant. The seawater will be pumped from the intake structure to plate and frame auxiliary cooling heat exchangers to absorb reject heat from the closed water/glycol cooling system. The water will then be routed back to the sea through the seawater discharge pipe (Outfall 001) after mixing with the cooled water from the LNG vaporizer system. The closed water/glycol cooling system will be arranged such that the glycol can be cooled by heat exchange with the vaporizing LNG. The cooled water from LNG regasification will be used to cool the inlet air to the gas turbines.

3.4.1.4 Sodium Hypochlorite Generator

The sodium hypochlorite generator will receive seawater from dedicated feed pumps located in the pumphouse structure. The seawater will be filtered to remove suspended solids and then routed to the sodium hypochlorite generator. The generator will produce a solution of sodium hypochlorite in seawater by electrolysis of the sodium chloride salt present in seawater. The generator will consist of a cell containing a platinum anode and titanium cathode used to form a bipolar electrode. The anode and cathode will be used to pass a direct electrical current through the seawater to produce a liquid sodium hypochlorite solution. The liquid sodium hypochlorite will be in a 1500 ppm solution and will be stored in a 227 m^3 (60,000 gal.) tank and used for chlorination at the seawater intake structure and the potable water system. An MSDS sheet for sodium hypochlorite is included in Appendix F. A process flow diagram illustrating the sodium hypochlorite system is presented on Figure 3.3. The liquid sodium hypochlorite tank will be located in the Chlorination Building at the location shown on Figure 1.4.

To remove hydrogen gas, a by-product of the electrochlorination process, the discharge from the generator cell assembly will be fed into a hydrogen removal tank. The hydrogen removal tank will be sized for a 3 to 5 minute retention time to allow the hydrogen to degas from the water. The hydrogen gas will be diluted with air introduced by a fan to less than a 1.0 percent mixture to be below the lower explosion limit of 4.1 percent for hydrogen. As a safety measure, the fan used to mix the hydrogen gas with air will be provided with a pressure switch to monitor the fan discharge air pressure and shut down the electrochlorination process in the event of a fan failure.

The sodium hypochlorite system will be used to control bacterial slime and algae that could potentially create biological fouling in the intake and LNG regasification systems. The potential sodium hypochlorite injection points will be at the intake pipe, the intake screens and the discharge of the seawater pumps. The need for chlorination is dictated by the nature and extent of biological activity and growth in the systems. It is anticipated that the chlorination requirements will be minimal. The potential points for sodium hypochlorite addition to the system are shown on Figure 3.4. Of the potential sodium hypochlorite injection points, the preferred injection point will be at the discharge of the seawater pumps. The chlorine residuals in the discharge will be kept under 0.2 ppm, on a 24 hours average basis, by continuous monitoring and automatic control of hypochlorite feed.

3.4.1.5 Emergency Firewater

The fire water system will use service water as its main source of water. In the unlikely event that a sufficient quantity of service water is not available, seawater will be used as the emergency source of firewater. The emergency firewater supply will be provided by vertical wet pit pumps located in the seawater pumphouse structure.

3.4.2 Construction Uses

Water will be required throughout the construction phase of the project, including island expansion activities, soil improvement activities, concrete mixing, fugitive dust control, system hydrostatic testing, and various other construction activities. During construction, AES anticipates that the project will supply its own source of fresh water by desalinating seawater with a self-contained barge-mounted RO system capable of generating 2,270 m^3/day (600,000 gpd) of potable water.

The barge-mounted RO system will consist of a single stage system with filtration, suction and discharge pumping, an RO membrane, chemical additives, and backwash capabilities. The barge will contain a storage tank for water storage. The water produced by the barge-mounted RO system will not be suitable for worker consumption. The RO system is expected to be 40% efficient. Seawater will be delivered from an intake manifold that will be positioned approximately 1 m (3.3 ft) below the seawater surface. The potential for entrainment at the intake will be minimized by restricting the velocity to 0.3 m/s (1 ft/s). The intake flow rate is anticipated to be approximately 3.8 m^3/minute (1000 gpm). The discharge from the RO system will be positioned near the seafloor, the maximum possible distance away from the intake line. The brine discharge will have a salinity of 57,000 ppm TDS, which will quickly defuse near the point of discharge. If it is determined that sodium hypochlorite addition is required to prevent biofouling, the discharge will be controlled to be less than of 0.2 ppm chlorine residual on a daily basis.

Seawater will be used for hydrostatic testing of the LNG and LPG tanks prior to commissioning. The seawater utilized for the hydrostatic test operations will be drawn through the seawater intake and pumped into the LNG and LPG tanks. The water will be filtered for solids following completion of the test and will be discharged through the wastewater discharge structure to the sea. Hydrostatic testing to be performed on the LNG and LPG tanks is described in sections 2.4.2.2.B.

3.4.3 Facility Water Discharge System

The facility discharge Outfall 001 will be used to discharge cooled water from the LNG vaporizers, warmed water from the auxiliary cooling system, waste brines and backwashes from the desalination plant, and pretreated wastewater from the plant equipment and floor drains. Approximate volumes of each waste stream and its source are detailed on the water balance provided on Figure 2.15. These waste streams will be combined prior to discharge through a common pipe that will be routed to the facility water discharge Outfall 001 located at the turning basin on the South Side of Ocean Cay as shown on Figure 1.4.

The primary continuous wastewater streams that will be discharged from the outfall structure are as follows:

- LNG vaporizer discharges (207,100 m^3/day (54.7 mgpd) maximum);
- RO reject brines and sand filter backwashes from the desalination plant (combined total of 6,900 m^3/day (1.8 mgpd) maximum); and,
- auxiliary cooling system discharges (150 m^3/day (0.04 mgpd) maximum).

Average discharge flows are expected to be about 6 percent less than the maximum expected flows, and will depend on operational parameters such as power generation needs, LNG deliveries, gas transmission demands, and seawater quality, among others.

Liquid effluents will be sampled and measured at least daily for temperature, pH, flow, and chlorine. Liquid effluents will be sampled monthly for total oil and grease, total suspended solids, total dissolved solids, total residual chlorine, and chlorine. The effluent will be sampled quarterly for biological monitoring. Water sampling procedures are summarized in Section 10, Environmental Management Plan.

In addition to these major categories of wastewater, additional smaller and comparatively intermittent waste streams will be generated, as described below:

- Floor Drainage

  Floor drainage includes wastewater generated during floor or equipment wash-downs, maintenance activities, and other miscellaneous service water-dependent activities in the plant. Wastewater from these drains (180 m^3/day (47,000 gpd) maximum) will be collected and routed through an oil/water separator for removal of any oil that may be present. The small quantity of oil that collects in the oil/water separator will be pumped into containers for offsite disposal by a licensed waste management contractor.

- Equipment Drainage and Oily Wastewater

  Equipment drainage wastewater (11.4 m^3/day (3,000 gpd) maximum) will be generated on an intermittent basis when a system is drained for maintenance. The equipment drains will also collect wastewater from diked secondary containment areas around chemical and oil storage tanks, transformers, and selected other equipment. The waste streams with potential for oil contamination (180 m^3/day (47,000 gpd) maximum) will be collected separately by an oily waste system and processed via the oil/water separator for removal of oil. The oil from the oil water separator will be collected in containers for offsite disposal by a licensed waste management contractor.

- Gas Turbine Generator (GTG) Injection and Wash Water

  The demineralized water used for GTG water injection will not be discharged as wastewater but instead will be lost through evaporation at the stack at a maximum rate of 2,60 m^3/day (70,000 GPD)Approximately 0.8 m^3 (200 gal) of demineralized water will be used per GTG wash. Wash water from GTG turbine blade and off-line compressor washes will be collected in containers for shipment and off-site disposal by a licensed waste management contractor.

- Sanitary Wastewater
  The sanitary wastewater on Ocean Cay will be collected from the various points of generation in the plant, offices and living areas and will be routed to field septic tanks. Septic systems will also be used for the South Bimini permanent housing facilities. The septic systems will be designed in accordance with local codes and good engineering practice. This category of water is the only type of wastewater expected to be generated at the South Bimini location.

The discharge Outfall 001, on Ocean Cay, will be located on the south shore of the island, as shown on Figure 1.4. The outfall will consist of a reinforced concrete pipe or a concrete duct structure situated below the dock caissons. The discharge point will be approximately 10 m (33 ft) below the water surface in the turning basin. This location will minimize recirculation of the wastewater discharge back into the plant via the intake system, as described in Section 2.3.1.3 and 2.4.3.1.

The outfall structure will be designed to permit the discharge of the combined wastewater streams without undermining the pipeline, washing away the seabed, or creating undesirable disturbances in the approach channel. A maximum of approximately 214,600 m^3/day (56.7 mgpd) of water will be discharged through the discharge Outfall 001, with the vast majority of it (approximately 207,100 m^3/day (54.7 mgpd)) being cooled seawater from the LNG vaporizer system, while the balance of the wastewater will consist of the brine discharge from the desalinization plant (approximately 6,900 m^3/day (1.8 mgpd)). The discharge structure will provide mixing and dispersion to achieve a uniform temperature profile downstream. The discharge will not result in a temperature increase outside of the mixing zone, in accordance with Florida State, US Federal and World Bank guidelines. The thermal discharge has been modeled as described in Section 3.4.4.

The average concentration and mass of chemical contaminants expected to enter the process water discharge are summarized below on Table 3-6.

Table 3-6
Wastewater Discharge Waste Stream Constituents

Contaminant	Waste Stream Concentration	Annual Discharge
Chlorine (residual)	<0.2 ppm	23 tons/year
Cyclohexylamine	<2.0 ppm	3.6 lbs/year
Oil and grease	<15 ppm	NA
Acids	Neutralized (pH 6 to 9) prior to discharge	NA
Caustics	Neutralized (pH 6 to 9) prior to discharge	NA

Best Management Practices (BMP) proposed to prevent the discharge of oils and chemicals are summarized in the Integrated Spill Control Response, Pollution Prevention, and Stormwater Management Plan discussed in Section 10, Environmental Management Plan.

3.4.4 Thermal Plume Modeling

Because the temperature of the discharge from Ocean Cay is expected to be approximately 15.5°C (28°F) lower than the temperature of the receiving water, modeling was used to optimize the design of the discharge structure to allow adequate mixing and minimize thermal impacts to the surrounding water resources. The modeling was conducted using a 3-D hydrodynamic and transport model, called the "Generalized Environmental Modeling System (GEMSS) model" (Kolluru 1999). In Appendix H, a summary description of the GEMSS model is contained in Attachment A, a list of government agencies who have reviewed and approved modeling performed by the GEMSS model is contained in Attachment B, and a representative list of projects which utilized the GEMSS model in presented in Attachment C.

The model used available information on the site, the outfall location and configuration (i.e., in the turning basin), site bathymetry, currents, meteorological data and the water quality characteristics of both the receiving water and effluents.

A mixing zone is the volume of water within which the initial dilution of a discharge takes place. The allowable mixing zone is further defined as an assigned impact zone wherein numerical criteria governing water quality may be exceeded so long as conditions toxic to marine life are prevented. Standards or regulations governing allowable temperature increases/decreases or other water quality impacts are assessed at the edge or boundary of the mixing zone. The World Bank guideline regarding the maximum allowable increase in temperature of a receiving water is 3° C (5.4 °F) at the edge of a mixing zone assumed to be 100 m (328 ft) from the discharge point. Florida State regulations were also reviewed in the evaluation of the thermal discharge.

Three scenarios were modeled to provide information to the designers and to predict the size and shape of the thermal plume from the cooling water discharge at Outfall 001. These scenarios include the following:

Scenario 1

Discharge rate of 2.52 m^3/sec (89 cfs) (40,000 gpm) with a temperature fall of 15.55 °C (28 °F). The cold water from the LNG/Desalination plant is discharged through a circular pipe of approximately 2 m (7 ft) diameter and located approximately 10 m (33 ft) below MSL. The total water depth at the discharge location is 15 m (49 ft). The discharge pipe is oriented 45° facing up and 45° to the south-side reclamation wall facing almost southeast direction. The intake is located approximately 250 m (830 ft) from the pump house location and oriented perpendicular to it. The intake configuration is a circular pipe of approximately 2 m (7 ft) diameter. The intake structure is located approximately 1.5 m (5 ft) from the seabed. The total water depth at the intake location is approximately 7 m (23 ft).

Scenario 2

Scenario 2 was run using the same parameters as Scenario 1 except with a larger discharge pipe diameter of 5.5 m (18 ft).

Scenario 3

Scenario 3 was run using the same parameters as for Scenario 2 with the exception of the discharge orientation being horizontal instead at a 45^0 angle.

The methodology and results of the modeling simulation are detailed in Appendix H. Based on the results of the thermal plume modeling, the orientation represented by Scenario 2 has been adopted as the basis for design of the discharge pipe at Outfall 001. The model results for the selected scenario include the following conclusions:

- Thermal plume dimensions comply with the World Bank guideline and associated Florida State regulations, there are no 95% probability occurrences of 3 °C (5.4 °F) temperature rise plumes at the surface, sub-surface and the bottom of the water column.

- Maximum temperature change at Outfall 001 is -1.6 °C (-2.86 °F) at the bottom, and -0.17°C (-0.31 °F) at the surface. This temperature change occurs within 135 meters of the discharge point, at the bottom due to the thermal plume's density.

- Maximum temperature change at the intake structure is -0.09 °C (-0.15 °F) at the bottom and -0.07 °C (-0.13 °F) at the surface.

- Since the discharge is colder, the plume descends down and spreads towards the approach channel. The plume oscillates and resides in the northern portion of the approach channel during a typical tidal cycle.
- The 1.8 ºC (3.3 ºF) temperature decrease plume extends to less than 5 m (16.4 ft) along the discharge pipe axis.

A technical report detailing the thermal plume modeling procedures and results is presented in Appendix H.

3.5 Stormwater Management

Stormwater runoff from the plant areas on Ocean Cay will be managed with a combination of techniques including infiltration directly into pervious surfaces, sheet flow discharge across sloped land surfaces and coastline, and structural elements designed to control or direct flows to specific outlet locations. Structural elements may include drainage structures such as swales, culverts, and catch basins that discharge to the surrounding surface waters. Velocity dissipation devices may be used where necessary to prevent washouts of slopes or seabed surfaces near outfall locations and to minimize the potential to disturb and suspend bottom sediments. The permanent housing developments on South Bimini will manage stormwater runoff with a combination of the aforementioned techniques.

The 24-hour duration, 10-year return period historic rainfall intensity data of Miami, Florida was used for stormwater runoff estimates for Ocean Cay. Stormwater runoff from Ocean Cay will be discharged at Outfalls 001, 002 and 003 as shown on Figure 1.4 and as described in Section 2.3.1.3.D. The stormwater discharge to Outfall 001 will drain an area of approximately 0.45 hectares (1.1 acres) associated with oil and chemical storage areas. The runoff flow from this area is projected to be 0.014 m^3/sec (0.5 ft^3/sec). The stormwater discharge to Outfalls 002 and 003 will be from an area of approximately 25.1 hectares (62 acres) consisting of the LNG/LPG Tank areas and other plant areas. The projected runoff flow to Outfalls 002 and 003 is 0.28 m^3/sec (10 ft^3/sec).

Containment dikes will be used around bulk storage tanks (oil and chemical), oil-containing equipment such as storage tanks, transformers, and other areas where oil or chemicals are used or stored, to minimize the potential for release of contaminants with stormwater runoff. Stormwater that collects in the containment areas will be inspected, and treated if necessary via oil/water separators, to ensure it is uncontaminated prior to its release. Stormwater drainage from equipment areas and exterior storage area drains will also be directed to the oil/water separator. Stormwater inside the LNG tank containment area will collect in a drainage sump and will then be automatically discharged and monitored for temperature prior to entrance into the discharge channel outside the containment area. Berms will be constructed in accordance with all applicable regulations and codes, at a minimum the berms will contain 100% of the volume storage capacity of the tanks.

During the construction phase of the project elements on Ocean Cay and the permanent housing development on South Bimini, the Construction Sediment and Erosion Control Plan, discussed in Section 10, will be implemented by the construction contractor to minimize soil erosion within areas disturbed by the construction activities. The Construction Sediment and Erosion Control Plan will provide for appropriate measures that include the following:

- Installation of silt fencing, as needed, at the perimeters of actively disturbed areas;
- Grading of exposed soil surfaces to minimize runoff and increase infiltration;
- Reinforcement of soil slopes, as needed, with suitable materials to minimize erosion;
- Diversion of runoff, as needed, to sedimentation basin(s) or grit removal chambers;
- Providing secure storage for oil, chemicals, and waste materials to prevent contamination of runoff;
- Diverting the runoff from uncovered bulk construction waste piles to suitable collection/treatment systems; and,
- Performing periodic inspections and maintenance of soil erosion measures and stormwater control structures.

During the operational phase of the project, this plan will be modified to include the following means and measures to minimize the potential for oil, chemicals, particulate matter, and other pollutants to contaminate stormwater runoff from the project area:

- Oil, chemical, and waste storage containers or vessels will be stored in or equipped with roofed, adequate, secondary containment to contain spills and leaks;

- Protection from erosion will be provided as needed, by properly grading susceptible slopes and by paving or reinforcing exposed surfaces with riprap or other suitable means;
- Discharges of oil, chemicals, or wastewaters will be prohibited to the ground or to drainage structures, unless properly treated and approved;
- Periodic inspections will be conducted to check for leaks from equipment, storage containers and vessels, and to observe the integrity of secondary containment structures;
- Preventative maintenance of equipment will be performed on a routine basis to reduce the potential for leaks; and,
- The Integrated Spill Control, Response, Pollution Prevention and Stormwater Management Plan, discussed in Section 10, will be implemented, which defines procedures, roles and responsibilities for release response, control, clean up, and management of materials and stormwater runoff.

3.6 Petroleum and Chemical Storage and Use

During construction and operation of the proposed facilities on Ocean Cay, petroleum products and chemicals will be required. All hazardous (ignitable, reactive, flammable, corrosive, and toxic) materials will be stored in clearly labeled containers or vessels. All storage locations will be equipped with secondary containment and fire prevention systems in accordance with good engineering practices. MSDS sheets for the chemicals to be used on Ocean Cay are included in Appendix F. A description of chemical management strategies for construction and operation is provided below.

3.6.1 Construction

During construction of the proposed facilities petroleum products and chemicals will be shipped to Ocean Cay to support the operation of heavy equipment, electrical generating equipment and the construction process. A materials inventory listing the approximate types and quantities of petroleum and chemical materials to be stored at the facility is provided below in Table 3-7. Generally, petroleum and chemical uses will include the following:

- Aboveground oil storage
  - Two 75.7 m^3 (20,000 gal) above ground storage tanks with integral containment systems located south of the SVH;
  - Aboveground diesel fuel oil storage tanks associated with electrical generators;

- Fuel Oil Transport
  - Fuel oil delivery by barges to the facility's SVH and to construction related offshore vessels;
  - Fuel oil delivery by tanker trucks to the various construction work sites on the island;
- Chemical storage
  - Paints and coating materials;
  - Cleaners;
  - Water treatment chemicals for mobile RO unit;
  - Ethylene glycol;
  - welding and welding inspection chemicals and compressed gases;
- Lube and hydraulic oil storage systems
  - Drummed storage of oils and greases to support heavy equipment maintenance; and
  - Small containers of lubricants and oils used for on-site equipment.

Table 3-7
Chemicals Usage Quantities – Construction

Chemicals	**Quantity Range of Materials On Site at Any Given Time**				
	Less than 0.21 m^3 (55 gal)	**0.21 to 3.8 m^3 (55 gal to 1,000 gal)**	**3.8 to 37.9 m^3 (1,000 to 10,000 gal)**	**37.9 to 378.5 m^3 (10,000 to 100,000 gal)**	**Greater than 378.5 m3 (100,000 gal)**
Lubricating Oils		X			
Fuel Oils				X	
Paints and Coating Materials		X			
Cleaners		X			
Water Treatment Chemicals			X		
Ethylene Glycol (or equivalent)		X			
X-Ray Development Chemicals		X			
Compressed Gases		X			
Concrete Additives		X			
Sodium Hypochlorite		X			

Solid and chemical materials and waste management practices are described below in Section 3.7. Additional details on petroleum and chemical management practices, and spill control, response and pollution prevention programs are presented in the Requirements for the Contractor's, Spill Prevention, Control and Countermeasures Plan, contained in Section 10.

3.6.1.1 Decommissioning and Disposition of Construction Materials

Each construction contractor selected for the project will prepare a written plan detailing how construction related equipment, materials and wastes will be decommissioned and disposed of at the completion of their work. The decommissioning and disposal plan will be reviewed by AES prior to mobilization of the contractor to the site, and AES will maintain ultimate responsibility for the proper management of equipment, materials and wastes within the project area.

Prior to demobilization, the contractor will prepare a detailed list of all remaining equipment, unused materials, and wastes transported to the project area or generated as a result of work they performed. The equipment, unused materials and waste list will contain a description of the following:

- How each piece of equipment will be prepared for off-site shipment and the type and quantity of waste materials that will be generated during the equipment demobilization effort;
- The quantities and types of all unused materials, and the planned disposition of those materials; and
- The types, quantities and disposal plan for all wastes generated by the contractor which still remain within the project area.

The equipment, unused materials and waste list will be submitted to the AES Environmental Inspector prior to demobilization of the contractor to ensure that all equipment, unused materials and wastes are managed and disposed off in accordance with good practices, applicable regulatory requirements, and the procedures described below in Section 3.7.

3.6.2 Operation

During facility operations, fuel oil and certain chemicals will be shipped to Ocean Cay. The following is an overview of the activities involving petroleum and chemical materials on Ocean Cay during operation of the LNG facility, in addition to the LNG/LPG tanks and accessory systems described in previous sections. A materials inventory listing the approximate types and quantities of petroleum and chemical materials to be stored at the facility is provided below in Table 3-8:

- Aboveground oil storage
  - One 1,135.6 m^3 (300,000-gal) aboveground and two 75.7 m^3 (20,000-gal) aboveground fuel oil storage tanks;
  - 3 Oil-filled transformers (Non-PCB) (6.8 m^3 (1,800 gal) each);
  - Aboveground diesel fuel storage tanks associated with emergency generators;
  - 57 m^3 (15,000 gal) closed loop hot oil system associated with LPG Stripping operation;
  - Waste oil generated from oil/water separator;
- Oil/water separator(s); Fuel oil transport
  - Fuel oil delivery operations performed by barges to the facility;
  - Fuel oil delivery operations performed by tanker trucks on the island;
  - Fuel oil piping used to transport fuel from the harbor to aboveground storage tanks;
  - Oil transfer pumps;
- Chemical storage
  - Aboveground ethylene glycol circulation loop storage tanks (57 m^3 (15,000 gal as 50 percent solution);
  - Water treatment chemicals/additives;
  - Water treatment wastes;
  - Sulfuric acid aboveground storage tank (3.8 m^3 (1,000 gal));
  - Sodium hydroxide aboveground storage tank (7.6 m^3 (2,000 gal));
  - Underground sanitary wastes in septic tanks;
  - Sodium hypochlorite solution tank (disinfectant) (227 m^3 (60,000 gal));
  - Gas Odorant System;
  - Paints, cleaners, oils, automotive fluids stored in the maintenance buildings (small containers, generally less than 209 liters (55 gal.) in size).
- Lube and hydraulic oil storage systems
  - Lubricating oil systems;
  - Small containers of lubricating and oils used for on-site equipment;
  - Hydraulic oil systems (located on the pier, power generating area, and LNG storage);
  - Compressors and oily compressor blow-down;

Table 3-8
Chemical Usage Quantities – Operation

Chemicals	Quantity Range of Materials On Site at Any Given Time				
	Less than 0.21 m^3 (55 gal)	0.21 to 3.8 m^3 (55 gal to 1,000 gal)	3.8 to 37.9 m^3 (1,000 to 10,000 gal)	37.9 to 378.5 m^3 (10,000 to 100,000 gal)	Greater than 378.5 m3 (100,000 gal)
Lubricating Oils		X			
Fuel Oils					X
Mercaptain Blend Odorant		X			
Cleaners		X			
Water Treatment Chemicals (acids and caustics)			X		
Ethylene Glycol (50 percent solution)				X	
LNG					X
LPG					X
Compressed Gas Cylinders	X				
Sodium Hypochlorite				X	

The 1,135 m^3 (300,000 gal) fuel oil storage tank will be situated inside a secondary containment structure designed to have a storage capacity of at least 110 percent of the tank volume and a floor constructed to be impervious to oil. The two 75.7 m^3 (20,000 gal) double walled storage tanks will be used both during construction and operation. Drainage from the large tank containment area will be routed to an oil/water separator. The three fuel oil storage tanks will have tank level monitoring systems and overfill alarms installed to prevent overfilling. Automatic shut-off valves will be installed in the fuel oil piping. Spill capture and containment pads will be provided in the fuel unloading and transfer areas as described in Section 10. All product oil piping will be installed aboveground.

There will be no storage of oil or chemicals on The Biminis, with the exception of very small quantities of cleaning and landscaping materials used for maintenance of the housing developments.

Further details of the management of fuel oil and other listed materials on Ocean Cay are outlined in the Integrated Spill Control, Response, Pollution Prevention and Stormwater Management Plan (Spill Plan) prepared for this project as discussed in Section 10.

3.7 Solid and Chemical Waste Management

The following section describes the types and sources of solid and chemical wastes that may be generated during the construction and operational phases of the proposed project facilities on Ocean Cay and The Biminis. A waste minimization plan for the disposition of spent petroleum and chemical products is included in Section 10.

3.7.1 Construction Related Waste

The construction contractor, under the oversight of AES, will be responsible for the proper characterization, collection, storage, and ultimate disposal of all construction-related waste materials, in compliance with The Bahamas Department of Environmental Health Services (DEHS) Solid Waste Regulations and the requirements of the DEHS Director. AES's facility personnel will be responsible for proper waste management practices during the operation of the completed project facility in compliance with the DEHS Regulations and the requirements of the DEHS Director.

The types, sources, and management of wastes anticipated to be generated during the construction of the proposed project facilities are as follows:

- Combustible wastes, such as scrap wood, cardboard, paper, and land clearing wastes (trees, brush, etc.) will be generated during the site preparation, construction, and operational phases of the proposed project facilities. These wastes will be burned on-site at the northeastern corner of Ocean Cay.
- Bulky construction wastes, such as concrete, clean fill material, scrap metal, glass, and plastics will be generated during construction of the proposed project. Clean fill materials and other bulky construction wastes may be reused on-site at Ocean Cay as fill material or otherwise disposed of at an approved off-site disposal area. The construction contractor, under the oversight of AES, will be responsible to select disposal locations for bulky construction wastes.
- Special wastes, such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumpings, lead acid storage batteries, and used oil, will be generated during the construction and operational phases of the proposed project. Special wastes could also include

items such as waste lubricants, paints, maintenance-related wastes, used air and liquid filtration media, and empty or partially full chemical containers.

Special wastes will be segregated from other waste streams, collected and stored in suitable containers, within secondary containment and periodically transported off-site by barge for disposal at an approved location by an approved waste transporter.

- Sanitary wastes will be managed through the use of incinerating toilets as described in Section 2.3.1.1.

- Shipboard Wastes. It is anticipated that one or more cruise ships or quarters barges will be used to provide temporary housing for construction workers during the construction phase of the proposed project. Additionally, barges and other vessels will be utilized as work platforms and support vessels during the dredging operations and construction of the pipelines associated with the proposed project. Shipboard wastes that may be managed differently than the practices described above are as follows:

  - Combustible commercial and industrial wastes, such as office wastes, packaging materials, food service wastes, scrap wood, cardboard, paper, garbage, refuse, and rubbish that are generated on board vessels associated with the project will be incinerated in approved incinerators on board the vessels, if so equipped. For vessels not equipped with approved incinerators, such wastes will be collected and periodically transported by barge directly for off-site disposal at an approved location, or transferred to Ocean Cay for temporary storage or burning, or for transfer to an approved off-site location.
  - Special wastes generated on board vessels associated with the project will be segregated from other waste streams, collected and stored in suitable containers, and periodically transported by barge directly for off-site disposal at an approved location, or transferred to Ocean Cay for temporary storage and later transfer to an approved off-site location.
  - Blackwater and greywater will be periodically pumped as necessary to a barge for disposal outside the 4.8 km (3 mi) limit in accordance with MARPOL 73/78 (1997). Bilgewater will be treated by the ship's oil/water separator to a concentration of less than 15 ppm oil and grease (per MARPOL requirements) prior to discharge.

Short-Term Waste Accumulation Areas. Prior to off-site shipment, commercial, industrial, and special wastes will be accumulated in suitable containers that will be temporarily stored at Ocean Cay in storage areas equipped with the following: impervious flooring, roofing or other protection from the weather, and adequate structural means to contain reasonably anticipated potential releases.

Spills and Releases. Accidental releases or spills of waste materials will be controlled, cleaned up, and managed in accordance with the requirements, as described in Section 10, Environmental Management Plan.

3.7.2 Operational Related Waste

The types, sources, and management of wastes anticipated to be generated during the operation of the proposed project facilities are as follows:

- Municipal Wastes will include food wastes, paper, household wastes generated from the hostel and food preparation facilities.

  All recyclable materials will be segregated and stored in suitable containers, and periodically transported offsite for recycling or disposal at an approved location by an approved transporter and vendor. Combustible waste will be burned. Non-burnable wastes will be collected and transported off-site for disposal. Waste materials will be managed on Ocean Cay in accordance with the requirements of the DEHS.

- Plant Wastes such as office wastes, packaging materials, ashes, garbage, refuse, and rubbish will be generated during the construction and operational phases of the proposed project. Combustible office waste will be burned. Non-burnable wastes will be collected and transported off-site for disposal. Plant wastes will be segregated from other waste streams, collected and stored in suitable containers, and transported off-site and disposed in the United States at an approved location by an approved waste transporter.

- Special Wastes such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumpings, lead-acid storage batteries, septage, and used oil, will be generated during the construction and operational phases of the proposed project. Special wastes could also include items such as waste oils, waste lubricants, paints, maintenance-related wastes, used air and liquid filtration media, and empty or nearly empty chemical containers.

Special wastes will be segregated from other waste streams, collected and stored in suitable containers, within secondary containment and periodically transported off-site by barge for disposal in the U.S. or The Bahamas at an approved location by a waste transporter.

- Process Waste Water, such as waste desalination brine, RO Treatment system back wash, Demineralized regeneration wastes, compressor blowdown, and wash water will be treated and monitored prior to discharge through the water discharge structure described above.

- Sewage wastes will be disposed of in an on-site septic system.

Table 3-9
Estimated Quantities of Waste Generation – Operations

Waste Category	**Quantity Range of Wastes to be Generated Annually**		
	Less than 1 MT	**1 to 10 MT**	**10 to 50 MT**
Office Wastes		X	
Municipal Waste			X
Plant Waste			X
Special Waste		X	
Sewage	X		

4.0 BASELINE DESCRIPTION OF THE DEVELOPMENT SITE

4.1 Natural Environmental Baseline

Multiple studies were commissioned by AES to collect information used to assess existing baseline conditions of the marine and terrestrial environment within the project area. As described below, the project area baseline assessment consisted of an evaluation of the following:

- Topography and Climate,
- Oceanographic Conditions,
- Land Use,
- Regional Geology;
- Hydrology and Surface Waters;
- Biological Aspects;
- Fisheries;
- Terrestrial Habitats;
- National Parks, Protected Areas, and Marine Reserves;
- Air, Noise, and Environmental Contamination;
- Social, Economic and Institutional Resources;
- Cultural Resources;
- Provision of Services; and,
- Legal, Regulatory and Administrative Requirements.

The information presented in this section, along with the description of the facilities and construction techniques described previously, was used to identify the potential impacts of the project discussed in Section 5, Potential Environmental Impacts of the Proposed Project.

4.1.1 Topography and Climate

The climate of The Bahamas, including the project area, is subtropical marine with winter and summer seasons. The summer season, from May to November, is warm with abundant rainfall; and, the winter season, from December to April, is mild and dry. The climate is influenced by the warm waters of the Gulf Stream, which has the effect of slightly lowering temperatures in the summer and contributing to mild winters. Because of its small area, isolation from other land masses, and lack of topographic features, the climate on Ocean Cay and the Biminis are also influenced by trade winds. The air temperature in The Bahamas during winter months averages approximately 25 °C (77 °F), while the summer temperature ranges between 23-32 °C (73 - 90 °F). Water temperature ranges between 20-30

°C (68 – 86 °F) with an average temperature of approximately 25 °C (77 °F). Much of the Bahama Bank has a relatively humid climate with annual rainfall between 100 and 150 cm (39-59 in) per year. Rainfall is seasonal and predominantly occurs during the summer months. Trade winds, which are the product of a pressure feature known as the Bermuda high, blow in a predominately easterly direction with consistent wind speed. The Bermuda high is a semi-permanent high pressure system. Although the prevailing wind is from the east and northeast, wind direction ranges from southeast to northeast throughout the year. Average wind speeds during summer months typically fall below 10 knots, while exceeding 13 knots during the winter season. Conditions within the project area are expected to fall within these general ranges for The Bahamas area.

Much of the Bahamian archipelago lies within the Atlantic hurricane belt. Hurricanes are cyclones that develop over the warm tropical oceans and have sustained winds in excess of 64 knots. These storms occasionally hit The Bahamas with dangerous winds, torrential rains, and flooding.

The Great Bahama Bank, together with the Florida Peninsula and the island of Cuba, separate the Atlantic Ocean from the Gulf of Mexico and the Caribbean Sea. The connection between these oceans is limited to the seaways between The Bahamas, the Florida Peninsula, and Cuba. As such, the seaways serve to funnel water masses in and out of the major ocean basins, resulting in high velocity currents in the Straits of Florida and the Santaren Channel. The Antillean Current flows northwest through the Santaren Channel and is believed to mix with the Florida Current off the southern tip of Florida before flowing north through the Straits of Florida as the Gulf Stream.

The western, Gulf Stream side of Ocean Cay and the Biminis is sharply cut; however, beaches of coarse aragonite sand are found on both the exposed west side of the islands as well as the more protected lee side of the islands. The aragonite sand sea floor falls away sharply on the west shorelines of Ocean Cay, North and South Bimini, and within one quarter to one half mile of the islands begins the drop off that extends into hundreds and thousands of feet in the Gulf Stream (Craton 1968: 32).

During the period starting 1 October 2001 and ending on 22 January 2002, an intensive short-term meteorological and oceanographic data collection effort to support the design of the LNG receiving terminal on Ocean Cay (MetOcean Study) was conducted. An automated meteorological station was installed on the southwestern corner of Ocean Cay, with an anemometer height of 4.1 m (13.5 ft) above grade. The collected data consisted of average, minimum, and maximum wind speeds; wind direction; air temperature; relative humidity; and precipitation values, each recorded once every 15 minutes. In addition, average, minimum and maximum atmospheric pressures were recorded once every hour. The data are presented in time series plots in Appendix A and a wind rose (wind speed and direction frequency plot) based on the data is presented in Figure 4.1. The investigation was conducted to collect relevant oceanographic and meteorological data in support of the design effort for the LNG receiving terminal and power plant at Ocean Cay. Specifically, the objectives of the MetOcean Study were to provide fundamental wave, current, and water level data necessary to calibrate the numerical models to be used during the design of the marine elements of the project.

A total of ten instruments were deployed during the MetOcean Study to the locations shown on Figure 4.2. They included the following:

- Acoustic doppler profiler (2)
- 3D wave/current meters (2)
- Wave/tide gauges (4)
- Conductivity, temperature, and depth sensor (1)
- Meteorological station on Ocean Cay (wind speed and direction, atmospheric pressure, temperature, humidity, and precipitation) (1)

All instruments with the exception of the conductivity, temperature and depth sensor (SEACAT SBE 19 plus model) were deployed in-situ for the duration of the MetOcean Study. The SEACAT was used in profile mode only. The results of the MetOcean Study are incorporated into several of the following sections.

4.1.1.1 Wind

During the period starting 1 October 2001 and ending on 22 January 2002, an intensive short-term meteorological and oceanographic data collection effort to support the design of the LNG receiving terminal was conducted. The results of the study are presented below. Figure 4.1 is the wind rose for Ocean Cay that was developed from data collected during the short-term MetOcean Study conducted by AES (Appendix A). Over 75 percent of the recorded winds had an average speed less than or equal to 5.0 meters per second (m/s) (11.2 mph) and are considered to represent “calm” conditions. The strongest winds recorded during the study were from east to northeast. The highest average wind speed during the study was 17 m/s (38 mph) and was recorded in early November 2001 when Hurricane Michelle passed to the south of Ocean Cay.

Figure 4.3 presents the frequency distribution of wind speeds for Ocean Cay, Nassau and Settlement Point, The Bahamas, and Miami International Airport. The wind climate at Ocean Cay appears to be reasonably similar to that observed at other area stations. In general, 98 percent of wind speeds are less than 12 m/s (26.8 mph), with wind speeds above 16 m/s (35.8 mph) are extremely infrequent.

Based on the meteorological data acquired at Ocean Cay, the operational wind climate at Ocean Cay appears to be slightly less severe than those observed at the other stations. This is believed to be caused by the short observation period at Ocean Cay, seasonal variations in wind speeds, and that wind speeds at Ocean Cay have not been converted to a 10 m (32.8 ft) elevation. Conversion of anemometer height (from +4.1 m to +10 m (+13.5 to +32.8 ft)) will result in a 14 percent increase in wind speeds. However this change will not affect the operational design criteria for the proposed facilities on Ocean Cay as long-term wind data acquired at the Nassau meteorological station will be used in the development of design criteria. The extreme wind climate for the site is governed by the strength of tropical systems that occasionally affect the area and is not developed based on the field measurements taken on Ocean Cay.

4.1.1.2 Precipitation

Precipitation data for Nassau were examined as representative of the Ocean Cay climate. This data is available from the National Climatic Data Center (NCDC), a line office of the U.S. National Oceanic Atmospheric Administration (NOAA), in the form of monthly statistics based on a 135-year record spanning from 1855 to 1989. The Nassau site was selected as it is the NCDC monitoring site closest to Ocean Cay and is assumed for the purposes of this study to experience precipitation typical of the Ocean Cay area. Figure 4.4 shows the variations in average monthly rainfall at Nassau. The average annual precipitation is about 1.3 m (4.3 ft), with the precipitation typically occurring during the months of May to October. Drier conditions prevail during November to April, with a total precipitation of approximately 0.30 m (1 ft) for this period.

Figure 4.5 provides statistics on the maximum rainfall experienced during each month. The highest annual rainfall during the 135-year time period was 2.3 m (7.54 ft), and the minimum was 0.5 m (1.64 ft). Estimated stormwater discharge quantities are presented in Section 3.5.

4.1.1.3 Meteorological Data for Dispersion Modeling

Representative hourly meteorological data (surface and upper air) are required to evaluate air quality impacts from the proposed project using the US EPA-approved dispersion model - Industrial Source Complex short-term (ISCST3). US EPA criteria for determining representative meteorological data for air quality impact analyses were used to evaluate available data sets. These criteria include proximity to the project site, similarity in terrain features, similarity in wind direction and speed frequency distribution, and the quantity and quality of the available data.

The site meteorological data set described above in Sections 4.1.1.1 and 4.1.1.2 does not represent a sufficiently long collection period and does not contain all of the required input parameters to perform the air quality dispersion modeling analysis. However, it is useful in evaluating whether other available and sufficiently detailed meteorological data sets are representative of the project site for use in the dispersion modeling.

Based on these criteria, sources of meteorological data potentially suitable for dispersion modeling on Ocean Cay were preliminarily identified and data were obtained from monitoring stations located at Settlement Point and Nassau Airport in The Bahamas and from Key West, Miami and West Palm Beach in Florida. After review of these data sets based on the US EPA criteria, upper air data from Station #12844 - West Palm Beach International Airport, Florida and surface data from Station #12836 - Key West International Airport, Florida were selected for input in the ISCST3 modeling analysis. The most recent 5 years of meteorological data available from these stations was used in the ISCST3 modeling analysis. These upper air and surface data sources are judged to be the most meteorologically representative of available data for refined dispersion modeling purposes based on proximity to Ocean Cay and the similarity of climatological and terrain features and maritime influences.

The West Palm Beach upper air data is the closest meteorological monitoring station with upper air data that are both sufficiently complete and in the appropriate format for input in ISCST3 (upper air data is available from the Nassau Airport, but the data set is incomplete). Although there are closer monitoring stations with surface data (e.g., Miami and West Palm Beach airports – within 105 and 162 km (65.2 and 100.7 mi) of Ocean Cay, respectively), the location of the Key West monitoring station is judged to be the most representative with respect to similarity in lack of complex terrain, and the similarity in wind speed and wind direction frequency distributions. Key West is located 285 km (177 mi) southwest of Ocean Cay, near the southern end of a narrow line of small islands or reefs, more than 80.5 km (50 mi) from the Florida mainland. The location of Key West is considered more representative than the locations of the Nassau and Settlement Point monitoring stations, which have more influences from larger landmasses than Key West.

Appendix A provides further substantiation of the Key West surface wind data. Wind speed and direction frequency distributions from the identified surface wind data sets are compared. This comparison shows a high correlation between all of the data sets with respect to wind direction and wind speed distribution. In addition, a comparison of meteorological data collected at the project site between 1 October 2001 and 22 January 2002, and the same parameters from the Key West monitoring station over the same date range, shows high correlation.

4.1.2 Oceanographic Conditions

In evaluating the oceanographic conditions in the vicinity of Ocean Cay that may affect the AES Ocean LNG, Ltd. project, salinity and temperature profiles, offshore and near shore wave climates, currents, and water levels have been analyzed. Each of these conditions is discussed below.

4.1.2.1 Ocean Salinity and Temperature Profiles

Ocean water salinity and temperature profiles were taken at three locations on October 7, 2001, and at one location on January 12, 2002, in the vicinity of Ocean Cay, Bahamas, using a Sea-Bird Electronics (SBE) Conductivity, Temperature and Depth Sensor (CTD), as shown in Figure 2-3, included in Appendix A.

All locations sampled in October show slight variations in vertical distribution of both salinity and temperature, oscillating between constant values throughout the water column to a slightly stratified profile due to the influence of surface winds and tides. The temperature ranges at all depths and times vary slightly between 28.5 ^{o}C to 30.0 ^{o}C (83.3 ^{o}F to 86 ^{o}F), with a maximum surface to bottom difference of approximately 1.0 ^{o}C (2 ^{o}F). The salinity measurements at all depths and times compare similarly, ranging from 35.5 practical salinity units (PSU) to 36.5 PSU, with a maximum surface to bottom difference of approximately 0.8 PSU.

Samples collected in January (Location CTD4), exhibited a nearly uniform vertical distribution of both temperature and salinity, showing slight variations with time. The temperature from the surface to the bottom remained at approximately 24.7 ^{o}C (76.5 ^{o}F) throughout the sampling period. The salinity remained constant with depth but increased slightly throughout the sampling period from 33.0 PSU to 34.8 PSU. All temperature and salinity measurements were lower than those measured in October, as expected, due to seasonal variability.

4.1.2.2 Offshore Wave Climates

Waves in the vicinity of Ocean Cay were monitored during the period of October 2001 through January 2002 during the MetOcean Study by instruments deployed as shown on Figure 4.2. This report of results has made a distinction between operational and storm wave climates. In general, the term "operational wave climate" refers to the day-to-day wave climate, whereas the term "storm wave climate" is used to describe the wave conditions during the passage of tropical cyclones that occasionally affect the site. In addition, as an island, Ocean Cay is exposed to waves from all directions. However, due to its location on the edge of the Great Bahama Bank, the severity of the operational and storm wave climates around the island varies significantly from one coastline to another. Relatively speaking, the wave climates (operational and storm) off the western shore of Ocean Cay (i.e., eastern boundary of Straits of Florida) are more severe than those off the eastern coast of the island. This is mainly due to the deep nature of the Straits of Florida. The shallow nature of the Great Bahama Bank limits the potential for large waves to develop or propagate. Waves travelling towards Ocean Cay will undergo transformation processes such as refraction, diffraction, shoaling, and breaking, which will affect their propagation direction and wave height near Ocean Cay.

4.1.2.3 Operational Wave Climate

A. West Coast

In addition to the MetOcean Study, data regarding wave strength were collected during a 10-year hindcast period. The hindcast data discussed below were extracted at data point 3044 located approximate 15 km (9.3 mi) to the southwest of Ocean Cay in about 800 m (2,625 ft) water depth.

The wave climate offshore of the western coast of Ocean Cay is variable and at times energetic. As shown in Figure 4.6, from an operational point of view there is little variation in the monthly average significant wave heights.

Figure 4.7 shows the Deepwater Wave Rose for the 10-year hindcast period. Waves less than 0.50 m (1.6 ft) are assumed to be calm. Figure 4.7 indicates calm conditions prevail approximately 37 percent of the time. The frequency of occurrence of waves with significant heights in excess of 1.5 m (4.9 ft) is approximately 5.2 percent, with only 1.65 percent of occurrences with significant wave heights in excess of 2.0 m (6.6 ft).

Most waves are small and travel in an easterly direction. This can be attributed to two factors: (1) the propagation direction of these waves coincides with the predominant wind directions over the Great Bahama Bank, which are from southeast to northeast, and (2) the chain of cays that are located to the south and north of the project site tend to limit the propagation of waves from the east into the Straits of Florida. The hindcast model's resolution did not permit the inclusion of these small cays into the simulation, and as such, it is believed that the contribution of waves from the east to the operational wave climate on the west coast of the site is overly conservative. Waves traveling from the eastern direction tend to be small and are not expected to cause any significant operational difficulties. In general, the larger waves tend to be coming from the south, southwest, west, northwest, and north.

The dominant wave period ranges from 3 seconds (s) to 7 s, indicating that most waves are locally generated. Peak periods in excess of 10 s represent only 0.05 percent of the occurrences. These are due to the passage of tropical cyclones within the hindcast area.

The overall day-to-day wave heights can be characterized as relatively mild, with the monthly average deepwater significant wave heights ranging from 0.4 m (1.3 ft) to 0.9 m (3.0 ft). It is important to note that during the hurricane season, which starts on 1 June and ends on 31 November, significantly larger than average waves can and should be expected due to the passage of tropical cyclones. These storm-induced high wave energy events tend to be of short duration and therefore are not fully represented in the monthly average wave heights. For example, according to the storm hindcast, during the 1990's the largest significant wave height offshore of Ocean Cay for the month of August was 8.4 m (27.6 ft) (Hurricane Andrew), which is much larger than the monthly average of 0.5 m (1.6 ft).

Figure 4.8 shows the frequency distribution of swell heights (i.e., waves that are not locally generated). Swells are important because they may impact the motion of moored vessels, which may result in a reduction in berth availability. As shown on Figure 4.8, swells tend to be very small.

B. East Coast

The wave climate off the east coast of Ocean Cay is shown in Figure 4.9. From an operational point of view, there is very little variation in the monthly averaged significant wave heights.

Figure 4.10 shows the wave rose for the 10-year hindcast period for the east coast of Ocean Cay. Waves less than 0.25 m (0.8 ft) are assumed to be calm. The hindcast data presented in this wave rose was extracted at data point 3045, located approximately 17 km (10.6 mi) to the east of Ocean Cay in about 5 m (16.4 ft) water depth. According to Figure 4.11, waves with a significant height of less than 0.50 m (1.6 ft) (i.e., calm) represent about 61 percent of the occurrences. The frequency of occurrence of waves with significant heights in excess of 1.5 m (4.9 ft) is only 0.01 percent.

As expected, most waves are relatively small and come in from the east. The dominant wave period ranges from 2 s to 4 s, indicating that most waves are locally generated. Wave peak periods in excess of 4 s represent less than 1 percent of the total occurrences.

The overall day-to-day wave heights can be characterized as relatively mild, with the monthly average deepwater significant wave heights ranging from 0.35 m (1.1 ft) to 0.5 m (1.6 ft). However, during the passage of tropical cyclones, larger waves should be expected.

4.1.2.4 Storm Waves

Storm waves in the Ocean Cay area are mainly due to the passage of tropical cyclones, which are low-pressure systems that generally form in the tropics from June to November. These cyclones are accompanied by thunderstorms and, in the Northern Hemisphere, a counterclockwise circulation of winds near the earth's surface. Tropical cyclones are classified as follows:

- Tropical depressions, which are an organized system of clouds and thunderstorms with a defined surface circulation and maximum sustained wind speed of 17 m/s (38 mph) or less;
- Tropical storms, which are systems of organized thunderstorms with defined surface circulation and maximum sustained wind speed of 17 m/s to 33 m/s (38 to 74 mph); and,
- Hurricanes, which are intense tropical weather systems of thunderstorms with a well defined surface circulation and maximum sustained wind speed of over 33 m/s (74 mph).

As shown in Table 4-1, hurricanes are categorized according to the strength of their winds using the Saffir-Simpson scale.

Table 4-1
Saffir-Simpson Tropical Cyclone Scale

Category	Mean Pressure (mb)	Sustained Wind Speeds (m/s)
1	980 or more	33.0 – 42.0
2	965 – 979	43.0 – 49.2
3	945 – 964	49.3 – 58.1
4	920 – 944	58.2 – 69.5
5	Less than 920	> 69.5

The potential for a hurricane to generate very large waves is related to the hurricane's sustained wind speed and its forward moving speed. Thus, the above described categories are relative terms, as lower category storms with a slower forward moving speed can sometimes generate larger waves than higher category storms, with faster forward moving speeds.

A review of the best predicted tropical storm and hurricane tracks compiled by National Hurricane Center (NHC) for the Caribbean region indicates that during the 1886-2001 period, a total of 64 systems have passed within one degree latitude or longitude of Ocean Cay. Out of these 64 systems, 30 were categorized as tropical depressions or storms, and 34 were hurricanes. Table 4-2 provides a summary of the available statistics.

Table 4-2
Tropical Cyclones Passing Within One Degree Latitude and Longitude of Ocean Cay (1886-2001)

System Category	Number of Occurrences	Cumulative
Topical Depression	8	8
Tropical Storms	22	30
Hurricane 1	9	39
Hurricane 2	10	49
Hurricane 3	6	55
Hurricane 4	8	63
Hurricane 5	1	64

According to Table 4-2, on average the site is exposed to a tropical cyclone approximately once every two years, and exposed to a hurricane approximately once every 3 years.

Review of the hurricane tracks also reveals that most tropical storms and hurricanes affect the Ocean Cay area between the months of August and October (inclusive), with the bulk of the systems passing within relative proximity of Ocean Cay during the months of September and October. The results of this analysis are summarized in Table 4-3.

Table 4-3

Monthly Distribution of Tropical Cyclones Passing Within One Degree Latitude and Longitude of Ocean Cay (1886-2001)

Month	Tropical		Hurricane Category					Total
	Dep.	Storm	1	2	3	4	5	
June	1	2	0	0	0	0	0	3
July	0	1	0	0	1	0	0	2
August	5	4	1	4	1	2	0	17
September	2	6	1	1	2	5	1	18
October	0	6	6	5	2	1	0	20
November	0	3	1	0	0	0	0	4
Total	8	22	9	10	6	8	1	64

The 25 most severe hurricanes among the population of 34 hurricanes that had passed within one degree latitude/longitude of the project area were selected for hindcasting. The hindcast approach consisted of implementing a highly refined mesoscale hindcast methodology for the specification of surface wind and pressure fields in tropical cyclones, in conjunction with a proven basin and regional-scale spectral wave model combined with a two-dimensional hydrodynamic model developed by Ocean Weather Inc. These wave and surge/current models were run to the practical limit of resolution to achieve numerical stability, which is about 1.5 km (0.93 mi). To develop a detailed prediction of the extreme waves, currents, and water levels at the site, the hindcasted results were further refined through the use of regional and local wave and hydrodynamic numerical models. Local wave transformation modeling was carried out using the Near shore Spectral Wave (NSW) module of the Mike 21 Suite of Software and other specialized state-of-the-art wave generation/transformation numerical models developed by Han-Padron Associates (HPA). Details concerning the storm hindcast methodology, analysis, and results can be found in HPA's report provided in Appendix A.

Table 4-4 provides a complete listing of the hindcasted hurricanes. A sectored extreme analysis was carried out to develop wave conditions associated with storms with long return periods. The extreme analysis was conducted using HPA developed software and according to the approach and methodology described in Kamphuis (2001) and recommended by International Navigation Association (PIANC). The analysis was carried out for the eastern and western coasts of the project site. Wave heights associated with the 10, 25, 50, 100, 200, and 500-year return periods were estimated using Weibull and Gumbel distributions. In addition, confidence bands were estimated using LeMahaute and Wang (1985). According to this analysis, the deepwater significant wave heights associated with the 100, 200, and 500 year events are 12 m (39.4 ft), 14 m (45.9 ft), and 16.5 m (54.1 ft), respectively.

Table 4-4

List Of Hindcast Hurricanes

Storm	File Name	Date			Storm Name
		Year	Month	Day	
1	1926_01	1926	07	24	Not Named
2	1926_10	1926	10	14	Not Named
3	1928_01	1928	08	04	Not Named
4	1928_04	1928	09	14	Not Named
5	1929_02	1929	09	22	Not Named
6	1932_03	1932	08	26	Not Named
7	1933_12	1933	09	02	Not Named
8	1933_18	1933	10	01	Not Named
9	1935_04	1935	09	23	Not Named
10	1936_01	1936	06	12	Not Named
11	1936_05	1936	07	27	Not Named
12	1937_03	1937	08	25	Not Named
13	1941_05	1941	10	04	Not Named
14	1945_09	1945	09	14	Not Named
15	1946_04	1946	09	12	Not Named
16	1946_06	1946	10	31	Not Named
17	1948_08	1948	10	04	Not Named
18	1949_02	1949	08	24	Not Named
19	1964_05	1964	08	26	Cleo
20	1965_03	1965	09	11	Betsy
21	1966_09	1966	09	29	Inez
22	1979_04	1979	08	31	David
23	1984_10	1984	09	25	Isidore
24	1987_07	1987	10	09	Floyd
25	1992_02	1992	08	22	Andrew

Deep water waves propagating into shallow water undergo wave transformation processes that result in changes in their significant heights, propagation directions, and potentially wave periods. These wave transformation processes reduce the storm waves as they travel from offshore over the western boundary of the Great Bahama Bank. At this site, the near shore wave heights will be depth-limited and therefore the influence of storm surge was considered in the wave transformation analysis required to develop the near shore wave climate.

A similar analysis was carried out for the eastern coast of the island. The extreme offshore waves on the East Side of Ocean Cay are depth-limited and storm surge has a clear impact on the magnitude of extreme waves. The non-transformed significant wave heights associated with the 100, 200, and 500 year events range from 5.5 m (18 ft) to 7.0 m (23 ft).

4.1.2.5 Near shore Wave Climate

The near shore wave data were measured during a four-month long MetOcean Study offshore of Ocean Cay from October 2001 through January 2002. This wave climate represents the wave conditions during this monitoring period only.

Figure 4.10 shows the directional distribution of the measured significant wave heights in 8 m (26 ft) water approximately 1.5 km (0.9 mi) to the southwest of Ocean Cay. Waves with a significant height of less than 0.25 m (0.8 ft), which represent approximate 41 percent of the occurrences, are assumed to be calm. The frequency of occurrence of waves with significant heights in excess of 1.5 m (4.9 ft) is about 0.3 percent. The largest measured wave had a significant height of about 1.7 m (5.6 ft), which occurred during the passage of Hurricane Michelle well to the south of Ocean Cay. During the monitoring period, the most energetic waves were traveling from the northwest. Approximately 20 percent of the observed waves traveled from the southeast to northeast; these waves tend to be small, rarely exceeding 0.75 m (2.5 ft) in significant height.

The dominant mean wave period off the west coast ranged from 2.0 s to 4.0 s. These are equivalent to peak periods ranging from 3.0 s to 6.0 s.

Figure 4.11 shows the directional distribution of the measured significant wave heights in approximately 5 m (16.4 ft) water depth about 2.0 km (1.2 mi) to the east of Ocean Cay. As shown on Figure 4.11, waves with a significant height of less than 0.50 m (1.6 ft), which represent about 61 percent of the occurrences, are assumed to be calm. The frequency of occurrence of waves with significant heights in excess of 1.0 m (3.3 ft) was extremely low during the monitoring period. The dominant wave direction ranged from east to northeast, coinciding with the dominant wind direction.

The dominant mean wave period off the east coast ranged from 1.5 s to 3.5 s. These are equivalent to peak periods ranging from 2.0 s to 4.5 s.

4.1.2.6 Currents

A detailed, intensive, and short-term current measurement study was conducted to assess the hydrodynamic conditions at and around the project site. The data acquired during the aforementioned study are the only known source of measured current data at the site. Details regarding the measurement and data processing techniques are provided in Appendix A.

The currents around the island are mainly tidally driven, although the near surface currents are strongly influenced by wind. Except near the surface, currents have a nearly uniform vertical profile. Figure 4.12 is a current rose developed using depth-averaged currents observed west of Ocean Cay in approximate 8 m (26.2 ft) water depth. The depth-averaged current rarely exceeds 0.5 m/s. The directional distribution associated with the currents is quite variable due to tidal oscillations. The net easterly current is caused by the strong wind-induced near surface currents.

Figure 4.13 shows the near surface current off the West Coast of Ocean Cay. As expected, the near surface currents are stronger than the depth-averaged currents and tend to be dominated by easterly and northeasterly currents that coincide with observed wind direction. The near-surface currents rarely exceed 1 m/s.

Figure 4.14 presents the near-bottom currents measured at a location about 2.5 km (7.8 mi) to the east of Ocean Cay in approximately 3.5 m (11.5 ft) water depth. The magnitudes and characteristics of currents off the east coast of Ocean Cay differ from those on the west side of the island. It can be seen that the currents on the Great Bahama Bank flow mainly in east/west and west/east directions and are primarily tidally driven. The easterly currents are slightly stronger than the westerly currents due to the wind's contribution. The current speeds on the Great Bahama Bank are larger than those observed off the west coast of Ocean Cay. This is mainly due to the shallow nature of the Great Bahama Bank.

4.1.2.7 Water Levels

Water levels at the site vary mainly in response to the action of tides and storm surge. The tides are semi-diurnal, with a mean tidal range of approximately 0.7 m (2.3 ft) and a maximum tidal range of approximately 1.3 m (4.3 ft). Table 4-5 summarizes the tidal elevations reported at Cat Cay, which are representative of tidal conditions at the project site.

Table 4-5

Estimated Tidal Elevations at Cat Cay

Tide Level	Elevation (m Chart Datum)
Highest Astronomical Tide (HAT)	+1.3
Mean Sea Level (MSL)	+0.7
Lowest Astronomical Tide (LAT)	-0.1

During the MetOcean Study (Appendix A), a number of tide gauges were installed at and in the relative vicinity of Ocean Cay. Tide measurements showed the occurrence of semi-diurnal tides with diurnal inequalities between each succeeding high tide. During neap tides, the tidal range was about 0.4 m (1.3 ft), whereas during spring tides, the tide range was about 0.85 m (2.8 ft). The largest measured tide during the short monitoring period of October 2001 through January 2002 had a range of about 1.05 m (3.4 ft).

Using harmonic analysis, the four main tidal constituents for Ocean Cay were estimated. These, along with published tidal constituents for Cat Cay, are shown in Table 4-6. The constituents for Cat Cay are published in Admiralty Tide Tables (The United Kingdom Hydrographic Office, 2001).

Table 4-6
Main Tidal Constituents for Ocean Cay and Cat Cay

Constituents		Ocean Cay	Cat Cay
M2	Amplitude (m)	0.3342	0.3400
	Phase (°)	262.79	235.00
S2	Amplitude (m)	0.0681	0.0700
	Phase (°)	286.59	259.00
K1	Amplitude (m)	0.0039	0.0100
	Phase (°)	131.41	138.00
O1	Amplitude (m)	0.0149	0.0100
	Phase (°)	268.33	262.00

Storm surge refers to the rise (or fall) in water level associated with the passage of storms and is the combined result of barometric pressure effects, wind stress on the water surface (wind setup), and wave setup.

Reliable estimates of historical storm surge levels for The Bahamas region are scarce. NOAA reports that during the passage of Hurricane Andrew, the maximum storm surge experienced at Current Island and Lower Bouge was +7.0 m (23 ft) and +4.9 m (16 ft), respectively. Storm surge values tend to have a significant spatial variation and, depending on the bathymetric conditions and the hurricane track, the storm surge at Ocean Cay can vary significantly.

The nominal elevation of Ocean Cay is about +3.5 m (11.5 ft) (MLLW). The surface of the island is not flat and areas with surface elevation as low as +1.8 m (5.9 ft) and as high as +4.5 m (14.8 ft) exist. In its current configuration, Ocean Cay is susceptible to flooding in the event of a direct hurricane hit. Based on interviews conducted at the site, areas on the island with an elevation of +3.5 m (11.5 ft) (2001 topographic survey) were flooded by as much as 0.2 m (0.7 ft) in 1992 during the passage of Hurricane Andrew.

A flood study is being carried out to determine surge levels around the island for storms with different return periods. Significant spatial variations in surge levels exist and depending on the hurricane track in reference to the coastline of Ocean Cay, surge values can vary significantly. Maximum surge is expected to occur along the eastern coast of Ocean Cay, followed by the northern and the southern coasts. The western coast of Ocean Cay is expected to experience the smallest (relative) surge conditions. Preliminary results indicate that the surge levels associated with the 100-year event will range +2.7 m (8.9 ft) to +3.3 m (10.8 ft) (MLLW). The smaller surge estimate is for the west coast of Ocean Cay, while the larger one is for the east coast. These estimates do not include the contribution of wave setup or wave run-up (overwash). The contribution of wave setup can be significant.

4.1.3 Land Use

4.1.3.1 Ocean Cay

Ocean Cay has been used for processing and stockpiling of bulk aragonite since the 1970s. The island, as it currently exists, has been largely created by mining operations and aragonite stockpiling as described in Section 2.2. Aragonite is dredged from the surrounding ocean bottom within the limits of the area described in The Bahamas Department of Lands and Surveys Lease #959, dated 15 April 1992, as shown on Figure 4.15. Geologic conditions for the project area are summarized in Section 4.1.4.

Site operations have historically involved the onshore and offshore use of a variety of heavy mining equipment. Currently, land-based operations include a large-scale electrically driven belt conveyor system for mobilizing and stockpiling bulk aragonite materials, as well as various bulldozers, loaders, excavators, cranes and other diesel-fueled equipment. Offshore operations have involved the use of several large-scale, self-unloading barges, work-boats, dredges and various other diesel fueled watercraft The majority of the mining operation vehicles and watercraft use diesel fuel, which is stored in four 95 m^3 (25,000 –gal) underground storage tanks (USTs) located on the southeastern portion of the island. Lesser amounts of gasoline are utilized for small watercraft and some support equipment. Gasoline is stored in an UST also located on the southeastern portion of the island. The components of the existing mining operation are shown on Figure 1.3.

The bulk aragonite product is shipped to market via ocean freighter traffic on ships of up to 244 m (800 ft) in length. These ships are accommodated by deepwater harbor moorings located near the south side of Ocean Cay, and are bulk loaded from the aragonite stockpile by belt conveyor via a large radial stacker. A small harbor with a barge pier is located at the southeastern corner of the island.

Two large (totaling 1800 kilowatts) diesel-driven generators located on the southeastern portion of Ocean Cay operate on a 24-hour basis to supply electricity for the island. The generators are located within a concrete structure known as the powerhouse. The northeastern corner of the powerhouse building is used as a tool shop. An electrical transformer is located on a concrete block outside the eastern wall of the powerhouse building. A second transformer is located west of the powerhouse, near a conveyor belt assembly. A small back-up generator and associated aboveground fuel tank are located on the southwestern portion of the island near two residential trailers used as short term worker housing. Two small airport runways are located along the western and northern shorelines of the island. Retired work-boats and other equipment have been discarded at the northeast disposal area and elsewhere on the island. Refer to Section 4.2.3 for a discussion of the environmental conditions on Ocean Cay.

Short term housing and eating facilities for the mining crew are provided on the southwestern corner of the island. There are currently no permanent residences on Ocean Cay.

4.1.3.2 The Bimini Islands

There are two major islands in the Bimini Group: North Bimini and South Bimini. Structurally, the Bimini group of Islands is part of the wider Great Bahama Bank. A narrow navigable channel of approximately one quarter mile separates North Bimini from South Bimini. A regular ferry service connects North and South Bimini. The majority of the population, approximately 1500 individuals, resides on North Bimini. South Bimini is the largest of the islands in the group and has a population of approximately 160 persons.

North Bimini has a substantial infrastructure of hotels, restaurants, and shops that cater to tourism, centering largely on fishing and recreational diving. Several cultural institutions are located on the Bimini Islands including the Bimini Museum on North Bimini, which focuses on the history of the islands. The Hemingway Museum is located in the Complete Angler Hotel on North Bimini and documents the era of Nobel Prize winning author and big game fisherman, Ernest "Papa" Hemingway. South Bimini Island is the home of the Lerner Marine Laboratory, which specializes in shark research. An airport is located on South Bimini as are a number of small farms, hotels, and residential cottages. Historic Chalk Airline, one of the last amphibious airlines in The Bahamas, operates from a terminal on North Bimini Harbor. All of the islands in the Biminis are low land forms with the highest elevation consisting of a ridge approximately 6.1 m (20 ft) above sea level, that extends along the west shoreline of North Bimini.

4.1.4 Regional Geology

The project area is located on the western flank of The Bahamas, an archipelago in the North Atlantic Ocean. The Bahamian archipelago is a carbonate province extending southeast off the edge of the North American continent, with Ocean Cay and the Bimini islands located generally towards the northern margin of the island chain (approximately 95 km (60 mi) to the east of the United States coastline).

Physiographically, the Bahamian islands are situated on a series of banks that make up the Bahama Platform. Additionally there are several deep channel features, which separate the series of banks. The area contains over 15 major islands and hundreds of small islands, islets and rocks located on the banks of the Bahama Platform. Ocean Cay and the Biminis are situated on the Great Bahama Bank, the largest of this series of banks. The water depth on the Great Bahama Bank is relatively shallow (generally less than 10 m or 30 feet), however it slopes to depths of greater than approximately 800 meters (2,600 feet) in the Straits of Florida to the west and greater than approximately 4,000 meters (13,000 feet) to the east in the Hatteras Abyssal Plains province of the Atlantic Ocean.

The islands making up The Bahamas are comprised primarily of limestone originating as coral and lithified sediments formed in a shallow depositional oceanic setting. The sediment and carbonate bedrock making up the Great Bahama Bank is estimated to be approximately 6 km (approximately 3.7 miles) thick. The type of bedrock making up the basement complex beneath the carbonate sequence of the banks is not well known.

Recent (Pleistocene) and modern deposition of sediments on The Bahamas Platform originates from various carbonate sources including coral-algal reefs, oolitic and skeletal sands, pellet sands or muds and carbonate mud. The depositional nature for these various sediment types are dependent on the local marine environments present on The Bahamas Platform and adjacent areas.

4.1.4.1 Structure and Seismicity

Although bedrock faults may exist in the basement rock, they are unlikely to exist in the carbonates of the Bahama Platform based on the structure and nature of the rock. Deeper bedrock faults within the basement rock may have exerted some influence on the creation and locations of the channels between the series of banks, which comprise the Bahama Platform. The Bahama Platform lies in a location where the North American crust meets the oceanic crust; however there is no plate boundary in this region (a geologic setting referred to as a passive continental margin). Passive margins are characterized by low rates of earthquake activity and surface deformation. No references have been found in published literature to indicate modern active faulting exists in the Bahama Platform.

Available earthquake databases indicate almost no record of earthquakes centered in the northern Bahamas. One minor earthquake, a 3.2 body-wave magnitude with an epicenter approximately 109 km (approximately 67 miles) north-northeast of Ocean Cay; was recorded in 1992. The available data indicate Ocean Cay is located in a tectonically stable region with no history of significant seismic activity. The site is located within Uniform Building Code (UBC) Seismic Zone 1. The UBC categorizes seismic hazard with seismic zones 0 through 4, with Seismic Zone 0 representing the lowest seismic hazard and Seismic Zone 4 representing the highest. A seismic hazard analysis performed for Ocean Cay as part of this environmental assessment revealed that only minor ground shaking is likely to be experienced at Ocean Cay at a mean repeat time of 4975 years. A copy of this seismic hazard analysis, which determined the "Operating Basis Earthquake" (OBE) ground motions and the "Safe Shutdown Earthquake" (SSE) ground motions, Report on Seismic Hazard of a Proposed LNG Site on Ocean Cay in The Bahama Islands, by Dr. John Ebel, dated 19 July 2001, is included in Appendix I.

4.1.4.2 Site-Specific Geology

Ocean Cay is situated within a linear north-south oriented string of cays located on the northwestern edge of the Great Bahama Bank. This series of cays is bounded by the Bimini islands on the north and South Riding Rock on the south. The area proximate to Ocean Cay and the Biminis is characterized by shallow waters to the east extending to islands on the east side of the Great Bahamas Bank margin separated by a deep channel (Tongue of the Ocean). West of Ocean Cay and the Bimini islands is a relatively steep slope to the deep waters of the Straits of Florida on the west.

The geologic history and environment of the Bimini islands is similar to conditions at Ocean Cay as described above. Based on published literature regarding Bahamian geology, the Biminis are generally similar to conditions observed in the investigations at Ocean Cay, overlying sand deposits and/or limestone originating as coral with lithified sediments formed in a shallow depositional oceanic setting.

The 38 hectare (approximately 95 acre) island of Ocean Cay is man-made primarily from sand and gravel spoils dredged from the surrounding ocean floor (as part of the historic/ongoing mining operation). Topographically, the land surface at Ocean Cay is relatively flat and relief is generally a result of spoils distributed on the man-made island as part of the mining operation. Portions of the north and southwestern flank of the island include exposures of pre-existing natural bedrock that served as a nucleus upon which the remainder of the island was built. These limestone bedrock exposures are generally consistent with the underlying limestone bedrock observed in the recent geotechnical drilling investigations.

Recently, test boring programs were conducted both onshore and offshore in areas near Ocean Cay. Eight offshore test borings were performed in October 1998, primarily east and northeast of the island. These offshore test borings were completed to depths ranging from 14.5 to 27.5 m (48 to 90 feet) below the ocean floor. Twenty-four test borings were performed on Ocean Cay between August and December 2001. The onshore test borings at Ocean Cay ranged in depth from 20 to 70 m (65 to 230 feet) below ground surface. Additional offshore geotechnical investigations to support design activities are planned.

Offshore borings encountered a few feet of sand overlying bedrock generally described as yellowish-white slightly to moderately weathered limestone. Core recoveries and Rock Quality Designation (RQD) of these borings were observed to be relatively low. Onshore test borings at Ocean Cay encountered overburden sediments overlying limestone bedrock. Overburden sediments primarily consisted of very loose to dense, tan to white sand with varying amounts of silt and gravel, with interbedded silt. Limestone bedrock was encountered at depths ranging from at ground surface to 10.5 m (35 ft) below existing ground surface. The limestone was generally described as off-white to tan clastic limestone. RQD values ranged from 0 percent to 100 percent. Depth to groundwater observed during this investigation was shallow, generally less than 3 to 5 m (10 to 15 feet below ground surface).

The overburden sediments observed on Ocean Cay generally consist of sand from the mining operation overlying naturally deposited aragonite sand. Bedrock is comprised of limestone reef deposits underlying the island to an estimated depth of approximately 60 m (200 ft). Based on preliminary review of the investigation test boring logs, this shallower bedrock unit appears to be associated with deposition of Pleistocene Age (or later). Based on increased sample recoveries observed at depths greater than approximately 60 m (200 ft), there may be a stratigraphic contact in the bedrock (i.e. underlying dolomite), but the initial investigations yielded limited information within this zone. During the initial exploration program, voids (typically up to approximately 0.5 to 1.0 m (1.6 to 3.2 ft) in size) were encountered at many of the borings at varied depths, however, void zones between borings were observed to be inconsistent and sporadic in nature. A review of these initial investigation results indicates the presence of significant solution cavities is not likely in bedrock at Ocean Cay. Further analysis of the subsurface conditions and geology will be conducted as part of the additional geotechnical investigations planned to support the project design activities.

4.1.5 Hydrology/Surface Waters

4.1.5.1 Ocean Cay

Naturally occurring freshwater resources on Ocean Cay are not expected to exist. Potable water for the mining operation is produced at an on-site reverse-osmosis water plant using seawater withdrawn by an offshore intake structure at an average rate of approximately 26.5 m^3 (7,000-gpd). Four shallow, unlined surface impoundments are located around the central aragonite sand stockpile. The impoundments are reportedly used to collect saltwater runoff from stockpiled aragonite processing (dewatering) and as settling basins, but may temporarily contain freshwater following periods of heavy precipitation. Rainwater accumulated during storm events is rapidly lost due to breaching of the shallow impoundments, evaporation, subsurface infiltration and mixing with saltwater runoff emanating from the central aragonite stockpile area.

4.1.5.2 The Biminis

Hydrologic and Surface Water conditions on the Biminis will be assessed pending response from a letter submitted to the Bimini Administrator.

4.1.6 Biological Aspects

The existing biological systems, both terrestrial and marine, were investigated through a series of studies conducted in the Fall of 2001. These studies included the following:

- Geophysical Survey (bathymetry, side scan sonar, magnetometer) (Appendix D)
- Light Detection and Ranging (LIDAR) Survey (Appendix J)
- Terrestrial Biological Survey (Appendix K)
- Benthic and Planktonic Survey (Appendix L)

These studies were conducted to assist in the selection of the proposed pipeline route to North Bimini, proposed pipeline route to Florida, and activities associated with the planned island expansion and construction of the proposed project (refer to Section 8 Alternatives). The studies were also performed to collect baseline biological information required to interpret the potential impacts of the proposed project. In addition to the work discussed in this report, seasonal benthic sampling is planned to be conducted during indicator species spawning periods, as described in Section 4.1.6.3. The report for the terrestrial biological assessment is located in Appendix K.

AES investigated the benthic communities and planktonic organisms along a submarine corridor that is bounded to the north by North Bimini and to the south by Ocean Cay. The area covers a distance of approximately 20 km (12.4 mi) in a north-south direction and 3 to 5 km (1.9 to 3.1 mi) in an east-west direction. The islands, cays and exposed rocks that occur between the Biminis and Ocean Cay mark the western rim of The Bahamas Bank, west of which is the narrow Bahama Platform. Video reconnaissance of biological and geological characteristics of The Bahamas Escarpment from the Platform to the Straits of Florida is planned.

Included in the following sections are a description of the functionally dominant flora and fauna, an estimate of the relative abundance of organisms, the presence of species of special concern, and the locations of habitats and communities in the study areas.

4.1.6.1 Marine Investigation Methodology

A marine biological survey was conducted between September and December, 2001 utilizing a variety of techniques and methods to achieve the objectives described below:

- A geophysical survey of the shallow substrate at the project site was performed to map the locations of soft-bottom and hard-bottom areas. Substrate type has been shown to influence the types of benthic communities that colonize the area.

- Over forty-four video lines, each 300 to 1400 m (984 to 4,593 ft) long, were run at spacings of approximately 1 km (0.6 mi) or less on both the Bahama Platform (western route to Bimini and pipeline route to Florida) and the Bahama Bank (east route to Bimini). An additional 18 video lines, 300 to 4950 m (984 to 16,240 ft) were run at various spacings around Ocean Cay in areas where construction or operational activities are planned. Some of the video transects were situated perpendicular to potential routes for the pipelines between Bimini and Ocean Cay and between Ocean Cay and the Straits of Florida. Additional video lines were run the full length of the eastern route to Bimini and the start of the 610 mm (24 in) pipeline route to Florida. Video lines are shown on Figure 4.16 and Figure 4.17. Marine biologists performed dives on selected portions of the video transects using SCUBA to verify the video information and enable more accurate and thorough interpretations of video data. Additional ground truthing dives were done in areas outside of the video transects to verify adjacent habitat features.

- Once a preferred pipeline route from Ocean Cay to Bimini had been selected, Marine biologists conducted benthic sampling at 14 locations along 25 m (82-ft) transects and within 1 m (3.2 ft) by 1-m (3.2 ft) quadrants. These sites were selected to represent all of the habitat and community types identified by previous work. In general, five quadrants were sampled at each site within the field sampling intervals. The benthic sampling provided quantitative data characterizing species presence and abundance.

- In order to establish baseline diversity and abundance of phytoplankton and zooplankton, plankton samples were collected and analyzed from four locations along the preferred eastern Bimini to Ocean Cay pipeline corridor. Videos, still photographs, field observations and sample collections were used for taxonomic identification. Biotas were classified to the lowest practical level based on project constraints. Samples were also brought to a qualified facility for laboratory analysis of key allometric and mass determinations to increase the amount of quantitative information available for the site. Representative voucher samples are being stored in the Academy of Natural Sciences collections and will be maintained for at least two years.

Biota that were found to be dominant in abundance or mass, or that indicated high diversity, were then selected for more thorough analysis. Taxa examined that met one or more of these criteria consisted of the seagrasses *Thalassia testudinum* and *Syringodium filiforme*, macroalgae, molluscs, and sea stars. Although all organisms provide important functional services to the ecosystems, this investigation was focused on species that could be evaluated efficiently and that play a major role in structuring the communities. Corals are important community builders along the western corridor from Ocean Cay to Bimini, and this region of the project area was evaluated with more detailed video coverage and ground truthing dives using SCUBA and/or snorkeling.

4.1.6.2 Aquatic Habitats

Aquatic habitats include both the water column and benthic communities. Habitat types observed in the project area are summarized below. Figure 4.17 shows the bottom types and habitats determined by geophysical, video, and dive surveillance. Habitat types shown in Figure 4.17 are general descriptions that provide an overview of habitat trends observed along each video transect. Colored habitat types do not indicate complete coverage along the video transects, but rather a general trend toward that habitat type. In all cases, habitat trends exhibit different levels of patchiness along a video transect. Boundaries separating habitat areas can be dramatic and depending on the precise location where video transects cross, different habitat types may be graphically represented as overlapping or abutting each other.

A. Substrate and Community Structure

The results of the initial reconnaissance survey indicate that the substrate and community structure is different on The Bahamas Bank than it is on the Bahama Platform. The shallow water Bank is structured by processes that influence the distribution of the sediments and by numerous biotic factors that operate at spatial scales smaller than sediment depositional processes. The Platform is deeper, more directly influenced by waters from the Gulf Stream, and partially buffered from conditions associated with the chemical formation and distribution of aragonitic oolites. Large parts of the mobile oolite sediment belt on the Bank are nearly devoid of emergent vegetation and only support limited infaunal organisms. Bare sand bottoms are common features and occur most frequently around the Biminis, between South Cat Cay to Ocean Cay, and between reef features on the Platform. Areas with less mobile sediments have been colonized by sparse to moderate *Thalassia testudinum* beds and these are common from the Turtle Rocks to South Cat Cay. Substantial areas of hard bottom were also encountered in the vicinity of Bimini and around Ocean Cay. These areas support macroalgal communities, often at 100 percent canopy cover. Transitional areas between these habitats were common from South Cat Cay to Ocean Cay and it was common to encounter low density seagrass areas that were colonized by both *Syringodium filiforme* and *Thalassia testudinum*. To the west of Ocean Cay and other parts of the Platform seagrass areas, microalgal hard bottoms, and unvegetated sands were also common. What is different in this region, though, is the abundance of corals, particularly soft corals, and the occurrence of patch coral reefs. The patch reefs occupy waters typically deeper than 15.2 m (50 ft); whereas, soft corals are common at depths as shallow as 4.6 m (15 ft).

Corals are abundant to the west on the Platform and absent to the east of the chain of islands on the Bank. The pattern of vegetation changes moving further to the east, within 5 to 6 km (3.1 to 3.7 mi) to the east of the chain of islands emergent vegetation becomes very sparse. This may reflect nutrient deficiencies and/or seasonally high salinity. Seagrass areas, microalgal hard bottoms, and unvegetated sands were also common to the west of Ocean Cay and other parts of the Platform. The Platform is deeper than the area discussed above, more directly influenced by waters from the Gulf Stream, and partially buffered from conditions associated with the chemical formation and distribution of aragonitic oolites. An additional difference is the abundance of corals, particularly soft corals, and the occurrence of patch coral reefs in this region. The patch reefs occupy waters typically deeper than 15 m (50 ft) whereas soft corals are common at depths as shallow as 4.6 m (15 ft). The two major project areas can support locally important biota at different times of the year. Specifically, spawning of Queen Conch and Grouper take place in the deeper waters of the Platform while the Bank is used for nursery grounds and development habitat for young adults. Potential impacts to the spawning of Queen Conch and Grouper are discussed in Section 5.2.4.

B. Benthic Communities

A variety of benthic communities were observed in the project area from Bimini to Ocean Cay and in the waters surrounding Ocean Cay. Data collected from video surveys, ground truthing, and biological sampling, as described in the methods (above), were used to identify and categorize the various habitat types observed. A summary of the results of the video analysis is shown in Appendix M. Benthic habitats were defined according to 7 categories lettered A-G, which are defined below. Figure 4.16 and Figure 4.17 illustrate the approximate distribution of these various habitats observed along each of the video lines surveyed.

A) Barren sand/soft bottom or sand/rubble/rocky bottom community with <10 percent cover of epibenthic macrofauna and/or flora.
B) Low to high relief hard bottom community dominated by algae and/or seagrass. Some soft corals and/or sponges may occur.
C) Low to high relief hard bottom or patch reef supporting a diverse community of invertebrates including hard corals and diverse fishes.
D) Sand/soft bottom with patches of seagrass and/or algae <50 percent cover.
E) Sand/soft bottom with patches of seagrass and/or algae >50 percent cover.
F) Sand/soft bottom with variable seagrass and/or algae cover; patches range from sparse (<50 percent) to dense (>50 percent) cover throughout.
G) Sand/soft bottom or sand/rubble community of sparsely distributed epibenthic macrofauna, particularly soft corals, sponges, and/or tunicates, <50 percent cover.

Each of the benthic communities and their components are linked and share the effects of both positive and negative impacts. The macroalgae and coral-dominated areas are habitat for many organisms that sustain the local system and provide fishing and recreational resources. The seagrass meadows are nursery grounds for various species and provide food for pelagic organisms and shellfish harvesting areas. Seagrass and epiphytes (attached or living on seagrass blades) also generate detritus that can be exported to deeper waters and become a nutritional component of the platform food web. The large areas of nearly bare sand bottom have the lowest ecological value in terms of habitat variety and diversity.

A wide variety of benthic invertebrates were identified in the project area. A list of benthic invertebrates, identified to the lowest practicable level, that were observed and/or sampled during the benthic survey is shown in Table 4-7. Additional molluscan species that were collected in benthic cores are not shown in this table. A reconnaissance level analysis of soft-bodied organisms at four locations of bottom inspection via SCUBA or snorkel indicated that most hard- and soft-bottom sites have a relatively low diversity of soft-bodied benthic organisms. These bottom inspections were performed at video transect locations, as shown on Figure 4.17.

A number of other infaunal (living within) and epifaunal (living on) organisms were also noteworthy for their relative abundance in the area. These include crabs, shrimp, sea stars, sand dollars, tunicates, brittle stars and sea cucumbers. The most abundant macroinvertebrate group was the tunicates, although these animals were found in high concentrations only in the denser seagrass habitats. Macroinvertebrate groups appear to be moderately diverse as a whole, and to be patchy in distribution. The brittle stars and sand dollars were found only on hard-bottom substrates, while the sea stars were found only on soft-bottom substrate. The molluscan fauna was very diverse and over 150 species were found in the benthic cores and as epifauna. Most of these were gastropods (60 percent) and clams (30 percent). Specific taxa such as the Atlantic Bittersweet, Slipper Shell, West Indian Worm Shell, and Ivory Cerith had a patchy distribution and some species of molluscs are specific to intertidal areas.

Young adult *Strombus gigas*, the commercially important Queen Conch, was observed in relatively high abundance at mixed seagrass and macroalgae sites towards South Bimini (Site 4E) and in significant, but lesser, abundances near South Cat Cay. Conchs were also common along the edge of the platform west of Ocean Cay (Site 20W). No live conch juveniles were found in the sediment cores during the study in the Fall of 2001. In order to obtain additional data regarding potential spawning of queen conch, Nassau grouper, and spiny lobster, the three most important commercially fished taxa in the region, additional plankton sampling specifically for larval stages is described in Section 4.1.6.3.

Table 4-7 Benthic Macroinvertebrates Observed and/or Sampled (NI = Not Identified)

Phylum	Class	Taxon	Common Name	Habitat
Annelida	Oligochaeta	NI	NI	soft bottom
Annelida	Polychaeta	Family Sabellidae	Feather duster worm	soft bottom
Annelida	Polychaeta	Family Amphinomidae	Fire worm	soft bottom
Annelida	Polychaeta	Family Hesionidae	NI	soft bottom
Annelida	Polychaeta	Family Syllidae	NI	soft bottom
Annelida	Polychaeta	Family Glyceridae	NI	soft bottom
Annelida	Polychaeta	Family Lumbrineridae	NI	soft bottom
Annelida	Polychaeta	Family Dorvilleidae	NI	soft bottom
Annelida	Polychaeta	Family Paraonidae	NI	soft bottom
Annelida	Polychaeta	Family Spionidae	NI	soft bottom

Table 4-7 (continued)

Benthic Macroinvertebrates Observed and/or Sampled (NI = Not Identified)

Phylum	Class	Taxon	Common Name	Habitat
Annelida	Polychaeta	Family Magelonidae	NI	soft bottom
Annelida	Polychaeta	Family Opheliidae	NI	soft bottom
Annelida	Polychaeta	Family Capitellidae	NI	soft bottom
Annelida	Polychaeta	Family Sabellidae	NI	soft bottom
Arthropoda	Crustacea	*Callinectes sapidus*	blue crab	soft bottom
Arthropoda	Crustacea	*Paguristes punticeps*	White-speckled hermit	soft bottom
Arthropoda	Crustacea	*Periclimenes pedersoni*	Pederson cleaner shrimp	soft bottom
Arthropoda	Crustacea	NI	hermit crab	soft bottom
Arthropoda	Crustacea	NI	crab	soft bottom
Arthropoda	Crustacea	NI	shrimp	soft bottom
Arthropoda	Crustacea	NI	*Callianassa* sp. habitat	soft bottom
Arthropoda	Crustacea	Subclass Cephalocarida	NI	soft bottom
Arthropoda	Crustacea	Subclass Ostracoda	NI	soft bottom
Arthropoda	Crustacea	Order Tanaidacea	NI	soft bottom
Chordata	NI	Subphylum Cephalochordata	NI	soft bottom
Chordata	Ascidiacea	*Salpa* sp.	pelagic tunicate	soft bottom
Cnidaria	Anthozoa	*Condylactis gigantea*	Giant anemone	soft bottom
Cnidaria	Anthozoa	*Gorgonia* sp.	gorgonian octocoral	hard bottom
Cnidaria	Anthozoa	*Millepora alcicornis*	hydrocoral	hard bottom
Cnidaria	Anthozoa	Scleractinia	hexacoral	hard bottom
Cnidaria	Anthozoa	*Dichocoenia stokesii*	Elliptical star coral	soft bottom
Cnidaria	Anthozoa	*Solenastrea* sp.	Star coral	soft bottom
Cnidaria	Anthozoa	*Pseudoplexaura* sp.	gorgonian octocoral	hard bottom
Cnidaria	Anthozoa	*Diploria strigosa*	Symmetrical brain coral	hard bottom
Cnidaria	Scyphozoa	*Aurelia aurelia*	Moon jellyfish	soft bottom
Echinodermata	Asteroidea	*Oreaster reticulatus*	Cushion sea star	soft bottom
Echinodermata	Echinoidea	*Clypeaster subdepressus*	Sand dollar	soft bottom
Echinodermata	Echinoidea	*Holothuroidea* sp.	Sea cucumber	soft bottom
Echinodermata	Echinoidea	*Mellita sexiesperforata*	Six-keyhole sand dollar	soft bottom
Echinodermata	Echinoidea	*Meoma ventricosa*	Red heart urchin	soft bottom
Echinodermata	Echinoidea	*Tripneustes ventricosus*	West Indian sea egg	soft bottom
Echinodermata	Ophiuroidea	*Ophiurodea reticulata*	Reticulated brittle star	soft bottom
Echinodermata	Ophiuroidea	*Ophiurodea* sp.	brittle star	soft bottom
Mollusca	Bivalvia	*Anadara notabilis*	Eared ark	soft bottom
Mollusca	Bivalvia	*Atrina rigida*	Rigid pen shell	soft bottom
Mollusca	Bivalvia	*Chione elevata*	Florida cross-barred venus	soft bottom
Mollusca	Bivalvia	*Codakia orbicularis*	Tiger lucine	soft bottom
Mollusca	Bivalvia	*Glycymeris undata*	Atlantic bittersweet	soft bottom
Mollusca	Bivalvia	*Laevicardium laevigatum*	Egg cockle	soft bottom
Mollusca	Bivalvia	*Lima* sp.	Fileclam	soft bottom

Table 4-7 (continued)
Benthic Macroinvertebrates Observed and/or Sampled (NI = Not Identified)

Phylum	Class	Taxon	Common Name	Habitat
Mollusca	Bivalvia	*Lucina pensylvanica*	Pennsylvania lucina	soft bottom
Mollusca	Bivalvia	*Pinctada imbricata*	Atlantic pearl oyster	soft bottom
Mollusca	Bivalvia	*Pinna carnea*	Amber pen shell	soft bottom
Mollusca	Bivalvia	*Tellina radiata*	Sunrise tellin	soft bottom
Mollusca	Cephalopoda	*Octopus* sp.	octopus	soft bottom
Mollusca	Gastropoda	*Astralium phoebium*	Long-spined star shell	soft bottom
Mollusca	Gastropoda	*Crepidula plana*	Slipper shell	soft bottom
Mollusca	Gastropoda	*Cassis madagascariensis*	Queen helmet	soft bottom
Mollusca	Gastropoda	*Cerithium eburneum*	Ivory cerith	soft bottom
Mollusca	Gastropoda	*Fasciolaria tulipa*	True tulip	soft bottom
Mollusca	Gastropoda	*Oliva reticularis*	Netted olive	soft bottom
Mollusca	Gastropoda	*Strombus raninus*	Hawkwing conch	soft bottom
Mollusca	Gastropoda	*Strombus gigas*	Queen conch	soft bottom
Mollusca	Gastropoda	*Terebra doslocata*	Common Atlantic auger	soft bottom
Mollusca	Gastropoda	*Vermicularia spirata*	West Indian worm shell	soft bottom
Mollusca	Gastropoda	NI	NI	soft bottom
Nemertea	NI	NI	NI	soft bottom
Porifera	Demospongiae	*Diplastrella* sp.	Encrusting sponge	hard bottom
Porifera	Demospongiae	*Ircinia strobilina*	Black-ball sponge	hard bottom
Porifera	Demospongiae	*Callyspongia* sp.	Branching vase sponge	hard bottom
Porifera	Demospongiae	*Anthosigmella* sp.	Brown variable sponge	hard bottom
Sipuncula	NI	NI	NI	Soft bottom

C. Macroflora

Macroflora sampling along the Ocean Cay to the Biminis corridor provided some quantitative measures of species composition and biomass allowing qualitative assessment at other seagrass areas. Table 4-8 lists observed taxa of macroalgae and seagrass in the project area. Macroalgae constituted a significant portion of the biomass at hard-bottom sites. At sites where seagrass predominated, macroalgae represented less than 10 percent of the biomass. Seagrass and macroalgae were nearly absent at sites adjacent to the western borders of North and South Bimini. To the south of this area, algae becomes important on hard-bottom habitats where they can attach. The highest macroflora biomass measured in this investigation was found at site 3E (721 g/m^2). Further south, soft-bottom sand dominates the substrate and *T. testudinum* becomes increasingly more abundant, although the seagrass coverage throughout the area is generally low and below 40 percent. The highest coverage and largest biomass were measured at sites east of South Cat Cay, at approximately 30 percent and 73 g/m^2, respectively.

This biomass is on the low end compared to other seagrass meadows measured in The Bahamas where biomass ranges from 5.0 to 200 g/m^2 (Short 1986). Further south to Ocean Cay, the macroflora becomes less abundant. This is one of the areas where mobile oolitic sands form and dominate the Bank floor, which makes it very difficult for plants to become established.

Thalassia testudinum epiphytes (attached to or living on) were present in significant, but varying amounts along the Ocean Cay to Bimini pipeline corridor. These organisms are a potential source of food to many grazers and are known to be significant contributors as a food source in sub-tropical and tropical waters. Total epiphyte biomass, including the inorganic and organic components, ranged from 0.2 to- 3.1 g/g of leaf. The organic fraction ranged from 10-25 percent of the total biomass, which indicates that epiphytes comprise an equivalent of 75 percent of the organic carbon of some of the *T. testudinum* leaves. The highest abundances of epiphytes were found at sites 4E, 6E and 12E. Sites 4E and 6E occur in areas previously designated as Queen Conch habitat (refer to Figure 4.17 video transect line locations). Conchs, which feed on seagrass detritus, were observed at the relatively high abundance of 3.2 conchs/100 m^2 (3.2 conchs/1076 ft^2) at site 4E during this investigation.

Table 4-8
Observed Taxa of Macroalgae and Seagrass

Botanical Category	Taxon	Habitat
Chlorophyta (Green Algae)	*Penicillus* sp.	hard bottom/soft bottom
Chlorophyta (Green Algae)	*Avrainvillea* sp.	hard bottom/soft bottom
Chlorophyta (Green Algae)	*Neomeris annulata*	hard bottom/soft bottom
Chlorophyta (Green Algae)	*Halimeda* sp.	hard bottom/soft bottom
Chlorophyta (Green Algae)	*Caulerpa prolifera*	hard bottom/soft bottom
Chlorophyta (Green Algae)	*Caulerpa lanuginosa*	hard bottom/soft bottom
Chlorophyta (Green Algae)	*Cladophora prolifera*	hard bottom
Chlorophyta (Green Algae)	*Acetabularia* sp.	hard bottom/soft bottom
Chlorophyta (Green Algae)	*Udotea* sp.	hard bottom
Chlorophyta (Green Algae)	*Dictyosphaeria cavernosa*	hard bottom
Phaeophyta (Brown Algae)	*Cystoseira myrica*	hard bottom/soft bottom
Phaeophyta (Brown Algae)	*Sargassum pteropleuron*	hard bottom
Phaeophyta (Brown Algae)	*Dictyota cervicornis*	hard bottom
Phaeophyta (Brown Algae)	*Padina* sp.	hard bottom
Rhodophyta (Red Algae)	*Gelidium* sp.	hard bottom

Table 4-8 (continued)
Observed Taxa of Macroalgae and Seagrass

Botanical Category	Taxon	Habitat
Rhodophyta (Red Algae)	*Rhipocephalus* sp.	hard bottom
Rhodophyta (Red Algae)	*Chibdrua* sp.	hard bottom
Angiospermae (Flowering Plants)	*Thalassia testudinum*	soft bottom
Angiospermae (Flowering Plants)	*Syringodium filiforme*	soft bottom

In summary, the communities along the pipeline corridor from Ocean Cay to the Biminis consist of three varieties: bare soft bottom, macroalgae-dominated hard bottom, and low to moderate density, soft- and hard-bottom seagrass meadows. Around Ocean Cay and on the Platform along the western corridor from Ocean Cay to Bimini these three habitats predominate; however, areas of hard bottom patch reef and soft bottom soft coral communities were also observed.

D. Plankton

The plankton community was examined because this group is a vital food source and contains the larval stages of many important vertebrate and invertebrate organisms. The community observed during this study was typical of the nutrient-poor waters of the subtropics. Forty-five species of phytoplankton were identified at four locations along the Ocean Cay to Bimini corridor although densities did not exceed 5×10^5 cells/L. Highest abundances were observed over seagrass habitats and low abundances were found over hard bottom, macroalgal habitats. Microzooplankton concentrations varied differently: higher concentrations were found over hard-bottom habitats near Bimini and lower concentrations near Ocean Cay.

4.1.6.3 Biological Resources Evaluated in the Vicinity of Each Major Project Element

A. Water Intake Line

The proposed water intake structure will be located approximately 280 m (918.6 ft) west of Ocean Cay as shown on Figure 4.16. Marine video was collected during the geophysical reconnaissance survey for the areas surrounding Ocean Cay. Seven video transect lines were performed along the sea floor in the vicinity of the proposed water intake structure, as described below in Table 4-9. The data collected from the surveys was utilized to determine baseline biological conditions and to optimize the intake structure location to avoid or minimize impacts to biological resources. The baseline conditions for the proposed water intake structure are described below. The video transect lines are shown on Figure 4.16.

Table 4-9

Biological Video Transects in the Vicinity of the Water Intake Structure

Video Line	Alignment	Location	Length
BRN 1	North to South	260 m (853 ft) West of Ocean Cay across the intake structure location	1000 m (3280.8 ft)
BRN 2	North to South	570 m (1870 ft) West of Ocean Cay	1400 m (4593.2 ft)
BRN 3	North to South	1500 m (4921.2 ft) West of Ocean Cay	1800 m (5905.5 ft)
BRN 4	North to South	1250 m (4101.1 ft) West of Ocean Cay	1150 m (3773 ft)
BRN 5	East to West	1300 m (4265.1 ft) West of Ocean Cay	600 m (1968.5 ft)
19 W	East to West	20 m (65.6 ft) North of the proposed intake structure	3600 m (11,811 ft)
21 W	North to South	1000 m (3280.8 ft) West of Ocean Cay	1600 m (5249.3 ft)

The bottom habitat type for the proposed water intake structure was determined based upon the seven video transects listed above. The bottom habitats in the area are predominantly sand with patches of seagrass and/or seaweed ranging from 10 to 50 percent cover. Gorgonians and sponges were noted at intermittent locations (<5 percent cover), as described in Appendix M. As shown on Figure 4.16, the area 20 m (65.6 ft) south of the intake structure exhibits patchy seagrass cover, with patches generally ranging from 10-50 percent cover, and in a few small areas coverage up to 80 percent was observed.

The area 20 m (65.6 ft) north and west of the intake structure is predominantly flat bare sand with a small area of low relief rock and rubble bottom. This may be the remains of a spoil pile placed offshore during previous island development activities. Some soft corals and sponges were observed attached to rock and rubble in this area, but coverage was sparse with sponge coverage 5-10 percent and soft coral coverage ranging from 15-60 percent, but generally less than 25 percent cover for most of this area. Review of video transect line 100 m (328 ft) west indicates a predominantly sand bottom with patchy seagrass cover ranging from 10 to 50 percent. Patches of rubble with tufts of algae were noted intermittently along the video tract.

A preliminary assessment of relative abundance for the benthic organisms and fish species was conducted between October and December 2001, as described in Section 4.1.6.1. The results of the benthic analysis for the project area are discussed in Section 4.1.6.2, and a summary of the benthic macroinvertebrates observed and sampled in the project area is included in Table 4-7. The preliminary assessment of fish species included an evaluation of commercial and recreational fisheries that occur in the project area, as discussed in Section 4.1.7, including a summary of the fish species observed in Table 4-17. Species present in the vicinity of the proposed intake structure that have planktonic larval stages may be susceptible to impingement or entrainment in the intake structure. Commercially significant species known to occur in the project area include Queen Conch, Spiny Lobster, and Nassau Grouper. Potential impacts to commercially significant species are discussed in Section 5.2.4. An additional study focused on the potential impacts to these commercially important species is planned, as discussed below.

Based upon spawning information collected in other areas of The Bahamas, a study design for additional seasonal biological sampling has been developed focusing on the three commercially important species. The additional sampling for plankton and juvenile Nassau Grouper, Queen Conch, and Spiny Lobster is planned to be conducted in the vicinity of the proposed water intake, among other areas. There are two different purposes for the sampling events:

1. to estimate the abundance of planktonic grouper, lobster, and conch that may be impacted by the water intake; and
2. to estimate the use of the waters surrounding the intake area by post-settlement (juvenile) grouper specifically, and post settlement lobster and conch generally.

The youngest life forms of the Nassau Grouper, Spiny Lobster and Queen Conch in the plankton samples and the juvenile forms in the habitat field will be analyzed. AES will submit the data collected and analyses performed as an addendum to this EIA. The seasonal sampling will be conducted as follows.

Table 4-10
Additional Marine Biology Sampling Events

Plankton	
Sampling Event.	Date
1	Late January/early February
2	Early June
3	Early July
4	Early August
Juvenile Grouper Habitat	
Sampling Event	Date
1	March/April
2	Late May/early June

The methodology utilized for the plankton investigation is included in Appendix N.

B. Approach Channel

The proposed approach channel expansion will include the enlargement of the existing approach channel located along the south shore of Ocean Cay, as shown on Figure 4.16. Marine video was collected during the geophysical reconnaissance survey. Three video transect lines were performed in the vicinity of the approach channel. The first transect was performed along the centerline of the existing channel and the second was conducted to the north. The third video transect was performed south of the approach channel. The data collect from the surveys was utilized to determine the baseline conditions in the existing approach channel. The baseline conditions are discussed below.

Table 4-11
Biological Video Transects in the Existing Shipping Channel

Video Line	Alignment	Location	Length
Approach Channel Centerline	West to East	Centerline of the existing shipping channel	4700 m (15,419.9 ft)
Geo Groundtruth Line 8	East to West	1000 m (3280.8 ft) North of existing shipping channel	3100 m (10,170.6 ft)
Geo Groundtruth Line 18	East to West	15 m (49.2 ft) South of existing shipping channel	4200 m (13,779.5 ft)

Based upon the marine video collected in the vicinity of the existing approach channel, the entrance to the channel (southwest of Ocean Cay) consists of sand bottom with patches of rubble and sparse reef patches surrounded by sand. Specifically, the first 1000 m (3281 ft) of the approach channel is bare sand and rubble with patchy seagrass (10 to 50 percent) cover that yields to sand and rubble bottom with isolated patches of soft corals and an isolated small reef patch. Approaching the turning basin area, the sea bottom is predominantly mixed sand and rubble with patches of bedrock and sparse macro-organisms (predominantly soft corals), then soft bottom sand with patches of dense mixed seagrass and seaweed beds ranging from 50 to 80 percent cover to greater than 80 percent in some patches.

C. Turning Basin

The area intended for dredging of the proposed expansion turning basin was also examined by review of video transects collected during the geophysical survey. Four video transect lines were performed in the vicinity of the proposed turning basin expansion, as described below in Table 4-12. The data collected from the surveys was utilized to determine baseline biological conditions in the existing turning basin, as described below.

Table 4-12
Biological Video Transects in the Vicinity of the Turning Basin

Video Line	Alignment	Location	Length
TB1	North to South	125 m (410 ft) south of Ocean Cay	750 m (2460.6 ft)
TB2	North to South	125 m (410 ft) south of Ocean Cay	750 m (2460.6 ft)
Shoal Line 1	Northeast to Southwest	750 m (2460.6 ft) south of Ocean Cay (South of existing turning basin)	1875 m (6151.6 ft)
Shoal Line 2	Northeast to Southwest	1000 m (3280.8 ft) south of Ocean Cay (South of existing turning basin)	1875 m (6151.6 ft)

Based upon the marine video collected in the vicinity of the existing turning basin, the ocean bottom is predominantly sand and rubble with a few soft corals and patches of seagrass to 50 percent cover within the existing turning basin area. Few organisms were noted in the area during evaluation of the video transects. The area south of the existing turning basin is characterized as predominantly bare sand with sparse patches of organisms (soft corals and tunicates) and dense seagrass. The southernmost ends of two of the Island Expansion lines (IE4 and IE5) are in the vicinity of the proposed turning basin expansion. Habitat type related to these two lines is discussed below.

D. Island Expansion

To accommodate the proposed AES Ocean LNG, Ltd. facilities, the footprint of Ocean Cay will be expanded. This proposed expansion will predominantly be along the western and northern boundaries of the existing island footprint. Marine video was collected during the geophysical reconnaissance at the areas around the west and north sides of the island. The following video transects were used to characterize the bottom types and current conditions:

Table 4-13
Biological Video Transects in the Vicinity of the Proposed Island Expansion

Video Line	Alignment	Location	Length
BRN 1	North to South	260 m (853 ft) West of Ocean Cay	1000 m (3280.8 ft)
IE Line 1	Northeast to Southwest	500 m (1640.4 ft) North of Ocean Cay	1750 m (5741.5 ft)
IE Line 2	Northeast to Southwest	250 m (820.2 ft) North of Ocean Cay	1350 m (4429.1 ft)
IE Line 3	Northeast to Southwest	East of the northeast corner of Ocean Cay	750 m (2460.6 ft)
IE Line 4	North to South	250 m (820.2 ft) East of the eastern shore of Ocean Cay	1500 m (4921.3 ft)
IE Line 5	North to South	500 m (1640.4 ft) East of the eastern shore of Ocean Cay	1250 m (4101.1 ft)
20 E	Northeast to Southwest	North of the northwestern most point of Ocean Cay	500 m (1640.4 ft)

Based upon the marine video collected along the western coast of Ocean Cay, the bottom type in the area is predominantly sand with patches of seaweed and seagrass ranging from 10 to 50 percent cover. The bottom type in the vicinity of the northeastern portion of Ocean Cay consists mainly of sand mixed with rubble with patchy seaweed and intermittent seagrass patches from 10 to 50 percent coverage. As water depth increases the percent coverage of seagrass beds increases to approximately 50 to 80 percent. The video transects to the east of Ocean Cay indicate similar bottom types in that area.

The area north of the northern most point of the existing island is predominantly hard rock bottom with very little relief and covered by a thin sand layer, with sparse coverage of brown macro-algae (*Sargassum* sp.) and soft corals.

E. Excess Material Shoal Area

A excess material shoal area may be placed to the south of the turning basin to offer additional shore protection to the shipping area. This area was investigated on video transects Shoal Line 1 and 2 (Table 4-12 above). The bottom type and biological features of this area were described above in Sections 4.1.4 and 4.1.6.2.

F. 610 mm (24 in) Natural Gas Pipeline Route

Marine video was collected during the geophysical survey along the proposed route of the 610 mm (24 in) natural gas pipeline. Five video transect lines were performed along the sea bottom in the vicinity of the proposed 610 mm (24 in) pipeline route. One video transect was performed along the centerline of the proposed 610 mm (24 in) pipeline, extending from the shallow waters west of Ocean Cay to the edge of The Bahamas Bank, a distance of approximately 4500 m (2.8 mi) to the west of Ocean Cay. During the project reconnaissance surveys additional video transect lines were performed in the vicinity of portions of the proposed pipeline, as described below in Table 4-13. The data from the five video transect lines were used in route selection to avoid or minimize potential impacts to biological resources, and to assess baseline conditions along the selected pipeline route. Baseline conditions for the selected pipeline route are described below. The video transect tracts are shown on Figure 4.16.

Table 4-14

Biological Video Lines Along Proposed 610 mm (24-in) Pipeline Corridor

Video Line	Alignment	Location	Length
610 mm (24 in) Proposed Pipeline Centerline	Follows proposed route	Northwest of Ocean Cay	Approximately 4600 m (15091.9 ft)
Line 17W	East to West	Extending Northwest from Ocean Cay	Approximately 4300 m (14107.6 ft)
Line 20W	North to South	Approximately 4000 m (13123 ft) west of Ocean Cay	Approximately 4000 m (13123.4 ft)
Line 22W	North to South	Approximately 4300 m (14107.6 ft) northwest of Ocean Cay	Approximately 750 m (2460.4 ft)
Line 18E	Southwest to Northeast	Approximately 2500 m (8202.1 ft) northwest of Ocean Cay	Approximately 375 m (1230.3 ft)

The proposed pipeline route extends west from the Ocean Cay landfall and crosses a predominantly sand bottom for approximately 274 m (899 ft) to a water depth of 7 m (23 ft). In water depths greater than 7 m (23 ft) the proposed pipeline route crosses benthic habitat areas of consisting of soft bottom with patches of seagrass and/or mixed seagrass and algae ranging from 10-50 percent coverage as well as areas of more dense coverage ranging from 50-80 percent coverage. Small tunicates, sponges, and some soft corals were also noted at intermittent locations in water depths greater than 7 m (23 ft), as described in Table 4-14.

As water depths increase beyond 18 m (60 ft) to 34 m (112 ft) the bottom conditions are predominantly sand with low to high relief rock and rubble. Isolated patches of reef (i.e. small to large rock and/or rubble bits encrusted with sponges, soft coral and some hard corals) separated by sand areas were with coverage of sponges and corals estimated to be <30 percent. The field survey also identified the presence of diverse fish life.

G. Pipelines to North Bimini

Marine video was collected during the geophysical survey along the proposed route of the 60 mm (2 in) natural gas and 219 mm (8 in) potable water pipelines. Twenty video transect lines were performed along the sea bottom in the vicinity of the proposed pipeline route. One video transect was performed along the centerline of the proposed pipeline route extending the western coast of North Bimini south to Ocean Cay approximately 37.8 km (23.5 mi). Additional video transects were performed in the vicinity of portions of the proposed pipeline route as shown on Figure 4.17. The data collected from the video transects were used to assess baseline biological conditions along the proposed route and to optimize the route to avoid or minimize potential impacts to biological resources. A summary of the video transect lines is included below.

Table 4-15

Biological Video Lines Along the Proposed Bimini to Ocean Cay Pipeline Corridor

Video Lines	Alignment	Location	Length
Proposed Pipeline Center Line	North to South	North Bimini to Ocean Cay	Approximately 38 km (124.7 ft)
1W – 3E	West to East	West of North Bimini and South Bimini	Approximately 300 m (984.3 ft)
3E – 4E	West to East	South of Bimini to Turtle Rocks	Approximately 300 m (984.3 ft)
4E – 12E	West to East	Turtle Rocks to South Cat Cay	Approximately 300 m (984.3 ft)
12E – 14E	West to East	South Cat Cay to Victory Cay	Approximately 300 m (984.3 ft)
14E – 20E	West to East	Victory Cay to Ocean Cay	Approximately 300 m (984.3 ft)

The proposed pipeline route extends south from the western coast of North Bimini where the bottom type is predominantly bare sand with some areas of hard bottom exhibiting macroalgal coverage. As the pipeline extends east of South Bimini in water depths of 5-7 m (16 to 23 ft) the bottom is predominantly sand with seagrass and/or mixed seagrass and algal coverage ranging from less than 5 percent to 100% coverage. Intermittent patches of small tunicates, sponges and soft corals were noted as the proposed route approached each landfall location.

A summary of the predominant communities along the proposed pipeline corridors is presented below in Table 4-16

Table 4-16

Predominant Communities and Habitat along the Proposed Pipeline Corridors

Pipeline Corridor, (Biovideo Line Segment)	Predominant Communities and Habitat	Percent Floral Cover	Observations
West of North and South Bimini (1W-3E)	Bare sand (60%), hard bottom with high macroalgal coverage (40%)	<5% in sand areas, 50-100% in macroalgal areas	NA
South of Bimini Islands to the Turtle Rocks (3E-4E)	Hard rock bottom with macroalgae (80%), soft bottom patchy sea grass (20%)	5-90% on hard bottom, 50-95% in sea grass	NA
Turtle Rocks to South Cat Cay (4E-12E)	Soft bottom, patch sea grass meadows	10-80% increasing towards south	Significant occurrence of queen conch at 8E
South Cat Cay to Victory Cay (12E-14E)	Bare soft bottom (90%), low density sea grass (10%)	<5% in bare bottom, 30-50% in sea grass areas	Mobile oolite substrate
Victory Cay to Ocean Cay (14E-20E)	Soft bottom, patchy sea grass and macroalgae; bare bottom; hard bottom with macroalgae	20-100% sea grass, <5% bare bottom, 10-70% in hard bottom	Unvegetated areas part of Ocean Cay expansion, moderate occurrence of queen conch at 14E
610-mm (24-in) Pipeline Route	Predominantly sand/soft bottom throughout. Seagrass patched in shallower depths. Approach to escarpment characterized by some rubble and patch reef.	Isolated floral patches coverage ranges from 10 to greater than 80%.	Some isolated soft corals and macro-organisms, sparse distribution.
Ocean Cay west to Bahama Escarpment (20W-21W)	All identified habitats present, patch reefs increase with depth toward west	Patch reef 5-70%, sea grass 15-60%, hard bottom 25-50%, bare bottom 5-30%	Grouper and queen conchs observed at 20W

4.1.6.4 At Risk Species

The following discussion focuses on species potentially occurring within the project area that are recognized internationally as being endangered, threatened, or potentially at risk.

Four species are known to be endangered in The Bahamas Islands. These include the Green turtle (*Chelonia mydas*), Bahamian rock iguana (*Cyclura cychlura*, *C. carinata*, *C. rileyi*, and related subspecies), West Indian flamingo (*Phoenicopterus ruber*), and Bahamian parrot (*Amazona lecocephala bahamensis*).

The green turtle (*Chelonia mydas*) is widespread in waters between 35° north and 35° south latitude, including The Bahamas. Green turtles are a mobile species and utilize a variety of habitats during their life cycle including coral reef areas, where juveniles are often found and seagrass beds where the mainly herbivorous adults graze for food. Mating occurs in the water and adult females return to sandy beaches at night where they deposit their eggs into nests they have dug in the sand. They nest at intervals of 2-4 years and lay an average of 3-5 clutches within a given season. As with most sea turtle species, the eggs incubate for an average of 60 days. Nesting occurs on beaches throughout the Caribbean, including The Bahamas. Major threats to this species include anthropogenic modifications to their nesting grounds (coastal beaches), commercial fishing fatalities, ingestion of artificial trash and debris, direct impacts from boats, and dredging of their resting and foraging habitats. The green sea turtle also faces severe threats from the commercial harvest of the turtles and their eggs. Green turtles can be harvested in The Bahamas from August 1 – March 31, but taking of green turtle eggs is illegal in The Bahamas. No signs of nesting were noted during the field survey of Ocean Cay. It is unlikely that turtles would nest on Ocean Cay. Sea turtles are known to migrate and nest specifically on their native beaches. Given that Ocean Cay is approximately 30 years old, it is not likely that turtles of reproductive age (35-50 years) would have hatched from Ocean Cay. No evidence was identified during the assessment to indicate that green turtles nest on Ocean Cay

The Bahamian rock iguana is actually a complex of species including: *Cyclura cychlura*, *C. carinata*, *C. rileyi*, and related subspecies, which occur on Andros, San Salvador, Acklins, Mayaguana, and in the Exuma Cays. Rock iguanas live in dry areas characterized by limestone rock outcrops, which provide a shady retreat and sandy areas for breeding. Bahamian rock iguanas were not observed in the vicinity of the project area.

West Indian flamingos are large, distinctive pink birds found in areas throughout the Caribbean preferring shallow coast areas and mud flats where they forage for insect larvae, shrimp, and other small invertebrates in the sediment. This species is declining in abundance in The Bahamas although a large population is thriving on Inagua. West Indian flamingos were not observed in the vicinity of the project area.

The Bahamian parrot (*Amazona lecocephala bahamensis*) is currently found only on Abaco and Great Inagua Islands where they live in forested areas. On Inagua, Bahamian parrots nest primarily in Lignum vitae, mahogany and black mangrove trees. On Abaco, Bahamian parrots are found in coppice areas and pine forests. This species is not known to inhabit any other Bahamas islands.

Other species of turtles are known to occur in waters of The Bahamas Islands and may nest on some beaches in The Bahamas. These species are recognized internationally as at risk; endangered, threatened, or vulnerable. Species that may occur in the vicinity of the project area include Loggerhead Turtle (*Caretta caretta*), Leatherback Turtle (*Dermochelys coriacea*), Hawksbill Turtle (*Eretmochelys imbricata*), and Kemp's Ridley Turtle (*Lepidochelys kempii)*. No evidence was identified during the assessment to indicate that these turtles nest on Ocean Cay

Several species of whales and dolphins are known to occur in waters around The Bahamas Islands, particularly in the Straits of Florida, a common passage for migration between southern breeding grounds and more northern feeding grounds. None of these species is known to reside year-round in The Bahamas, nor are critical breeding or feeding areas known to occur within the project area. Species that potentially may occur in the vicinity of the proposed project include:

- Sperm Whale (*Physeter macrocephalus*);
- Sei Whale (*Balaenoptera borealis*);
- Blue Whale (*Balaenoptera musculus*);
- Finback Whale (*Balaenoptera physalus*);
- Northern Right Whale (*Eubaleana glacialis*);
- Bryde's whale (*Balaenoptera edeni*);
- Common dolphin (*Delphinus delphis*);
- Risso's dolphin (*Grampus griseus*);
- Pygmy sperm whale (*Kogia breviceps*);
- Dwarf sperm whale (*Kogia simus*);
- Fraser's dolphin (*Lagenodelphis hosei*);

- Blaineville's beaked whale (*Mesoplodon densirostris*);
- Gervais beaked whale (*Mesoplodon europaeus*);
- Killer whale (*Orcinus orca*);
- False killer whale (*Pseudorca crassidens*);
- Pantropical spotted dolphin (*Stenella attenuata*);
- Clymene dolphin (*Stenella clymene*);
- Striped dolphin (*Stenella coeruleoalba*);
- Atlantic spotted dolphin (*Stenella frontalis*);
- Rough toothed dolphin (*Steno bredansis*);
- Bottlenose dolphin (*Tursiops truncatus*); and
- Cuvier's beaked whale (*Ziphius cavirostris*).

In addition to the species discussed above, several other species of plants and animals have been identified as at risk within The Bahamas. A list of these at risk species is included below in Table 4.17. These species are known to occur in The Bahamas, but critical habitats for survival of these species are not known to occur on Ocean Cay, and none of these species have been specifically identified as occurring within the project area.

Table 4-17
Other Species Identified As At Risk That May Potentially Occur in the Bahamas

Scientific Name	Common Name	Risk Category	Habitat
Cesonia irvingi	Key Gnaphosid Spider	At risk, data deficient	Terrestrial
Charadrius melodus	Piping plover	Vulnerable	Near shore, beaches
Coccothrinax inaguensis	Thatch palm	At risk, data deficient	Coastal areas in scrub on sandy or limestone soils
Dendrocygna arborea	Black-billed wood-duck	Vulnerable	Coastlines, lagoons, estuaries, FW bodies, mangroves, swamps, marshes, bogs
Dendroica kirtlandii	Kirtland's warbler	Vulnerable	Shrublands, temperate mixed forest
Epicrates striatus fosteri	Bimini boa	Vulnerable/Threatened?	Forests
Geocapromys ingrahami	Bahamian hutia	Vulnerable	Lowland tropical rainforest, rocks, and shrublands

Table 4-17 (continued)
Other Species Identified As At Risk That May Potentially Occur in the Bahamas

Scientific Name	Common Name	Risk Category	Habitat
Guaiacum officinale	Commoner lignum vitae	Endangered	Coastland areas, lowland dry forest, woodland and thickets
Guaiacum sanctum	Holywood lignum vitae	Endangered	Lowland dry forest
Mustelis canis	Dusky smoothhound	Low risk	Continental shelf, oceanic
Swietenia mahagoni	American mahogany	Endangered	Dry or moist forest, often on limestone
Tachycineta cyaneoviridis	Bahama swallow	Vulnerable	Swamps, marshes, bogs, monsoon and dry forest, urban
Trachemys steinegeri	Central Antillean slider	Low risk	Terrestrial, fresh water
Trachemys spp. (includes T. terrapen)	Freshwater turtles	Status unknown; at least one species introduced; one possible endemic	Terrestrial, freshwater
Zanthoxylum flavum	Yellow sanders	Vulnerable	Thickets and woodland on rocky limestone

Coral reefs are an important marine ecosystem in The Bahamas. In the vicinity of the proposed project area coral reefs occur primarily on The Bahamas platform, along the western side of the Bimini Islands chain. On the eastern side of the Bimini Islands chains, on The Bahamas Bank, soft bottom/sand habitats predominate and no coral reefs were observed. There are no endangered species of corals listed internationally; however, three species of corals known to occur in The Bahamas are recognized to be at risk. These include Elkhorn coral (*Acropora palmata*), Staghorn coral (*Acropora cervicornis*) and Pillar coral (*Dendrogyra cylindrus*). Threats to these corals are primarily due to human impacts such as damage, pollution and sedimentation that directly affect the corals themselves or alter the environment in such a way that negatively impacts corals. These corals were not noted along the proposed pipeline route.

4.1.7 Fisheries

Commercial and recreational fisheries are essential to The Bahamas Islands, which are economically dependent upon their natural marine resources. The three main commercial fisheries in The Bahamas Islands are for Spiny lobster (*Panulirus argus*), Queen conch (*Strombus gigas*) and Nassau grouper (*Epinephelus striatus*). Other species are fished commercially, including snappers (*Lutjanus* spp), grunts (*Haemulon* spp), jacks (*Caranx* spp) other groupers, sharks, turtles, stone crabs and sponges; however, these are primarily artisanal fisheries with most landings occurring on New Providence, Abaco and Eleuthera. A list of all fishes observed in the biological survey is provided in Table 4-18.

Table 4-18

Species of Fishes Observed Within the Proposed Project Area

Common Name	Scientific Name	Overall Relative Abundance
Queen angelfish	*Holocanthus ciliarus*	Uncommon
Doctorfish	*Acanthurus chirurgus*	Abundant
Parrotfish	*Scarus sp.*	Uncommon
Blue chromis	*Chromis cyanea*	Common
Squirrelfish	*Holocentrus sp.*	Abundant
Triggerfish (Gray)	*Balistes capriscus*	Common
Gobies/Blennies		Abundant
Yellowtail Snapper	*Ocyurus chrysurus*	Common
Yellowhead wrasse	*Halichoeres garnoti*	Common
Blackear wrasse	*Halichoeres poeyi*	Uncommon
Yellow goatfish	*Mulloidichthys martinicus*	Uncommon
Bicolor damselfish	*Stegestes partitus*	Abundant
Ocean surgeonfish	*Canthidermis sufflamen*	Common
Sand tilefish	*Malaconthus plumieri*	Uncommon
Bluehead wrasse	*Thalassoma bifasciatum*	Abundant
Spotfin butterflyfish	*Chaetodon ocellatus*	Uncommon
Gray angelfish	*Pomacanthus arcuatus*	Uncommon
Blue tang	*Acanthurus coeruleus*	Common
Pluma	*Calamus pennatula*	Uncommon
Silver porgy	*Diplodus argenteus*	Common
Sheepshead porgy	*Calamus penna*	Uncommon
French grunt	*Haemulon flavolineatum*	Common
Sailor's Choice	*Haemulon parra*	Uncommon
Margate	*Haemulon album*	Uncommon
Queen triggerfish	*Balistes vetula*	Common
Spotted moray	*Gymnothorax moringa*	Uncommon
Tiger Grouper	*Mycteroperca tigris*	Uncommon
Scamp	*Mycteroperca phenax*	Uncommon
Hogfish	*Lachnolaimus maximus*	Uncommon

Table 4-18 (continued) Species of Fishes Observed Within the Proposed Project Area		
Common Name	**Scientific Name**	**Overall Relative Abundance**
Rock hind	*Epinephelus adscensionis*	Common
Bar jack	*Caranx ruber*	Uncommon
Great barracuda	*Sphyraena barracuda*	Common
Blue angelfish	*Holocanthus bermudensis*	Uncommon
White grunt	*Haemulon plumieri*	Common
Rock beauty	*Holocanthus tricolor*	Common
Graysby	*Epinephelus cruentatus*	Uncommon
Reef butterflyfish	*Chaetodon sedentarius*	Uncommon
Spottail pinfish	*Diplodus holbrooki*	Uncommon
Gray snapper	*Lutjanus griseus*	Uncommon
Cocoa damselfish	*Stegastes variabilus*	Uncommon
Barred hamlet	*Hypoplectrus puella*	Uncommon
Clown wrasse	*Halichoeres maculipinna*	Uncommon
Yellowcheek wrasse	*Halichoeres cyanocephalus*	Uncommon
Yellowtail damselfish	*Microspathodon chrysurus*	Uncommon
Red hind	*Epinephalus guttatus*	Uncommon
Blue runner	*Caranx crysos*	Uncommon
Nassau grouper	*Epinephelus striatus*	Uncommon
Fairy basslet	*Gramma loreto*	Uncommon
Spotted goatfish	*Psuedupeneus masulatus*	Uncommon
Cottonwick	*Haemulon melanarum*	Uncommon
Margate	*Haemulon album*	Uncommon
Southern stingray	*Dasyatis americana*	Uncommon
Black durgon	*Melichthys niger*	Common
Damselfish	*Stegastes sp.*	Common
Parrotfish	*Scarus sp.*	Common
French angelfish	*Pomacanthus paru*	Uncommon
Blue tang	*Acanthurus coeruleus*	Common
Threespot damselfish	*Stegastes planifrons*	Uncommon
Atlantic spadefish	*Chaetodipterus faber*	Uncommon
French Grunt	*Haemulon flavolineatum*	Uncommon
Brown chromis	*Chromis multilineata*	Uncommon
Dog snapper	*Lutjanus jocu*	Uncommon

4.1.7.1 Commercial Fisheries

The Spiny lobster (*P. argus*) fishery is the most important commercial fishery in The Bahamas Islands and is the fourth largest spiny lobster fishery in the world. Spiny lobster are found in a variety of habitats. They begin life as planktonic larvae carried by oceanic currents eventually settling in near shore waters in a variety of habitats including seagrass beds, algal communities, and mangroves until they metamorphose into small juveniles. From here they live out their juvenile life residing in rocky holes and crevices. Adults are found in deeper water in the protected crevices and caverns of coral reefs, sponge flats and other hard bottom areas. In The Bahamas artificial habitats known as “condos” have been constructed to attract lobsters for fishery purposes by providing additional juvenile and adult habitats. Lobsters are traditionally caught by spearfishing or trapping. Some spiny lobster were observed during biological surveys of the project area, and some spiny lobster habitat does occur in this area; however, observations were uncommon and do not appear to be abundant in the region, particularly in the vicinity of Ocean Cay. No evidence has been obtained to indicate that the waters around Ocean Cay are fished commercially for spiny lobster.

The Queen conch (*Strombus gigas*) is a large gastropod mollusk found throughout the Caribbean. It is second only to spiny lobster in terms of commercial importance in The Bahamas. As a result of years of study the life cycle of Queen conch is well known. Spawning generally occurs from late May into October and larvae remain planktonic for a period of 3- 4 weeks before settling and metamorphosing in shallow subtidal habitats where they spend much of their first year buried in soft bottom sediments. As the queen conch mature they emerge from the sediment and move to seagrass or algal habitats in deeper waters. Sexual maturity takes 3-4 years at which time adults will undergo seasonal migrations from seagrass or algal feeding grounds to shallow sand bottom spawning grounds. Typically queen conch live for 6-7 years, but may live as long as 26 years in deep water habitats where they are less susceptible to fishing. Heavy fishing has resulted in decline in the Queen conch populations in a variety of areas, particularly in shallow waters where fishing pressure is most intense. In The Bahamas Islands the fishery for Queen conch generally occurs during the closed lobster season when they are fished by free-diving. Capture of Queen conch using compressed air is allowed during the lobster season. In The Bahamas most of the commercial catch is sold directly to businesses and consumers with less than 25 percent of the catch being exported. Queen conch was observed during the biological surveys around Ocean Cay and from Ocean Cay to Bimini and in some places they appeared to be abundant. Many of the conchs observed were juveniles, often associated with seagrass and/or mixed seagrass/algae beds which is a preferred habitat for this species. Heavy fishing pressure has caused declines in the queen conch populations near Bimini. Conch populations in waters south of the Biminis Islands, particularly around Ocean Cay, do not appear to be targeted for the fishery.

The Bahamas Islands is probably the home of the largest Nassau grouper fishery in the world; however, exact landings are difficult to assess because a large portion of the catch is sold directly to businesses and consumers in The Bahamas. Adult grouper inhabit reefs and rocky outcrops, generally in shallower waters (<50 feet depth). Spawning occurs in December and January at which time adults form huge spawning aggregations. Early larval stages are planktonic and after a short planktonic stage the larvae settle to the bottom. During the larval stage they remain closely associated with the bottom, typically preferring complex habitat with significant structure, such as rock/rubble bottom, undermined seagrass and other low relief habitat with small crevices for protection. Tidal flow and currents are likely to influence habitat choice, with larvae preferring habitats with stronger water flow. After a juvenile phase of several months to 1 year, the juveniles return to the water column and move to coral reefs and rocky outcrop areas where they will spend their adult lives. In The Bahamas grouper are typically caught using spears while free-diving or using SCUBA. Traps, hook and line and nets are also used. Overexploitation of Nassau grouper is severe in the Caribbean, particularly due to intense fishing pressure during the annual spawning aggregations. Although data from The Bahamas is lacking, evidence from other parts of the Caribbean indicates that this species is extremely vulnerable to over fishing. Adult Nassau grouper were not commonly observed in the reef areas around Ocean Cay and north to Bimini and no information is available regarding spawning habitats and larval populations of grouper in the project area. Although much is known about the habitat and behavior of adult groupers, very little information is available with regard to essential habitats used by grouper for critical juvenile growth and recruitment stages. Identification and protection of essential habitat for grouper larvae is vital to maintaining a healthy grouper population and sustaining the fishery.

4.1.7.2 Recreational Fisheries

Recreational fishing is an important aspect of the tourism industry in The Bahamas. Big game fishes such as wahoo, billfish, and dolphin are primary targets. These large pelagics prefer deep water habitats and their larval habitat is the water column. These species are less dependent upon coastal habitats such as mangroves and seagrass beds, although they are to some degree depend upon these habitats for their food source. Other recreationally fished species are reef dwellers such as yellowtail, kingfish, mackerel, barracuda, jacks, sharks and grouper. A list of species of fishes observed in the project area is provided above in Table 4-17. Within the project area, the Bimini Islands attract the largest number of recreational fishermen due to their location near the blue waters of Florida and coral reefs on The Bahamas Platform.

The Biminis is also a known breeding and spawning area for sharks, particularly the lemon shark (*Negaprion brevirostris*). Long-term research on the lemon sharks at Bimini is ongoing at the Bimini

Biological Field Station and results of this work have been essential in understanding the migratory patterns and life history of this species. Efforts are currently underway to protect critical habitat for fisheries, such as mangroves and seagrasses around Bimini, as well as known spawning areas for sharks in the North sound.

The eastern side of the Straits of Florida, just off the western edge of The Bahamas Platform, is a known migration route for bluefin tuna (*Thunnus thynnus*). This area is commonly known as tuna alley. Migrating fish are travelling from spawning grounds in the Gulf of Mexico to feeding grounds in the Northern Atlantic. Migration through tuna alley occurs from late April to mid June. Since the mid-1970's numerous surveys of migrating fish in tuna alley have been conducted to determine estimates of population size. Total fish spotted in a season ranges from 368 to 3,125 with numbers dependent upon seasonal and weather conditions such as wind.

4.1.8 Terrestrial Habitats

4.1.8.1 Terrestrial Habitats on Ocean Cay

Ocean Cay, located approximately 32 km (20 mi) south of Bimini, is a manmade island formed in the late 1960's to early 1970's. According to workers familiar with the history of Ocean Cay, the island initially consisted of two limestone rock outcroppings that are now located on the west and north sides of the island. Since that time, the approximately 38 hectare (95-acre) island has been used for mining operations. The portion of the island that is being used for mining is essentially devoid of natural resources due to the disruptive nature of the operation. However, both native and exotic vegetation has colonized portions of the island, particularly on the north and west quadrants. Accumulation of various types of debris has also occurred on the island, including abandoned ships/barges, dredging equipment, vehicles, 55-gallon drums, and various other unidentifiable pieces of scrap metal and concrete.

Available aerial photography (an undated photograph from the late 1990s) was used to determine the approximate extent and locations of the natural communities on Ocean Cay. Subsequently, a detailed field survey of the terrestrial portion of Ocean Cay was conducted on September 20, 2001. All flora and fauna encountered during the survey were documented in a field notebook and identified. Locations of vegetative community types have been delineated on the aerial photograph, as shown on Figure 4.18. A second survey was completed by reviewing a November 2001 aerial photograph of the island. This photograph showed that, since the previous aerial photograph (September 2001), the vegetative cover on the island had been reduced by clearing the Australian pines and the coastal scrub community. The aerial photograph used in the second evaluation is presented on Figure 4.18.

Generally, both floral and faunal diversity on the island is low. Twenty-one species of plants and twelve animal species were documented. Of these twelve animal species, nine were birds and three were decapod crustaceans (crabs). The lack of biodiversity is due to the age, environmental condition, and isolation of the island.

4.1.8.2 Wildlife Observations

Most of the land area on Ocean Cay is used for the sand mining operation and does not provide suitable habitat for wildlife species. During the field reconnaissance a small amount of wildlife was observed on the island along the shoreline and within the vegetated northern portion of the island. Wildlife observations were limited to highly mobile animals (birds) and semi-aquatic animals (crabs). Table 4-18 provides a listing of the animal species observed during the field survey. A brief discussion of species encountered by habitat type is presented below.

Table 4-19

Faunal Observations

Common Name	Scientific Name
Laughing gull	*Larus atricilla*
Ruddy turnstone	*Arenaria interpres*
Herring gull	*Larus argentatus*
Terns	*Sterna sp.*
Warblers	*Parulidae*
Common ground doves	*Columbina passerina*
White ibis	*Eudocimus albus*
Snowy egret	*Egretta thula*
Willet	*Catoptrophorus semipalmatus*
Falcon	*Falco sp.*
Ghost crabs	*Ocypode quadrata*
Land crabs	*Cardisoma sp.*
Other crabs	N/A

A. Upland Areas

Descriptions of the existing land use and vegetative community types are provided below by designated area, and are separated into upland or wetland categories. The locations of these designated areas are depicted on Figure 4.18. The color designation for each area corresponds to the color in the Figure legend. A listing of the plant species observed is provided in Table 4-20. Photographs depicting each of the vegetative communities and land use found on the island are shown in the full report on the terrestrial assessment in Appendix K.

Table 4-20

Plant Species List – Ocean Cay

Common Name	**Scientific Name**
Australian pine	*Casuarina equisetifolia*
Inkberry	*Scaevola plumieri*
Crowfoot grass	*Dactyloctenium aegyptium*
Seashore saltgrass	*Distichlis spicata*
Beach morning-glory	*Ipomoea pes-caprae*
Coast sandbur	*Cenchrus incertus*
Coastal spurge	*Euphorbia mesembrianthemifolia*
Sea purslane	*Sesuvium portulacastrum*
Dog fennel	*Eupatorium sp.*
Fig	*Ficus sp.*
Seacoast blustem	*Schizachrium scoparium*
Seashore elder	*Iva imbricata*
Seashore paspalum	*Paspalum vaginatum*
Sea oat	*Uniola paniculata*
Bay Lavender	*Argusia gnaphalodes*
Saltwort	*Batis maritima*
Buttonwood	*Conocarpus erectus*
White mangrove	*Laguncularia racemosa*
Red Mangrove	*Rhizophora mangle*
Black Mangrove	*Avicennia germinans*
Cattail	*Typha sp.*

A.1. Aragonite Mining Area (Area #1) and Runway (Area #2)

The predominant land use on Ocean Cay is the aragonite mining operation, which occupies approximately the southern three-quarters of the island. Support facilities for this operation are located on the south end of the island, and include an administration building, several equipment and machinery buildings, materials storage buildings, the stacker apparatus used to offload aragonite onto ships, crew dormitories and recreational area, and a Bahamian immigration office. Compacted sand, gravel and asphalt aircraft runways are located along the western and northern shores. A harbor area, where barges unload aragonite from offshore dredging operations, is located in the southeast quadrant of the island. The central portion of the island is largely used to stockpile aragonite. Extensive debris areas are scattered throughout the mining operations, and include abandoned machinery equipment, portions of ships and dredging equipment, concrete culverts, and discarded 55-gallon drums.

This portion of the island is largely devoid of natural resources due to the amount of disturbance generated by the mining operation. Some vegetation is scattered throughout this area, including Australian pine (*Casuarina equisetifolia*), inkberry (*Scaevola plumieri*), crowfoot grass (*Dactyloctenium aegyptium*), seashore saltgrass (*Distichlis spicata*), beach morning-glory (*Ipomoea pes-caprae*), coast sandbur (*Cenchrus incertus*), and coastal spurge (*Euphorbia mesembrianthemifolia*). Overall vegetative cover within the mining area is less than five percent.

A.2. Australian Pine (Area #3)

A vegetative community dominated by Australian pine trees occupied the northeastern and northern sides of the island during the field survey. This tree is an extremely aggressive pioneer species from Australia that is frequently found on disturbed sites. This tree does well in coastal environments due to its high salt tolerance and ability to grow in sandy soils. Typically, as is the case on Ocean Cay, these trees form nearly monotypic stands. Other vegetation is present within this community in areas where the pines have not yet colonized, including inkberry, beach-morning glory, coast sandbur, sea purslane (*Sesuvium portulacastrum*), seashore saltgrass, dog fennel (*Eupatorium* sp.), a fig tree (*Ficus* sp.), and seacoast bluestem (*Schizachrium scoparium*). Overall vegetative cover within this community is approximately seventy-five percent. Approximately 50 percent represented canopy coverage from the Australian pine trees. According to the November 2001 aerial photos, a portion of the vegetated area on the north side of Ocean Cay has been cleared of all vegetation and debris. The Australian pine area on the northeast side of the island remains intact. Overall, the size of the Australian pine area has decreased by approximately 50 percent.

Faunal observations within this vegetative community included several falcons (*Falco* sp.) and doves. No nesting sites were observed, however, it is possible that either of these species may have established nest sites on the island.

The northeast quadrant of the island has been used extensively as a dumping area. Discarded 55-gallon lube and engine oil drums, conveyor belts, piles of abandoned machinery, vehicles and dredging apparatus, and two ships were observed.

A.3. Rock Outcrop (Area #4)

An area of eroded limestone rock is located on the southwestern tip of the island. In this area, the rock extends to the edge of water to form a jagged shoreline. Small sand patches within the rock are vegetated with beach morning glory, sea purslane, seashore saltgrass, inkberry, seashore elder (*Iva imbricata*), seashore paspalum (*Paspalum vaginatum*), coastal spurge, and bay lavender (*Argusia gnaphalodes)*.

Faunal observations in this area included laughing gulls (*Larus atricilla*), ruddy turnstone (*Arenaria interpres*), and crabs.

A.4. Beach Shoreline (Area #5)

This designation is used to describe a sandy beach area on the western, northern, and northeastern shoreline of the island. Along the western and northern shorelines, the shoreline exhibits severe erosion and a sand escarpment approximately three to eight feet in height has formed parallel to the water. Large amounts of debris have been dumped along the shoreline, including machinery, abandoned vehicles, steel storage tanks, 55-gallon drums, heavy equipment, tires, and various other unidentifiable pieces of metal and concrete. According to personnel on the island, the debris has been dumped in these areas to act as a makeshift revetment against erosion. Very little vegetation was noted in these areas; however, small amounts of beach morning glory, inkberry, and coastal spurge were observed at the top of the escarpment.

Fauna observed included several herring gulls (*Larus argentatus*), laughing gulls, sandpipers (*Calidrus* sp.), and an unidentified species of tern (*Sterna* sp.). No nest sites were directly observed during the field survey.

A.5. Vegetated Dune (Area #6)

A fairly well developed, albeit small, dune community was located on a peninsular area on the northwest quadrant of the island. Relative to the remainder of the island, this community is of good quality. This area was vegetated with an intermixture of sea oats (*Uniola paniculata*), buttonwood (*Conocarpus erectus*), bay lavender, sea purslane, inkberry, seashore saltgrass, and coastal spurge. Overall vegetative cover was estimated at approximately seventy-percent. According to interviews with island staff familiar with the history of Ocean Cay, this portion of the island was existing when the reclamation project for the rest of the island began. This area was re-examined on the aerial photo taken in November 2001 and it appears this community has been partially filled by sand that appears to be an extension of the existing runway. The majority of the fauna located on the vegetated dune is intact in the November photograph.

A.6. Coastal Scrub (Area #7)

A coastal scrub type community is located in the northwest quadrant of the island. Vegetation within this area primarily consist of seashore saltgrass and crowfoot grass. Also noted was inkberry, seacoast bluestem, sea purslane, beach morning-glory, saltwort (*Batis maritima*), dog fennel, and small Australian pine trees. Vegetative cover in this area is essentially one-hundred percent. Upon examination of the November 2001 aerial photograph, this area appears to have been cleared of all vegetation.

Faunal observations in this area included warblers and doves.

A.7. Sand/Rock Outcrop (Area #8)

An area of eroded limestone rock outcrop mixed with sandy beach is located on the perimeter of the dune community on the northwest tip of the island. The vegetation noted in this area included beach morning glory, inkberry, coastal spurge, and bay lavender.

Faunal observations in this community were limited to ghost crabs (*Ocypode quadrata*).

B. Wetland Areas

B.1. Mangrove Marsh (Area #9)

A small mangrove community and intertidal pond is located at the northwest quadrant of the island. This community is bordered by the aircraft runways to the south and on all other sides by the dune community described above. Vegetation around the perimeter of the pond area consists primarily of small white mangrove (*Laguncularia racemosa*), red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*) and buttonwood trees. The center of the pond is largely unvegetated. Hydrologic features observed in the field indicate that the pond area is connected to the ocean during periods of high tide. After November 2001, aerial photography indicated the mangrove marsh had been partially filled by sand that was intended as an extension of one of the island's runways. This sand has filled in approximately 50 percent of the mangrove marsh and appears to be eroding and sloughing, which may further fill in the marsh over time.

Faunal observations in this area included several ruddy turnstone, willet (*Catoptrophorus semipalmatus*), and one juvenile ibis (*Eudocimus albus*).

B.2. Salt Marsh (Area #10)

A small salt marsh area is located in the western quadrant of the island. At the time of the field assessment, there was standing water present in this area, which appears to receive a portion of the slurry runoff from the aragonite mining operation. No direct connection to the ocean was observed. Vegetation within this area consists almost entirely of seashore saltgrass, of which approximately fifty percent was dead. The center of the pond, where standing water was observed, was unvegetated. After November 2001, aerial photography indicated that the brackish marsh has been partially cleared of vegetation; however, the majority of the community is intact.

No faunal observations were noted in the salt marsh area.

B.3. High Marsh (Area #11)

This high marsh community is located adjacent to the salt marsh (Area #10) and ditch (Area #12) and is at a slightly higher elevation. Vegetation consists of seashore saltgrass, beach morning glory, coast sandbur, sea purslane, and inkberry. Small pockets of standing water were observed on the northern portion of the high marsh but in general it was dry. After November 2001, aerial photography indicated that most of the high marsh area previously identified has been cleared of vegetation. Two small strips on either side of the ditch (Area #12) are intact.

Faunal observations included several burrows likely belonging to an unidentified land crab species, doves, warblers, and snowy egret (*Egretta thula*).

B.4. Ditch (Area #12)

A ditch area is located on the west side of the island adjacent to the high marsh area. The ditch is rectangular in shape. The ditch is vegetated almost entirely with dead cattail (*Typha* sp.).

Fauna observed within this ditch area included several warblers (unknown species), doves, and snowy egrets.

C. Terrestrial Habitats on Bimini

A terrestrial habitat survey on the Biminis will be conducted in the vicinity of the proposed permanent housing locations and the onshore portion of the North Bimini pipeline route. The survey will be conducted to gather data related to the baseline biological conditions on the Biminis including wetlands delineation, habitat identification, and identification of threatened or endangered species potentially present in the Project area. Upon completion of the survey, a report will be submitted to BEST describing the baseline conditions identified on the Biminis, potential impacts from the Project construction, and mitigation measures if required.

4.1.9 National Parks, Protected Areas and Marine Reserves

Delineation and management of the protected land and marine resources of The Bahamas is the responsibility of The Bahamas National Trust (BNT) and the Department of Fisheries in the Ministry of Agriculture. The policy of The Bahamas government is to set aside a minimum of 20 percent of its marine resources in protected areas.

The Bahamas National Trust is a statutory, nonprofit, non-governmental organization, established by an Act of Parliament in 1959 to conserve and manage the country's natural and historic resources. In 1983, 53 sites throughout the country were proposed by the Trust for protection. In 1989, ten of these sites were designated as high priority, one of which has been declared a national park. The BNT currently manages 12 designated national parks and protected areas.

North and South Bimini, North and South Cat Cay and Gun Cay were among the 53 sites proposed, but none was among the ten priority areas. Although not designated as protected areas, their value for natural resources protection is recognized. The Rand Nature Center, Peterson Cay National Park, and Lucayan National Park located on the southern coast of Grand Bahama are the closest designated national parks to the project area. The northern terminus of the project along the western coast of North Bimini is approximately 116 km (72 mi) southwest of Grand Bahama, making it highly improbable that the proposed project would impact these Grand Bahama protected areas.

The Department of Fisheries manages five designated marine protected areas, primarily as nurseries to enhance and protect juvenile and breeding fish. Local citizen groups promote marine protected areas to protect fin and shell fisheries and lobby government and the Trust to declare them protected areas. The recently approved marine protected area in central Andros was proposed by local citizens. Five new marine protected areas are included in the new Fisheries Act that is awaiting approval. One marine protected area in the vicinity of the project is the mangrove and low-lying area located in the northeastern portion of North Bimini (Figure 4.19). Potential impacts associated with the proposed project are discussed in Section 5.

4.2 Air, Noise and Environmental Contamination

4.2.1 Air Resources

4.2.1.1 Existing Air Pollution Sources

The only existing stationary emissions sources on Ocean Cay consist of the existing aragonite and calcite mining operations and several small diesel engine generators. In addition, there are no major existing stationary sources identified within 30 km (19 mi) of Ocean Cay (Freeport is located more than 125 km (77 mi) to the northeast and Miami is located about 100 km (62 mi) to the west). The closest inhabited areas of significance are on South and North Cat Cay located about 11 and 16 km (7 and 9.9 mi) to the north, respectively and South and North Bimini located approximately 31 and 35 km (19 and 22 mi) to the north, respectively. A power plant, consisting of three 1,672 kW and one 1,825 kW diesel engine generators, is located in Alice Town in North Bimini, about 35 km (22 miles) to the north. However, air pollutant emissions from these generators do not significantly impact on Ocean Cay based on their distance from Ocean Cay and the fact that the predominate wind direction is not from the North. The only other sources of emissions in the region are marine vessels.

With respect to air pollutant emissions, the existing aragonite and calcite mining operations on Ocean Cay exclusively involve materials transfer and screening operations and small electrical power generation to support those activities. Material transfer operations involve initial pumping of wet minerals from offshore to an onshore location, transfer by dozers to an open conveyor system, screening, and stockpiling. Screened materials from the stockpiles are transferred by an underground reclaim system to a conveyor and offloaded to barges via a ship loader. The only pollutant generated from these operations is fugitive particulate matter. There are no point sources associated with the material transfer and screening operations.

The existing power house on Ocean Cay to support the mining operations consists of two small 900 kW Caterpillar diesel engine generators. The diesel engines are fueled with No. 2 diesel oil with a maximum 2 percent sulfur content, by weight, and operate 24 hours per day. Estimated emissions, based on US EPA emission factors for these existing engines are summarized in Table 4-19.

4.2.1.2 Existing Air Quality

In order to provide an estimate of existing air quality in the region representative of Ocean Cay for use in the air quality impact dispersion modeling analysis, ambient air monitoring data were reviewed from monitoring stations located in similar climates and geographical locations with similar or greater levels of industrial activity and vehicular operations to create synthetic baseline conditions. While use of ambient pollutant concentration data from such sources overstates the actual conditions on Ocean Cay, it provides a conservatively high estimate of total impacts when modeled results representative of the new emission sources are added to the conservatively high background concentrations.

US EPA guidance (Ambient Monitoring Guidelines for Prevention of Significant Deterioration, EPA-450/4-87-007) was used to develop representative synthetic baseline conditions, which allows the use of monitoring data from regional sites as representative background data if the proposed source will be constructed in an area that is generally free from the impact of other point sources. EPA ambient monitoring data were first identified and obtained from monitoring stations in the Virgin Islands, Puerto Rico, and in Monroe, Dade and Broward Counties, FL. A composite set of representative background air quality data was then compiled based on the availability of data (not all monitoring stations monitor for all pollutants) and evaluation of the similarity of the geography, meteorology, and population/industrial density of the monitoring sites compared to Ocean Cay. (Figures 4.20 and 4.21 depict the location of the monitoring sites in southeastern FL, Puerto Rico and the Virgin Islands). In general, once the most representative monitoring station was identified, the maximum ambient concentration for each regulated pollutant and averaging period was selected from the most recent four years of available data. The following items summarize the rationale used for selection of the representative monitoring stations for each of the regulated pollutants:

- Ambient particulate matter (PM_{10}) data are available from monitoring stations located in Monroe County, FL (Marathon and Key West in the Florida Keys); 12 different counties in Puerto Rico; and St. Croix and St. Thomas in the Virgin Islands. The monitoring station located in Marathon in Monroe County in the FL Keys was judged to be the most representative of Ocean Cay with respect to geography, meteorological influences and population/industrial density. As shown in Figure 4.20, Marathon is located in the Florida Keys approximately 250 km (155 miles) southwest of Ocean Cay, near the center of a narrow line of small islands or reefs and more than 80 km (50 miles) south of the Florida mainland. As discussed in Section 4.1.1, the location of the Florida Keys is considered meteorologically representative of Ocean Cay, with its lack of terrain features, lack of large nearby landmasses and similar maritime influences. The predominant easterly wind direction and lack of upwind emission sources approximates conditions on Ocean Cay. Finally, the Marathon monitoring data was considered more representative than the Key West data due to its lower population/industrial density, which results in less emission sources.

- Ambient nitrogen dioxide (NO_2) data are available from monitoring stations located in Broward County, FL (Hollywood and Fort Lauderdale); Dade County, FL (Key Biscayne and Miami); and in Catano and San Juan, Puerto Rico. Ambient NO_2 data is not monitored at either of the monitoring stations in Monroe County, FL or in the Virgin Islands. The monitoring station located in Key Biscayne, FL was judged to be the most representative of Ocean Cay with respect to geography, meteorological influences and population/industrial density. As shown in Figure 4.20, Key Biscayne is located the furthest east of any of the monitoring stations in Florida on a narrow land mass in Biscayne Bay. As such, it is less influenced by upwind (easterly) air emission sources than any of the other available NO_2 monitoring sites. All of the other NO_2 monitoring sites are located further inland or have much larger numbers of upwind emission sources and have significantly higher upwind population/industrial densities.

- Ambient sulfur dioxide (SO_2) data are available from monitoring stations located in Broward County, FL (Fort Lauderdale); Dade County, FL (Miami); Puerto Rico (Barceloneta, Bayamon, Catano, and Yabucoa); and the Virgin Islands (St. Croix). Ambient SO_2 data is not monitored at either of the monitoring stations in Monroe County, FL. The monitoring station located in Yabucoa, PR was judged to be the most representative of Ocean Cay with respect to geography, meteorological influences and population/industrial density. As shown on Figure 4.21, Yabucoa is located in southeastern PR, near the coast, where it is less influenced by upwind (easterly) air emission sources than any of the other available SO_2 monitoring sites. All of the other SO_2 monitoring sites are located further inland or have much larger numbers of upwind emission sources and have significantly higher upwind population/industrial densities.

- Ambient carbon monoxide (CO) data are available from monitoring stations located in Broward County, FL (Hollywood, Fort Lauderdale, Pompano Beach and Lauderdale Lakes); Dade County, FL (Miami); and Puerto Rico (San Juan). Ambient CO data is not monitored at either of the monitoring stations in Monroe County, FL or in the Virgin Islands. The monitoring station located in Pampano Beach, FL was judged to be the most representative of Ocean Cay with respect to geography, meteorological influences and population/industrial density. As shown on Figure 4.20, Pampano Beach is located closest to the coast in southeastern FL, where it is less influenced by upwind (easterly) air emission sources than any of the other available CO monitoring sites.

- Ambient lead (Pb) data are available from monitoring stations located in Broward County, FL; Dade County, FL (suburban Miami); and Puerto Rico (San Juan). Ambient Pb data is not monitored at either of the monitoring stations in Monroe County, FL or in the Virgin Islands. The monitoring station located in Dade County was judged to be the most representative of Ocean Cay with respect to population/industrial density. The Dade County monitoring location, located in a suburban/residential area about 11 km (7 miles) west of Miami, has a lower population/industrial density that the other available data sets.

The synthetic ambient background data based on the selection methodology discussed above and used in the dispersion modeling analysis is summarized in Table 4-21. The 5-year summary of ambient data from each of the identified monitoring stations is presented in Appendix O.

Table 4-21

Summary of Estimated Ambient Background Concentrations and Air Quality Standards

(All Values in μg/m^3)

Pollutant	Averaging Period	Estimated Background Concentration	Monitor Location	USEPA National Ambient Air Quality Standards	
				Standard	Standard Type[a]
PM_{10}	24-hour	59	Monroe County, FL (Marathon)	150	Primary and Secondary
	Annual	19.9		50	Primary and Secondary
NO_2	Annual	13	Dade County, FL (Key Biscayne)	100	Primary and Secondary
SO_2	3-hour	---	Yabucoa, Puerto Rico	1300	Secondary
	24-hour	35		365	Primary
	Annual	11		80	Primary
CO	1-hour	6,402	Broward County, FL (Pampano Beach)	40,000	Primary
	8-hour	4,540		10,000	Primary
Pb	Quarterly	0.01	Dade County, FL (suburban Miami)	1.5	Primary and Secondary
Ozone	1-hour	106	Virgin Islands (St. Thomas)	235	Primary and Secondary

[a]Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

4.2.2 Noise

No existing baseline noise level measurements exist for Ocean Cay; however the only existing sources of noise on Ocean Cay are associated with the existing mining operations. The nearest potential receptors are located more than 11 km (7 mi) from the site on the nearest inhabited island (South Cat Cay).

The noise emitted from the proposed facility operations of will depend upon the equipment that is operated during each stage of the project. Those noise emissions were assessed with regard to their impact on the nearest residences to the project, on South Cat Cay.

The assessment of noise emissions addressed three stages of the project, as follows:

- Assessment of baseline noise on Ocean Cay from the existing aragonite mining operation and small airstrip;

- Assessment of construction noise on Ocean Cay from the proposed project, including: metal work, unloading of construction materials, underwater dredging, pile driving / sheet pile installation, making and pouring concrete, operating construction vehicles and operation of hand held construction equipment;

- Assessment of noise on Ocean Cay from the proposed LNG and power plant operation, including: Compressors, pumps, metering valves, gas turbines, blowdown exhausts, condensate pumps, a/c generators, transformers, lubrication oil coolers, generator cooling systems, plant and administration/maintenance building HVAC, barges, vehicles, and aircraft

The source noise emissions of each piece of equipment was characterized for use as input to a computer noise propagation modeling procedure. The equipment to be used during the construction phase of the project is further described in Section 2.4. The equipment that will be operated during normal, full load operation of the completed facility is presented in Section 2.3.

The source noise of each piece of equipment was characterized by that equipment's sound power output levels by standard frequency octave bands, its physical location and its circumstances of installation and use. Those source noise data was used as input to a computer modeling procedure which calculated the propagation of that sound through the atmosphere to the selected receiver position. The sound propagation calculation procedure accounted for the effects of the source installation and buildings, enclosures or barriers, and also terrain, distance and atmospheric conditions, in accordance with ISO 9613-1.

The sound levels, from each source emission that propagates to the receiver location, were summed to determine the impact that the total noise from the project may have at that location. The total noise signature at the receiver location was compared to World Bank noise standards to determine the state of compliance with those standards, as described below.

4.2.2.1 Baseline Noise Conditions

The baseline noise emissions from the existing mining operations were calculated for the equipment types currently being used, and for equipment planned to continue at that operation. The noise emissions from that equipment were assessed with regard to their impact on the nearest residence to the project, on South Cat Cay.

The baseline noise emission calculations were based on manufacturer data and also on actual noise measurements of typical equipment. The equipment source noise emission data set used for the baseline calculations included two electric generators (1.8 MW total), an equipment shop air compressor, a mobile excavator, and two wheel loaders. The equipment operating locations were on the southeastern portion of Ocean Cay. Power house Unit 1 was used as the coordinate origin.

The propagation of the noise emission signature for each piece of equipment to South Cat Cay was then projected, through the use of computer modeling procedures, described above. For this calculation, conservative assumptions were used for the elements of sound propagation from Ocean Cay to South Cat Cay. These included the modeling of the sound path over water to be equivalent to that over very hard ground, which tends to increase the calculated sound level. The only sound attenuation elements applied were geometric spreading and atmospheric absorption. Other sound reducing elements, such as barrier attenuation and atmospheric scattering were ignored for this model.

These calculations were conducted for the normal atmospheric conditions for the area, as given in Section 4.1.1. The average temperature of 25 °C (77 °F), and a relative humidity of 80 percent were used for the model. Calm winds were also assumed for these calculations.

Unusual atmospheric conditions which could increase the levels of sound that propagate from Ocean Cay to South Cat Cay are highly unlikely. For wind to carry sound from Ocean Cay to South Cat Cay it would have to come from a SSE direction. Examination of the wind rose in Figure 4.1 indicates that the predominant wind directions are from the east to northeast. Therefore, wind amplification of sound is considered improbable. Also unlikely would be sound amplification effects due to atmospheric temperature inversions. These inversions can occur when the air temperature at higher elevations is significantly warmer than the water below. However, since the average air and water temperatures are both 25 °C (77 °F), and vary only moderately with the seasons, the occurrence of a strong atmospheric temperature inversion is very improbable. For these reasons, noise propagation effects were calculated for normal atmospheric conditions only.

The noise modeling calculations were conducted in accordance with the procedures outlined in ISO 9613-1 and 9613-2. The detailed calculation results and a full description of the calculation method is given in Appendix P.

The noise level on South Cat Cay due to the baseline operation was calculated to be 18.1 dB(A). This is subjectively a very low sound level, and is likely to be well below the existing background ambient sound level on South Cat Cay, due to wind, waves on the beach, insects, birds and other noise sources. Therefore it is unlikely that the baseline operation would be audible at South Cat Cay.

The World Bank General Environmental Guidelines require that noise emissions from these operations, as measured at the nearest noise receptors outside the project boundary, not exceed levels of 55 dB(A) during daytime hours (0700 to 2200), and 45 dB(A) during the nighttime hours (2200 to 0700). The projected noise level due to baseline operations of 18 dB(A) is well below both the daytime and nighttime noise limits.

The baseline noise conditions in the vicinity of the North Bimini Landfall and the proposed onshore pipeline route were calculated for the equipment types currently being used at the Bahamas Electricity Corporation Alice Town power plant. The baseline noise emission calculations were based on manufacturers' data and also on actual noise measurements of typical equipment. It is noted that the worst case expected noise level is 54.5 dB(A) from the existing facilities.

4.2.3 Environmental Contamination

Land-based subsurface investigations at Ocean Cay were conducted in September and October 2001 to investigate the subsurface environmental conditions of the island. The investigation was performed to follow up on a preliminary environmental site assessment conducted in August 2001. The locations and features sampled and described during this investigation are shown on Figure 4.22.

The activities performed in September and October 2001 included soil borings, installation of groundwater monitoring wells, and laboratory analyses of soil and groundwater samples. Soil samples were analyzed for one or more of the following: volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH) and metals. Groundwater samples were analyzed for VOCs, TPH and metals. The explorations were located near, or in the inferred downgradient direction of underground fuel storage tanks (USTs), two chemical storage areas, maintenance facilities, and sewage or waste disposal sites.

During the investigation, oil-stained soils and petroleum odors were observed in soil and groundwater on the southeastern portion of the Ocean Cay near the powerhouse and fuel storage and dispensing areas. Up to 0.76 m (2.5 ft) of free phase floating product was encountered on the groundwater table in five observation wells and in a test pit located near the powerhouse and petroleum storage areas in the southeast part of Ocean Cay. Results of chemical testing of soil, groundwater and free phase product revealed the presence of petroleum hydrocarbon fuel constituents and weathered petroleum fuel. It is likely that much of the free-phase petroleum product observed on groundwater and along the nearby shoreline areas resulted from leakage and/or spillage from underground diesel storage tanks and associated piping. Also observed in this area were oil stained soils on the ground surface near the diesel USTs and dispensers, on the west side of the powerhouse, and in the drum storage areas in the southeastern part of the island

Empty drums, miscellaneous debris, and areas of stained soil were observed in a solid waste disposal area in the northeastern portion of Ocean Cay. It is believed that this disposal area was also used for burning of waste materials. Heavy metals (barium and chromium) were detected in soil samples collected at or below the water table in two explorations near the waste disposal area. Results of chemical testing of a groundwater sample from one of the explorations also detected an elevated level of chromium.

Results of chemical testing of soil and groundwater samples from a location (B-209) near existing septic holding tanks at the employee dormitories did not reveal evidence of TPH, PAH or heavy metals impacts. Laboratory analysis of duplicate groundwater samples from B-209 detected a low level of the VOC styrene in one of the two samples. Evidence of a source of the styrene on Ocean Cay was not encountered and no other VOCs were detected in samples taken from this location.

4.3 Social, Economic and Institutional Resources

The proposed project is to be developed on the small island of Ocean Cay, near the Bimini Islands in The Bahamas. Ocean Cay is located in the South Bimini Islands archipelago, approximately 80.5 km (50 mi) off the coast of Florida. It is a 38 hectare (95 acres), man-made island with a 30 year history of industrial use, primarily involving the dredging, mining, processing and shipping of aragonite and calcite deposits. There are no permanent island residents, nor does the project require or intend for a permanent residential community to be developed on the island. The closest permanent residential community is approximately eight miles away (northeast) over water at Cat Cay.

The development of the proposed multi-purpose energy services facility on Ocean Cay is likely to have a significant net positive impact on the region's social, economic, and institutional resources. Development of a Liquid Natural Gas (LNG) /Liquid Petroleum Gas (LPG) terminal and desalination plant on Ocean Cay would provide economic and social benefits to the Biminis and the Bahamian government, as well as providing a much-needed additional supply of natural gas to South Florida and, potable water, and natural gas to the Biminis.

In some of the Family Islands, including the Biminis, the current electricity supply is insufficient and/or unreliable, presenting a hindrance to economic development and expansion. The project plans to provide natural gas directly to the Biminis for conversion to electricity to allow the supplement of current supplies with reliable, reasonably-priced electricity. In addition, the project also includes development of a desalination plant on Ocean Cay that will be designed to supply fresh water to the Biminis in addition to project components on Ocean Cay. Further, the initial development and subsequent operation of the energy facility, as well as continued operation and expansion of the aragonite mining operations, will spur job creation for Bahamian nationals, particularly those in the Biminis.

Development of the energy service center at Ocean Cay involves an investment of approximately $550 million dollars, one of the largest foreign investments in Bahamian history. A significant positive impact of this investment will be the creation of jobs not only for the 2 to 3-year construction period, but also for the 30-year lifetime of the project. Additional benefits, primarily the significant annual business license fees and a much-needed diversification of the economic base, will be realized by the Bahamian government as a result of this project.

4.3.1 National Economic Overview

The Bahamas is a politically stable, middle-income, developing country with a population of just over 300,000. It consists of an archipelago of some 700 islands, many of which are uninhabited, with a total land mass of 13,942 km^2 (5,383 mi^2). At its closest point, The Bahamas is only 45 miles from the Florida coast. Most of the country's population resides on the Island of New Providence, where Nassau is located, and in Freeport on the island of Grand Bahama. Smaller settlements are scattered over several of the other islands of The Bahamas, known as the “Family Islands.” The most densely populated island is New Providence, with a population density of 2340.4 persons per square mile. The Biminis, the island group closest to the unpopulated Ocean Cay, has approximately 1,676 residents on its 9 square mile area.

The Bahamas is one of the wealthiest nations in the Caribbean region. In 1999, The Bahamas’ per capita income was $14,500, the highest of the Caribbean nations. The Gross Domestic Product (GDP), by government estimates, was approximately $4.81 billion in 2000. Nearly sixty percent of

The Bahamas' GDP is derived from tourism. Benefiting from an absence of personal and corporate income taxes, financial services constitute the second most important sector of the economy. Excluding the public sector, financial services account for up to 15 percent of GDP. Agriculture and industrial activities together account for less than 10 percent of GDP. The agricultural and fisheries sector produces such goods as vegetables, lobster and fish. The country produces some chemicals and pharmaceuticals for export, and products such as the aragonite from Ocean Cay, rum and sun-dried sea salt.

The Bahamas has an import-oriented, service-based economy that relies heavily on tourism for foreign exchange. With few domestic resources and little industry, The Bahamas imports nearly all its food and manufactured goods from the United States. The Bahamian economy has grown by three to four percent in each of the past two years, largely attributable to strong investment in the tourism sector. Continued economic growth is heavily dependent on economic conditions in the United States, which provides approximately 82 percent of the visitors to the islands. Recent growth in the economy, especially in the construction sector, has reduced the official level of unemployment in The Bahamas to around 7 percent. Government and consumer borrowing have increased along with the growth in the economy. The Government maintains the value of the Bahamian dollar on par with the U.S. dollar.

Foreign exchange reserves are at historically high levels ($404 million in 1999) as a result of recent inflows of foreign direct investment. Although the Bahamian government has actively encouraged foreign investment in industrial and agricultural areas as well as in tourism and banking, particularly to expand local employment in white-collar or skilled jobs, the vast majority of successful foreign investments have remained in the areas of tourism and banking. Because of the heavy dependence of the Bahamian economy on tourism and, to a lesser extent, the financial services industry, further diversification of the economy is desirable. Such development is particularly encouraged on the Family Islands. Nevertheless, despite its interest in foreign investment to diversify the economy, the Bahamian Government responds to local concerns about foreign competition and tends to protect Bahamian business and labor interests.

Remaining challenges for the Bahamian government are to privatize The Bahamas costly national corporations, to provide job retraining for hundreds of workers affected by the changes wrought by privatization as well as training for Bahamian nationals for jobs arising from new foreign investments, and to continue to create jobs for new entries in the employment market. These efforts follow on considerable progress in revitalizing the tourism industry, attracting new investment to The Bahamas, and rebuilding the country's infrastructure. Infrastructure improvement projects particularly involve construction of primary and secondary residences, electrification of all of the Family Islands, improvements to water systems on the Family Islands, and construction of roads in key locations. Building permit statistics indicate ongoing buoyancy in both residential and commercial construction activities in the near term.

4.3.2 Political Structure

The Bahamas is a constitutional, multi-party, parliamentary democracy and a member of the Commonwealth of Nations. This former British colony achieved official independence in 1973. Queen Elizabeth II is the nominal Head of State and is represented in The Bahamas by an appointed Governor General (currently Sir Orville Turnquest). The Governor-General in turn appoints the Prime Minister, who is currently The Right Honorable Perry G. Christie. The Bahamian capital is Nassau, New Providence.

The Bahamian political system is derived largely from the traditions of the British Parliamentary system. The bicameral Parliament consists of the House of Assembly and the Senate. Members of the House of Assembly (40 seats) are directly elected every 5 years. The Senate is a 16-member body appointed by the Governor-General upon the advice of the Prime Minister and the opposition leader for five-year terms. Elections are competitive, with wide public participation.

The Executive Branch is comprised of a Cabinet headed by the Prime Minister and includes a minimum of 8 other Ministers, one of whom must be the Attorney General. The governing Free National Movement (FNM) was elected to office in 1992, following 25 years of government by the Progressive Liberal Party (PLP). Since the March 1997 general elections, the FNM has held 35 seats in the 40 member House of Assembly. The most recent general elections were held in March 2002.

The Bahamian Judiciary is a well-established and fully independent branch of government. The judiciary consists of a Supreme Court, a Court of Appeal, as well as numerous Magistrates' Courts. English Common Law is the basis of the judicial system, although there is a large body of Bahamian statutory law.

The Bahamas is divided into 23 local administrative districts that generally correspond to individual island groupings. The Bimini Islands, where Ocean Cay is located, constitutes one of these administrative districts. Each district is administered by a popularly elected district council made up of nine members and headed by a chief councilor appointed by his peers. District councilors have authority over matters affecting the entire district, such as upkeep and maintenance of government buildings, business licenses, and the appointment of district boards. These boards, including the road traffic authority, town planning committee, licensing authority, hotel licensing and the port authority, also administer the budget. These officials, who are the Family Island's primary decision-makers, are mandated to meet once a month but can meet as often as necessary. Meetings are open to the public and press, although they are not permitted to participate vocally, as during the annual town meetings.

4.3.3 National/Regional Demographics and Labor Force

The Bahamas has a total population of approximately 303,000 (2000 estimate), with a growth rate per annum of approximately 1 percent. Almost 60 percent of the population live on New Providence, which includes the capital city, Nassau, and the resort areas of Cable Beach and Paradise Island. The Bimini Islands, the region where the proposed project is to be located, is sparsely inhabited with a total permanent population of approximately 1,676. There are no permanent island residents located on Ocean Cay.

The vast majority (65 percent) of the population in The Bahamas is between the ages of 15 and 64 years and the gender ratio is 0.96 men to each woman. The next largest sector is under the age of 15, making up almost 30 percent of the population. Bahamians enjoy a life expectancy of 70.5 years.

In 1999 the labor force consisted of approximately 158,000 workers, with tourism, financial services and government being the largest employers. This labor force is employed in the following major economic sectors:

- Tourism — 50 percent
- Other Services (includes financial services and government) — 40 percent
- Industry — 5 percent
- Agriculture and Fishing — 5 percent

The Bahamian government strongly focuses on job creation and protection for its citizens. Foreigners are required to obtain work permits before they can become employed in The Bahamas. The government will permit foreign employees to work in technical, supervisory or managerial capacities provided there are no qualified Bahamians available for the jobs. Foreign business owners are expected to train as many of their Bahamian employees as possible to eventually fill technical and managerial positions.

The official unemployment rate at the end of 1999 was estimated at 7.8 percent, now estimated to be down to approximately 7.0 percent, both historically low levels. Unemployment is highest among young people (approximately 40 percent of the unemployed are under 25 years old), and is higher for women than for men (9.7 percent versus 6.0 percent, respectively). Unemployment rates outside the two major population centers of Nassau and Freeport tend to be significantly higher than in the two cities, and underemployment can be considerable, especially in the Family Islands. Wage rates, although lower than those in the United States, tend to be higher than elsewhere in the Caribbean.

In the Biminis, employment is primarily focused on tourism (e.g., hotels, bars/food services, marinas, charter boats) and a limited amount of agriculture (primarily fishing), as well as a small amount of industrial employment associated with the aragonite mining operations at Ocean Cay. Currently, the level of unemployment in The Bahamas is 15 percent.

A written request has been submitted to the administrator for the Bimini Islands to gather additional social, economic and institutional data. Upon receipt of the requested information an additional socioeconomic evaluation of The Biminis will be conducted. This study will be submitted as an addendum to this EIA.

The country has a widespread education system available to all segments of the Bahamian population. There are more than 210 schools in the country, with a total enrollment at about 64,000 and a teacher to student ratio of 1:18. In the Biminis, education is provided at one school attended by 250 students. With sixteen teachers, the teacher student ratio is approximately 1:15. Education is compulsory for persons 5 to 16 years of age. Beginning in the 1960's, the government significantly expanded and strengthened its educational system in part to position its citizens for jobs resulting from future economic expansion initiatives. As a result, Bahamians are the most highly educated of the Caribbean nations, with a literacy rate of 98 percent. Likewise, technical and higher education was strengthened to address shortages of skilled and technical personnel, including expansion of The Bahamas Technical and Vocational Institute, a publicly managed institution.

4.4 Cultural Resources

The potential for existing submerged and terrestrial cultural resources within the project area was evaluated through the performance of a series of surveys conducted in the Fall of 2001. These surveys included:

- archival literature review;
- cultural resources field reconnaissance and diver verifications;
- magnetometer surveys;
- side scan sonar surveys; and
- ocean bottom video collection.

Based upon the results of the surveys performed, no findings of cultural significance were identified within the project area.

4.4.1 Submerged Cultural Resources

AES undertook a cultural resources study to assess the potential for submerged cultural resources in the project area using both archival and remote sensing field investigation techniques. Reconnaissance surveys were conducted on both the western and eastern routes from Ocean Cay to Bimini to collect information used to support the selection of the pipeline route to Bimini, as well as the route selected for the 610 mm (24 in) natural gas pipeline which will extend to Florida. Remote sensing data (e.g., magnetometer and side scan sonar surveys) and/or ocean bottom video were collected along specific transects to characterize the potential for cultural resources located within the project area.

The remote sensing surveys were designed to identify magnetic anomalies and side scan sonar images generated by undiscovered shipwreck resources or other cultural materials in the marine environment. The proton magnetometer portion of the remote sensing survey was performed to locate iron (ferrous) material that could indicate historic or modern era shipwreck sites that may lie undiscovered within the survey area. Similarly, the side scan sonar investigation was performed to produce images that could indicate the presence of hull structures of historic or modern shipwrecks or other cultural material that may be located within the survey area. The diver verification and ground truthing investigation was designed to physically locate and evaluate the cultural significance of magnetometer and side scan surveys. The archival research portion of the investigation was conducted to produce historic and cultural background material pertinent to the survey area and to identify known historic or modern shipwrecks that may be located in the survey area.

A scope of work for the remote sensing survey was submitted to the Government of The Bahamas prior to the implementation of the remote sensing investigation, the results of the Survey are included in Appendix Q. There were four primary areas designated for investigation along the Bahama Bank which correspond to the various structures proposed for installation (Figure 4.23). Data were acquired in each area to support the modeling, design, and engineering necessary for those structures to be suitably built. Those areas include the following:

- OSI Survey Area A1 for harbor development and redesign adjacent to Ocean Cay;
- OSI Survey Area A2 for hydraulic modeling to support the expansion of Ocean Cay and design of new plant structures and the marine terminal;
- a pipeline route west of the bank/cays in deep water; and,
- a pipeline route on the bank, east of the cays in shallow water.

Geophysical operations were performed in all of these areas, except along the Area A2 track lines where only water depth information was obtained (some of Area A1 and Area A2 lines coincide). Details of the survey methodologies and results for both the submerged cultural resource and terrestrial resource surveys are presented below.

4.4.1.1 Remote Sensing Survey – Proton Magnetometer and Side Scan Sonar

A. Methodology

The remote sensing survey was performed along the proposed western and eastern Bimini pipeline routes. During the period between 25 September and 8 October 2001, an initial reconnaissance survey was performed over the proposed routes. The reconnaissance corridors extended from Ocean Cay to North Bimini, and were 100 m (328 ft) in width, consisting of 10-11 survey lines per corridor. The magnetometer investigation around Ocean Cay was performed on a grid pattern as shown on Figure 4.25. This survey was intended to determine the alignment of the 100 m (328 ft) wide east survey corridor and a portion of the 100 m (328 ft) wide west survey corridor, each consisting of seven remote sensing survey lines.

Following the reconnaissance survey, the final project survey was performed during the period 16 September to 2 November 2001. The integrated remote sensing system used for the survey consisted of a proton magnetometer, a side scan sonar system, a sub bottom profile system, and a depth sounder to collect bathymetry data. During the magnetometer investigation of the pipeline route to North Bimini, the survey vessel performed seven survey lines within each three hundred-foot survey corridor, spaced a distance of 12 m (50 ft) apart. This insured maximum coverage by both the proton magnetometer system and the side scan sonar systems. Following the remote sensing investigation, the magnetometer and side scan sonar data were produced on charts and tables. Due to the length of the survey area and the number of anomalies recorded, five working charts (Master Charts 1-5) were designed to group the data and anomalies geographically for investigation.

Prior to diver investigation in the field, the magnetometer anomalies and side scan sonar images were prioritized as they were recorded on the Master Charts (Figure 2.18). A review of Master Chart 1, a summary chart of the entire study area, indicated that the majority of anomalies and clusters of anomalies were located north of Ocean Cay, north of Gun Cay and east of Turtle Rocks, and west of North and South Bimini Islands. The anomaly and side scan sonar information recorded on the individual anomaly charts was then converted to digital global positioning system (DGPS) locations based on the individual anomaly and side scan sonar locations as well as the size and duration of recorded anomalies and the configuration of each side scan image. The data was downloaded into two separate DGPS systems to insure that all selected diver verification locations would be successfully located. The results are presented below.

In addition to the physiographic cultural environment of the area, the study considered the physical environment indicative of shipwrecks. The physical and environmental factors affecting disposition and degradation of shipwrecks over time are highly variable. In the case of the Great Bahama Bank, the majority of shipwrecks could include two scenarios: passage north through the Straits of Florida within the Florida Current, and passage through the shallows of the Bahama Bank to destinations where water depths allow for safe navigation. In the case of the present survey area, shipwreck models include situations where vessels, through faulty navigation or storms, were forced into the rapidly shoaling water of the Little Bahama Bank or situations where vessels attempting navigation into individual islands situated along the Little Bahama Bank ran aground.

B. Marine Survey Results

Within the present survey area, it is expected that storm generated shipwreck sites of large vessels, if any, could be found generally west of the chain of islands from North Bimini to Ocean Cay. The barrier of these islands and the shallows east of the chain of islands could be expected to be free of larger shipwrecks with the exception of large vessels driven through narrow and often shallow passages during peak storm periods. Due to the extremely shallow areas north, east, and south of the Bimini Chain of Islands and lack of deep water passages through the eastern “flats” of the Great Bahama Bank, historic navigation of larger vessels navigating east to west was not possible. Vessels approaching the Bimini Chain in historic times could only approach the islands from the New Providence Channel to the north or from the open water of the Bahama Channel to the west. Thus, likely shipwreck sites of the nineteenth and twentieth centuries would be the passages between the major islands and anchorage sites in the lee of these islands. These would include North and South Bimini, the channel between Gun Cay and North Cat Cay, and the channel between North Cat Cay and South Cat Cay. Sites of small inter-island watercraft wreckage could be found anywhere in the shallows of the survey area east of the Biminis.

The field surveys performed for this evaluation discovered shipwreck scatter from twentieth century vessels anchored in the lee (east) of Turtle Rocks, between South Bimini and Gun Cay. This debris is believed to be from the 1926 cement ship Sapona, and possibly from barges and small sailing vessels destroyed in the 1926 hurricane. According to historic information reviewed during the archival investigation (Appendix Q), these vessels had been maneuvered into this semi-protected anchorage prior to the hurricane. No record of any other vessels lost east of the Bimini Islands was documented in the archival investigation, as discussed below.

Offshore of North Bimini in approximately 4.6 m (15 ft) of water are rock structures that have come to be known as the Bimini Road. Now a cultural site and popular tourist destination, the Bimini Road has been variously described. Marine geologists believe the formations to be natural geologic formations while other individuals and groups believe the formations to be sunken roads and evidence of ancient cultures now extinct. Further findings of the investigation are discussed below.

4.4.1.2 Archival Research - Documented Shipwrecks

A substantial number of shipping losses have occurred over the nearly five centuries of maritime traffic through the Bahama Channel. These are summarized in Table 4-22 below. The literature review included the following shipwreck-specific sources:

- The Encyclopedia of American Shipwrecks (Berman 1972);
- Merchant Steam Vessels of the United States 1808-1868 (Lytle and Holdcamper 1952);
- Disasters of American Vessels, 1841-1846 (Lockhead 1954);
- Shipwrecks of the American Civil War: The Encyclopedia of Confederate Naval Losses (Schomette 1973);
- Shipwrecks of the Western Hemisphere (Marx 1971); and
- The Treasure Hunters Guide (Potter 1972).

Other sources of shipwreck data include the National Oceanic and Atmospheric (NOAA) Chart Data Base, The Florida State University Shipwreck Data Base, as well as local Bahamian chart resources.

Table 4-22
Recorded Shipwrecks in the Vicinity of the Project Area

Date	Description
1694	Dutch merchantman, **Jufron Gertrude,** commanded by Captain Derreck Loffrey and transporting 74,000 pieces of eight and a quantity of merchandise, was wrecked near Issac Rock. Survivors reached Nassau in a small boat and salvors returned to the site, recovering all of the coinage and much of the ship's cargo. Nearby, they sighted another shipwreck and recovered goods from that vessel as well.
1723	Sailing vessel identified only as **Petatch**, which may be the English spelling of the Spanish word Petache, lost near Bimini in a storm.
1758	Ship of unknown registry, **St. Francis**, sailing from Philadelphia to Antigua, was forced ashore on Sandy Cay by pirates. Bullion was recovered.
1765	A very rich unidentified Spanish Galleon was wrecked on a shoal of sand located seven miles southwest from Beak Cay, the southernmost Cay in the Riding Rocks chain, in 17 feet of water. Some silver coinage was recovered shortly after the event, but the site became buried before the majority of the coinage could be recovered.
1753	English merchantman, **John**, Captain Madge, sailing from Jamaica to Bristol, was lost at Gun Cay, south of the Bimini Islands. The crew was saved but the cargo was lost.
1786	The sailing vessel, **Bahama**, sailing from Hondouras to Nassau, was totally lost during a gale at Bimini on March 4th.
1794	British merchantman, **Active**, Captain Howard, sailing from Jamaica to London, was lost at Cat Cay, south of Bimini. Part of her cargo was saved.
1812	American sailing vessel, **Neutrality**, Captain Kimball, sailing from Jamaica to Georgia, was totally lost January 13th off of Cat Cay. The crew was saved.
1813	Sailing vessel, **Fair Bahama**, Captain Graham, sailing from Nassau to Havana, was totally lost August 26th, at Cat Cay.
1816	Three American merchantman lost near the Biminis.
1817	Spanish merchantman, **Rosa**, nicknamed Las Profetes by the Spanish, wrecked near Little Issac Rock during October on a reef 13 nautical miles and bearing 73 degrees from the above location.
1818	English merchantman, **King George**, Captain Cook, sailing from Jamaica to London, was lost on a cay near Bimini. Most of the ship's cargo was saved.
1821	Two ships were lost near Cat Cay, the Canadian vessel, **Prince Regent**, Captain Wickes, sailing from Jamaica to Halifax on September 5th, the crew was saved; and German ship, **Rapid**, Captain Hinman, sailing from Havana to Hamburg.

Table 4-22 (continued)
Recorded Shipwrecks in the Vicinity of the Project Area

Date	Description
1825	American sailing vessel, **North America**, sailing from Nassau to Key West, was wrecked near Bimini.
1862	Sailing vessel attempting to elude Union blockade ran aground north of Bimini on Bahama Bank.
1863	Sailing schooner, **Emily**, out of New Providence Island, sunk by Union steam cutter north of Bimini near entrance to New Providence Channel.
1910	**El Dorado**, a large sailing schooner with four masts, went aground near Bimini carrying a cargo of wine, jewelry, lumber, and food stuffs. The wreck was extensively salvaged at the time of the wrecking incident.
1918	Cargo vessel near Riding Rock, with large supply of food stuffs, completely salvaged by Bimini residents during World War I food shortage.
1926	Cement vessel, **Sapona**, went aground while being towed from Gun Cay to South Bimini Island. The Sapona was carrying a cargo of building materials and possibly liquor.
1926	The barge, **Dreamland**, with a cargo of liquor, was destroyed near Gun Cay in the hurricane.
1926	Sailing vessel **Water Bird**, anchored near Turtle Rocks south of South Bimini, was destroyed in the hurricane.
1926	A motor vessel, **Spear Royal**, anchored near South Bimini was destroyed in the hurricane. Vessel was reported to be carrying a cargo of liquor.
1926	A barge, **Conchy Joe**, anchored near Turtle Rocks and reportedly carrying cargo of liquor and building supplies, was destroyed in the hurricane.
1926	A sailing vessel, **William H. Albury**, anchored near Gun Cay with cargo of liquor, was destroyed in the hurricane.
1926	A sailing vessel, **Louise F**, anchored south of South Bimini Island, was destroyed in the hurricane.
1926	A barge, **Columbus**, anchored between South Bimini Island and Gun Cay, was destroyed in the hurricane.
1926	A sailing vessel, **Francis**, anchored between South Bimini Island and Gun Cay, was destroyed the hurricane.
1926	A sailing vessel, **Bellamena**, anchored near Gun Cay, was destroyed in the hurricane.
1926	A sailing vessel, **Hattie Darling**, anchored near Turtle Rocks, was destroyed in the 1926 hurricane.

4.4.1.3 Diver Verification and Anomaly Ground Truthing Investigation

As described above, five working charts (Master Charts 1-5) were designed to group the results of the diver verification and ground truthing geographically. The data recorded on each chart and in each table was interpreted prior to the diver verification investigation. The content of each chart is as follows (the figures showing the information referenced in the Master Charts are noted below):

Master Chart Number	Description
Master Chart 1 (Figure 2.18 Sheet 1 of 14)	Shows the positions of all recorded anomalies along the proposed route from Ocean Cay to North Bimini.
Master Chart 2 (Figure 2.18 Sheet 1 of 14)	Shows the positions of all recorded anomalies from Ocean Cay to a position south of the Victory Cays.
Master Chart 3 (Figure 2.18 Sheets 4,5, and 6 of 14)	Shows the positions of all recorded anomalies from South Victory Cays, north to the north end of South Cat Cay.
Master Chart 4 (Figure 2.18 Sheets 10, 11, and 12 of 14)	Shows the positions of all recorded anomalies from Cat Cay, north to a position south of South Bimini Island.
Master Chart 5 (Figure 2.18 Sheets 12, 13, and 14 of 14)	Shows a portion of the west route, the position of recorded anomalies from South Bimini Island to the termination point on central North Bimini Island.

The results of the diver verification effort are presented below by Master Chart area.

A. Master Chart 2 – Ocean Cay – Near shore Anomaly M 836 - North to Anomaly M 854 (Areas A1 and 610 mm (24 in) Pipeline Route)

This area is located at the beginning of both the proposed pipeline route to North Bimini and the proposed 610 mm (24 in) natural gas pipeline route to Florida. It was closely investigated along its northwest route for a distance of 0.40 km (0.25 mi). The wide ranging magnetometer and side scan sonar investigation indicated that the area around Ocean Cay was strewn with ferrous debris. Diver verification was performed on the west side of Ocean Cay to verify the nature of the debris. A shoreline investigation was conducted along the northeast quadrant, the point where the pipelines will enter the marine environment. It was found that the debris along this littoral of Ocean Cay continues directly from the terrestrial environment into the marine environment. Both a swimming (surface) and diving investigation continued along the proposed route from anomalies M 385, M 386, and M 387 along the approximate one quarter mile route to anomaly M 854. At this point, the Ocean Cay debris field ended and an extended area of sandy bottom and sea grass began. This anomaly-free area continued for another two kilometers to four dispersed low gamma anomalies, then on to a cluster of four anomalies (S 528, M 822, M 852, M 866). Anomaly number M 866 registered 105 gammas in intensity. The side scan image was interpreted as an object 1.2 to 1.8 m (2 to 4 ft) wide and 12.2 to 18.3 m (40 to 60 ft) in length. An area of raised grassy bottom and drifted sand was observed with relief compatible with the side scan sonar image. This anomaly was likely a pipe discarded during Ocean Cay dredge operations.

According to the analysis of the remote sensing data and physical investigation of the four kilometers comprising the area of Master Chart 2, (Figure 2.18) no historic cultural resources are located in the area.

B. Master Chart 3, South Victory Cays, North to South Cat Cay (Bimini Pipeline Route)

Master Chart 3 (Figure 2.18) covers a distance of approximately 6 km (3.7 mi) and has the fewest anomalies recorded within any of the survey areas. The water depth averaged 4.6 m (15 ft). The anomalies in the Master Chart 3 investigation area extend from anomaly M 825 in the south to the northernmost anomaly, M 650. Two clusters of anomalies located directly east of the southernmost Victory Cays were selected for diver verification. A cluster of five anomalies around M 824 (789 gammas) and a smaller cluster of five anomalies around anomaly M 869 (22 gammas) indicated the presence of ferrous material along a conjoined area of approximately 0.25 km (0.16 mi). Two anomalies some distance apart, south of these clusters, and five anomalies some distance apart, north of these clusters were of low intensity and were not diver investigated. The five anomalies M 793, M 847, M 800, M 844, and M 848 around the large intensity anomaly M 824 (789 gammas) were verified by diver to be a winch pulley and cable of modern manufacture. Concretion on the winch pulley indicated that the material had been submerged for an extended period. Around the winch pulley there were associated pieces of steel cable. This pattern of cable material extended north to anomaly M869 (22 gammas), where a concreted two-foot long iron bar was found.

Investigation of the ferrous material detected during the Master Chart 3 investigation indicates the material is of modern manufacture and constitutes modern vessel debris with no historic or cultural value.

C. Master Chart 4, North Cat Cay To A Position South of South Bimini Island (Bimini Pipeline Route)

Master Chart 4 (Figure 2.18) covers an extended distance of approximately 6.25 km (3.9 mi). The majority of the anomalies and side scan images were recorded during this portion of the remote sensing survey. The anomaly recording area extends from anomaly M 701 in the south to the northernmost anomaly, M 785. The relative intensity of the anomaly scatter in this segment of the remote sensing survey is best understood by examination of Master Chart 1. Master Chart 1 shows the greatest anomaly concentration extends from a point just below the 30-km (18.6 mi) benchmark south to approximately the 26.5-km (16.5 mi) benchmark. This covers an area located generally east of Turtle Rocks, between Gun Cay and South Bimini Island. When Master Charts 1 and 4 were first examined, the intense scatter of anomalies was noted as well as the possible relationship between the anomaly scatter and the Sapona shipwreck site, located 0.8 km (0.5 mi) west of the anomaly scatter and 0.8 km (0.5 mi) east of the mid-point of the Turtle Rock formations. During the archival phase of the investigation, material relating to the Sapona shipwreck as well as a number of other vessels that were lost in the immediate area during the 1926 hurricane supported this relationship.

Four large conjoined anomaly areas are possibly associated with the present Sapona site, which is located approximately 0.5 miles west of the anomaly scatter documented on Master Chart 4. This anomaly area may also consist of wreckage of the barges and sailboats generated during the 1926 hurricane. This intensive area of ferrous scatter and debris begins just south of the 30-km (18.6 mi) benchmark at anomaly M 605 and continues south to anomalies M 617 to M 701, approximately 0.25 km (0.16 mi) south of the 28-km (17.4 mi) benchmark.

Diver verification along this corridor of anomalies revealed a large amount of modern shipwreck material. Anomaly M 687 (148 gammas) proved to be steel material, possibly from a vessel superstructure, or part of an iron stanchion. Continuing south along the scatter pattern, bits of steel and cable were located along with pillow-shaped debris that upon examination proved to be bags of cement, now hardened. Anomaly M 628 (357 gammas), approximately 0.25 km (0.16 mi) south of the 30-km (18.6 mi) benchmark revealed additional modern shipwreck material, specifically an iron winch and pulley apparatus partially buried in drifted sediment.

The most intensive anomaly scatter was recorded in the area midpoint between kilometer benchmarks 28 and 30. This included side scan images S 504 and S 514, which recorded as small circular targets. These were diver verified as encrusted automobile tires. Magnetic anomalies in this area included M 632 (146 gammas) and M 746 (187 gammas) surrounded by fifteen smaller anomalies from 52 to 2.3 gammas which continued the pattern of small iron scatter. The scatter pattern continued below the 28-km benchmark to the 26-km benchmark. The largest anomaly in this area was M 725 (71 gammas); there were three other anomalies (M 641, M 727, and M 697) between 23 and 20 gammas. All the other anomalies in the area registered below 13 gammas and were located in an area of sea grass. Continued diver investigation in this area revealed only paint cans and small pieces of metal which appeared as flat objects under one foot in length of indeterminate age.

The debris identified during the investigation of Master Chart 4 (Figure 2.18) area is associated with the nearby Sapona shipwreck and vessels destroyed in the hurricane of 1926. This debris is consistent with items that might have been on a vessel utilized for storage and includes the automobile tires, the bags of hardened cement, the iron scatter, and possibly encrusted nails and other building materials as well as bits of cable and fasteners. The larger iron objects, the winch and pulley mechanism, and large piece of joined superstructure material, possibly a stanchion, are definitely pieces of modern iron shipwreck material.

Diver observations of areas outside of the 100 m (328 ft) survey corridor indicate that the scatter pattern continues west toward the present location of the Sapona shipwreck. The principal investigator further believes that the position of the Sapona today, near the Turtle Rocks, may not be the position where the Sapona initially grounded. It may be that the vessel initially grounded further east in the area of intensive scatter. This would hold true if the vessel were being towed from the anchorage between Gun Cay and Cat Cay. The present centerline and corridor of the proposed pipeline follows this general route. It is known from historic accounts that there were efforts to lighten the Sapona and to free the vessel after its grounding; this would account for the intensity of the debris field as recorded in the remote sensing investigation. The failure to free the Sapona led to its temporary use as a warehouse facility. Such use would also add to the debris field around the vessel. It is further believed that later storms, including the hurricane of 1926, pushed the vessel to its present position near Turtle Rocks and added to the debris field.

Although modern shipwreck material lies within the proposed pipeline corridor, this material has no historic value.

D. Master Chart 5 – South Bimini Island Transition Area and West Route to North Bimini Island (Bimini Pipeline Route)

Master Chart 5 (Figure 2.18) covers an area of approximately 6 km from a point south of South Bimini Island, north to the pipeline landfall on North Bimini Island. The anomalies recorded on this portion of the survey range from anomaly M 735, south of South Bimini Island, north to the landfall anomaly M 530. Three distinct anomaly areas of interest were recorded within this survey area. A side scan image representative of a shipwreck (S 515) was recorded along with two other side scan images and eight magnetic anomalies in an area approximately 0.8 km (0.5 mi) offshore of the natural breakwater at the south end of South Bimini Island. Diver verification of the area located a modern overturned barge in twenty-five feet of water. The barge lay in a sandy bottom area within a raised semi-circle of natural rock and an associated area of sea grass. East of the sunken barge were a number of fish traps with iron fasteners and leader cable. Anomaly numbers M 731, M 782, M 370, M 372, and M 681 represent these fish traps and the iron waste associated with the fish traps.

South of the sunken barge and north of the sunken barge are two additional anomaly areas. Of twenty-eight anomalies recorded in these two areas, only three recorded over ten gammas. These are M 733 (23 gammas) south of the sunken barge, and M 525 and M 391 (both 13 gammas) north of the sunken barge.

Directly west of the entrance to the Bimini Sands Resort yacht basin, a cluster of anomalies and a side scan image were recorded. Anomalies M 414 (18 gammas), M 390 (21 gammas), M 491 (13 gammas) and M 524 (3 gammas) are located near side scan image S 519, which is described as a number of elongated objects. This area was chosen for diver verification due to the fact that rock ballast and modern iron shipwreck material had been found in the near shore area east of the anomaly cluster. Diver verification located three small pieces of modern iron of indeterminate origin in the anomaly area. Further investigation was conducted to the east out of the survey corridor in a murky area created by the littoral current caused by the entrance into Bimini Harbor. This area, located 0.5 km to the north, revealed nothing of interest to this study. Mr. Frank Cooney, proprietor of the Bimini Sands Resort, reported a number of contemporary wrecks in the area, all of modern vessels attempting to use the littoral channel to enter Bimini Harbor.

Directly west of the entrance to Bimini Harbor, a cluster of eight low gamma anomalies were recorded surrounding the side scan sonar image S 518. This was described as 0.3 m (1-ft) wide and 3.7 to 4.9 m (12 to 16 ft) long, perhaps a dredge pipe associated with earlier dredge operations at the mouth of Bimini Harbor. Diver verification of the area revealed some small scattered pieces of iron along an elongated raised area of sea floor, which might indicate buried pipe.

North of the entrance to Bimini Harbor was an extended line of eighteen small anomalies, all under 15 gammas, from M 410 north to M 540. Due to the shallow depth and clarity of the water, a towed visual survey was conducted in this area. North of M 540 the remains of at least six undersea communications cables were observed. This would conform to the pattern of all of the anomalies from

M 540 to side scan image S 516, described as an elongate object, along an observed cable that records as M 519, M 537, M 530, M 520 and M 538.

Thus, the area of Master Chart 5 (Figure 2.18) from M 735, located south of South Bimini Island, north to the power station east of M 530 indicates the presence of one modern shipwreck, specifically a barge with no historic or cultural value. The six cables located northeast of anomaly M 540 may have some historic interest linked to the past communications systems of the Bimini Islands. The cable history could be investigated by the Museum of The Bahamas and, prior to any construction operations, these cables should be removed so as not to pose a hazard to pipeline installation. With the exception of the communications cables, no historic resources are located in area of Master Chart 5.

4.4.2 Terrestrial Cultural Resources

Ocean Cay is a man-made island that has not supported previous historical settlements or residents. The island was essentially formed within the last 20-30 years as a result of the mining operation. Ocean Cay was formed by filling the shallows adjacent to the eastern side of Sandy Cay, a rocky islet located on the western edge of the Great Bahama Bank. The major portion of this area consisted of aragonite sand deposits which lacked vegetative cover. The formation of the island began in 1969, as Marcona Ocean Industries, Inc. dredged material from the surrounding area and deposited it between Sandy Cay and another natural rock formation south of Sandy Cay. These two rocky cays served as the original expansion points to form the existing island footprint of Ocean Cay. No terrestrial cultural resources exist on Ocean Cay.

The terrestrial cultural resources of the areas on the Biminis that may be impacted by the construction and operation of this project were assessed by a combination of field study and archival research. A report describing the study and its findings is found in Appendix Q.

4.4.2.1 Terrestrial Survey Results

Due to the recent construction of Ocean Cay, no terrestrial resources are expected to be located on Ocean Cay. A historical archival investigation noted three potential areas of culture resources located on the Biminis as discussed below.

- **"Healing Hole"** - Located on uninhabited East Bimini, the "Healing Hole" is a natural spring rising from a limestone sinkhole surrounded by mangroves. The "Healing Hole" is believed to have medicinal effects attributable to the combination of sulfur and mangrove peat in the spring water.

- **"Shark Island"** - Another natural feature of cultural significance is an island located in the lagoon between North and East Bimini, which seen from the air takes the realistic shape of a shark. Like the Bimini Road, the shark shaped island is variously held by different groups to be either manmade or natural.

- **"Fountain of Youth"** - One of the natural fresh water wells existing on the Bimini Islands is held by local experts to be the same "Fountain of Youth" attributed to the Ponce De Leon legend. This well, located on South Bimini, is believed to have provided the population of Bimini with fresh water during the disastrous hurricane of 1926 when other wells and cisterns were affected by salt-water intrusion. This site is located east of the airport road on South Bimini (Saunders A. 2000: 45-53).

4.4.3 Paleontological Resources

Contexts of the preservation of archaeological remains of terrestrial origin are almost nonexistent on the Florida and Bahamas Shelves. The late Pleistocene and Early Holocene environments of the Florida/Bahamas Platform were not optimal for the preservation of terrestrial archaeological sites as sea levels rose to their modern elevations. During the sea level rise, both current and tidal processes were of such force to preclude the preservation of such sites. No such resources were noted in the archival research phase of this investigation. Other recent investigations on the Bahama Shelf did not record the presence of such resources (Marmaduke 2001: 1-7).

4.5 Provision of Services (Existing Infrastructure and Utilities)

This following discussion of the existing utilities and infrastructure at Ocean Cay and the Biminis includes descriptions of potable water facilities, sewerage, electrical generation capabilities, transportation facilities, and emergency services.

4.5.1 Potable water

4.5.1.1 Ocean Cay

The natural freshwater resources on Ocean Cay are very limited. No permanent surface freshwater bodies exist on the 38 hectare (95 acres) island. Occasional small temporary impoundments of rainwater form during heavy rainfall, but are lost by rapid runoff or infiltration in a relatively short period of time due to the granular and highly transmissive nature of the subsurface soils. Temporary salt water impoundments can form from drainage and runoff of recently-mined aragonite material as it is transferred from the barges to the stockpile area, but this water generally infiltrates into the subsurface.

Fresh groundwater may exist in limited areas on the island, but is likely subject to saltwater intrusion from the mining operation runoff and subsurface tidal-influences. In addition, apparent historical petroleum contamination is present in the groundwater in the southeastern portion of the island, and potential sewage contamination may be present in the southwestern areas. The presence of these areas of potential contamination and the likely presence of saltwater in the subsurface make groundwater an unlikely source of significant fresh water on the island.

The current Ocean Cay mining operation employs a reverse-osmosis water treatment system to provide potable water for operations and employees. The system pumps ocean water directly from the existing harbor and treats it at a typical rate of 19,000 to 27,000 liters per day (5,000 - 7,000 gpd).

4.5.1.2 The Biminis

The majority of the potable water on the Biminis is currently supplied from wells located near the air strip on South Bimini. Water lines extending from this wellfield service Bailey Town, Alice Town and other areas on North Bimini. In addition, there are a limited number of privately owned water production well facilities on Bimini.

4.5.2 Sewerage and Solid Waste

4.5.2.1 Ocean Cay

Solid waste generated through everyday industrial and workforce personnel operations on Ocean Cay is currently disposed on-site. Solid waste is disposed in the northeast corner of the island, where combustible wastes are periodically burned. Retired work-boats and other equipment have also been disposed or buried in the northeast disposal area and placed elsewhere on the island, including along the shore features, to offer protection from erosion.

Since 1989, sanitary waste from the workforce personnel dormitories and a cafeteria has been collected in three underground holding tanks located near the southeast corner of the dormitory complex in the southwestern part of the Site. Sewage collected in the tanks is conveyed via plastic piping to an outfall pipe on the south side of the island. Reportedly, pipeline outfall pipe blockages have resulted in subsurface leakage of sanitary waste.

Sanitary waste from two mobile homes located in the southwest corner of the island also reportedly discharges into the ocean via an outfall pipe on the south side of Ocean Cay. Sanitary waste from the government customs building on the west side of Ocean Cay is discharged directly into the ocean via a plastic pipe and outfall.

Sanitary waste from a small dormitory located adjacent to the Ocean Cay recreation hall discharges to a drainage ditch behind that building. The drainage enters a runoff stream from the aragonite dewatering process. The combined runoff is channeled beneath the north-south aircraft runway and into the ocean on the west side of Ocean Cay.

4.5.2.2 The Biminis

There is no sewage collection system on the Bimini Islands. Instead, residents, institutions and commercial facilities utilize septic tanks and leach fields.

AES has requested information relative to existing solid waste practices on the Biminis from the Bimini Administrator. Upon receipt of the requested information, AES will submit an addendum to the EIA describing how the existing waste management practices on the Biminis may influence the management of household wastes generated by the residents of the proposed permanent housing development.

4.5.3 Electricity

4.5.3.1 Ocean Cay

Several large, diesel-driven generators operate on a 24-hour basis to supply electricity for Ocean Cay. The generators are located within the powerhouse, an approximately 12.2 m by 24.4 m(40 ft by 80 ft), corrugated metal building with a concrete floor, located in the southeastern portion of Ocean Cay, as shown on Figure 1.3. A small back-up generator and associated aboveground fuel tank are located in the southwestern portion of the island near two residential trailers. An electrical transformer, reportedly a non-PCB unit, is located on a concrete block outside the eastern wall of the powerhouse building. A second transformer is located west of the powerhouse, near the conveyor belt assembly.

4.5.3.2 The Biminis

Power is supplied to North and South Bimini by The Bahamas Electrical Commission (BEC) and distributed from their generating station on North Bimini to approximately 906 residential and business consumers. Power is generated by burning diesel fuel in four electrical generators with 6.8 megawatt total capacity located on the western coast of North Bimini as shown on Figure 2.18. The total electrical units generated at the station are 12,837,000 Kwh (kilowatt hours).

4.5.4 Transportation

4.5.4.1 Ocean Cay

The majority of the vehicles on Ocean Cay are equipment related to the aragonite mining process including excavators, bulldozers, and dump trucks. There are few roadways or other transportation related improvements other than two air strips along the western and northern shorelines and a small harbor with a barge pier. Transportation to the island is accomplished by use of small aircraft or waterborne vessels.

4.5.4.2 The Biminis

Transportation within the Biminis is accomplished by roadway (for vehicles and motor bikes), and between islands by ferry service. There is an airstrip on South Bimini that is serviced by small airline companies operating out of Nassau and the United States. Marinas exist on both North Bimini and South Bimini, which support a significant fishing and diving tourism base as well as mail delivery service and other transportation needs.

4.5.5 Emergency Services

4.5.5.1 Ocean Cay

There is limited emergency services, such as fire, police or medical services, located on Ocean Cay. The mining operation utilizes its own staff to respond to such emergencies, relying on assistance from other nearby populated islands as necessary. If required the mining operations staff will implement Medivac Procedures to ensure personnel affected by an incident receive proper medical treatment.

4.5.5.2 The Biminis

There are currently two police stations in Bimini, one each on North and South Bimini. The stations are staffed by approximately 14 to 16 policeman. Medical services are provided by a Government health center located in Bailey Town on North Bimini. The health center is staffed by one doctor, two nurses, and one auxiliary nurse.

Additional information relative to fire and emergency response capabilities on the Biminis will be included as an addendum to this EIA, pending response from a letter submitted to the Bimini Administrator.

4.6 Legal, Regulatory and Administrative Requirements

The Commonwealth of The Bahamas has established a comprehensive institutional and legal framework for environmental protection and natural resources management. Three key organizations, The Bahamas Environmental, Scientific and Technological Commission (BEST), the Department of Environmental Health Services (DEHS) and The Bahamas National Trust (BNT), together with specific governmental resource management agencies, provide the institutional direction for environmental protection and management. Environmental protection is supported by a number of laws and regulations that control activities in the physical and biological environment. Recent modifications to long-established natural resources laws, and new laws and regulations dealing with the physical environment, have enhanced the existing legal framework. Additional laws are currently under development to update the existing legal structure.

Summarized below are the institutional and administrative frameworks governing proposed new actions, followed by a listing of the laws, regulations and criteria that apply to this project.

4.6.1 Institutional

4.6.1.1 The Bahamas Environment, Science and Technology Commission

The Bahamas Environment, Science and Technology Commission (BEST), the country's environmental agency created in 1994, is responsible for the overall environmental and natural resources management of The Bahamas. The BEST Commission has developed Environmental Impact Assessment (EIA) guidelines and requires an EIA for major development projects. BEST has the primary responsibility for assessment of proposals submitted for development projects. The Commission reviews EIA reports, advises the Government as to the acceptability of projects and recommends amendments when necessary. BEST is developing policy and procedures for environmental management, including coastal zone management. The agency's mandate also includes:

- Advising the Government on the environmental impact of development proposals submitted to the Commission for review.
- Conducting site visits for projects under EIA review.
- Serving as the country's focal point and point of contact for all international organizations on environmental, scientific and technological matters.
- Coordinating activities related to international treaties, protocols and agreements to which The Bahamas is or will become a signatory.
- Representing the Government in discussions and negotiations with representatives of regional and international organizations and foreign governments on environmental, scientific and technological matters.
- Serving as a forum to encourage and enhance dialogue and information exchange between government agencies and private sector entities.

BEST's Board is headed by the Ambassador for the Environment and consists of representatives from the following:

- Senate, Department of Fisheries;
- Department of Environmental Health Services;
- Department of Agriculture;
- Water and Sewerage Corporation;
- College of The Bahamas;
- Ministry of Tourism;
- Ministry of Foreign Affairs;
- Ministry of Finance;
- Port Department;
- Department of Land & Surveys; and,
- Bahamas National Trust.

An Undersecretary, assisted by five technical officers, heads the daily operations. The InterAmerican Development Bank has provided the Commission with a technical cooperation grant for institutional capacity strengthening.

4.6.1.2 The Department of Environmental Health Services

The Department of Environmental Health Services is responsible for enforcing public health guidelines and industrial regulation and enforcement. The Department is responsible for solid waste management and oil spill contingency plans.

4.6.1.3 Other Government Agencies

Other Government agencies with specific environmental responsibilities are a) the Department of Fisheries - enforcing fisheries regulations and establishing marine reserves; b) the Department of Agriculture – conservation of birds and plants; and c) the Department of Lands & Surveys, Forestry Unit – managing forest resources.

4.6.1.4 The Bahamas National Trust

The Bahamas National Trust is a non-profit organization established through The Bahamas National Trust Act in 1959. It is responsible for establishing and managing national parks and protected areas, historic preservation, public awareness and outreach on environmental issues.

4.6.2 Legislative and Regulatory Framework

4.6.2.1 The Environmental Health Act

The Environmental Health Act, Chapter 217, and the Environmental Health Regulations (1998), promote the conservation and maintenance of the environment in the interest of public health. The Minister of Health is responsible for regulating, monitoring, and controlling the actual and likely contamination or pollution of the environment from any source, for ensuring compliance with all relevant regulations and for setting out minimum standards for a clean and healthy environment. The Minister is assisted by the Director of Environmental Health Services and staff, and is advised by an Environmental Health Board.

4.6.2.2 Certificate of Approval

A Certificate of Approval from the Director of Environmental Health Services must be obtained by anyone who intends to construct, alter, extend or replace any plant, structure, equipment, apparatus, mechanism or thing that may emit or discharge, or from which may be emitted or discharged, a contaminant or pollutant into any part of the environment.

4.6.2.3 The Conservation and Protection of the Physical Environment of The Bahamas Act

The Conservation and Protection of the Physical Environment of The Bahamas Act, No 12 (1997) is administered through the Department of Physical Planning in the Office of the Prime Minister and controls:

- The physical landscape to prevent environmental degradation, flooding and removal of hills;
- Excavation in the form of land removal, quarrying, mining, or harvesting sand or rock;
- Filling lands, wetlands, drainage basins or ponds;
- Digging or removing sand from beaches and sand dunes;
- Any work that will affect the coastlines; and
- Harvesting or removing protected trees.

Permits must be obtained from the Director of Physical Planning for any of these activities. Severe penalties, fines and imprisonment can be imposed for violations of the Act. The Quarrying and Mining Zones Order (1997) provides additional control over land removal.

4.6.2.4 Conservation and Protection of the Physical Environment of The Bahamas Act and the Declaration of Protected Trees Order

Certain species of hardwood trees, rare trees, and trees of remarkable growth or historical significance are protected under the Conservation and Protection of the Physical Environment of The Bahamas Act and the Declaration of Protected Trees Order (1997). A license to harvest any protected trees is required. Before any excavation or construction begins, the area would be inspected by a qualified person to identify potentially protected trees. Currently, ten tree species are protected by the Order.

4.6.2.5 The Wild Birds and Plant Protection Acts

The Wild Birds Protection Act (1987) protects birds and bird eggs during closed seasons. Protection of the bird habitats is not addressed by this Act. The Plants Protection Act (1987) relates to plant disease and controls importation of plants to prevent outbreaks of exotic disease and establishment of unwanted species.

4.6.2.6 The Fisheries Resources Act

The Fisheries Resources Act, Chapter 225, amended as No. 38 in 1993, provides for conservation of the fisheries resources of The Bahamas. It establishes an exclusive fisheries zone and regulates harvesting of fisheries resources within the zone. The Minister of Agriculture and Fisheries may declare any area within the zone, as well as the land adjacent to it, a protected area for the purposes of the Act. Department of Fisheries officers enforce the regulations. Permission must be granted to fish within an exclusive fisheries zone, and permission may include conditions necessary or expedient to conserve and manage the resource.

4.6.2.7 The Bahamas National Trust Act

The Bahamas National Trust Act directs The Bahamas National Trust to promote permanent preservation of lands, buildings, underwater areas of beauty, and areas of natural or historic interest. Additionally, the Act directs the Trust to identify sites for protection, and to administer those areas declared protected. The Trust administers the National Parks of The Bahamas, and it has been the leading organization in the country's conservation efforts.

4.6.2.8 Antiquities, Monuments and Museum Act

Areas or structures of cultural, anthropological, archeological, paleontological or historical significance are regulated under the Antiquities, Monuments and Museum Act (1998) and Regulations (1999). Discovery of a cultural or historical feature must be reported to the Minister and measures are required to preserve its integrity. A permit must be obtained to excavate, carry on building or other work, plant or fell trees, and deposit earth or refuse on, in or near a monument, or demolish, remove, obstruct, deface, or interfere with a monument.

4.6.2.9 The Public Works Act

The Public Works Act, Chapter 21, while providing for construction, management and development of public works, buildings and roads, also provides that the Minister of Works can make rules to regulate the use, obstruction, alteration, encroachment upon or damage to any government property.

4.6.2.10 Acquisition of Land Act

Land to be acquired for a specific building or construction by Government must meet the requirements of the Acquisition of Land Act (1913) and its regulations (1987). Whenever land in any locality is likely to be needed for any public purpose, a notification to that effect must be published in the Gazette, the official Government publication. A public notice is also required to be displayed at a convenient place in the respective district to show what land is needed and where. After notification, a

30-day public response period is observed. The selected land may be acquired by private purchase agreement or through compulsory purchase by the Government. In the event that a structure is moved, compensation is paid to the owner to cover the expense of moving the house to another site plus payment for any damages incurred.

4.6.2.11 Proposed Legislation

Proposed legislation to increase environmental protection and natural resources management includes the Environmental Planning and Protection Act, the Air Pollution Act, the Revised Fisheries Act, and the Ozone Protection Act.

4.6.3 Applicable Regulations

Currently BEST is in the process of promulgating new environmental regulations for The Bahamas. Because these standards and regulations are still in the development phase, AES proposes to comply with appropriate existing United States Regulations and World Bank Criteria, as described below.

4.6.3.1 Heads of Agreement

AES and the Government of the Commonwealth of The Bahamas are in the process of negotiating a Heads of Agreement for the AES Ocean LNG, Ltd. Project. AES anticipates that the Agreement will be finalized in September 2002. Article 6 of the Heads of Agreement, which addresses environmental protection and safety, requires AES to prepare an EIA for the LNG Project and undersea natural gas pipeline. (A separate EIA will also be prepared for the ongoing mining operations at Ocean Cay.) Upon completion of the EIA, an independent expert selected by the Government of The Bahamas will complete an assessment of the EIA to determine whether the document provides a comprehensive assessment of the potential impacts and appropriate mitigation measures associated with the AES Ocean LNG, Ltd. Project.

If the independent expert finds the EIA for the LNG Project to be acceptable, the Government of The Bahamas and AES will be required under the Heads of Agreement to enter into a more detailed Environmental Agreement. The Environmental Agreement will specify terms and conditions for construction and operation of the LNG Project, disposal of construction-related waste, and the procedures for monitoring and evaluating the LNG Project operations, including requirements for monitoring to be performed by an independent environmental consultant and completion of an annual environmental and safety audit. In addition, AES will be required under the Heads of Agreement to design, construct, operate and maintain the LNG Project in accordance with the more stringent of the environmental laws, standards, regulations and guidelines of The Bahamas or The World Bank.

The Heads of Agreement is expected to be finalized in September 2002. Upon final approval an addendum to this EIA describing the terms of the Heads of Agreement will be submitted to BEST.

4.6.3.2 LNG Criteria (US NFPA 59A)

The LNG systems at Ocean Cay will be operated consistent with the National Fire Protection Association, Inc. (NFPA) 59A Standard. NFPA 59A, the latest revision to the Standard was approved and adopted by NFPA on 9 February 2001. The Standard is inclusive of regulations and accepted practices in the United States and Canada.

The Standard applies to:

- Design,
- Location,
- Construction,
- Operation,
- Personnel training, and
- Maintenance of facilities at any location for the storage, vaporization, transfer, and handling of LNG.

The design and operating parameters, described below are covered by the NFPA 59A Standard and will be adhered to during the design, construction and operation of the facility at Ocean Cay:

- site provisions for spill and leak control,
- designer and fabricator competence
- design criteria for process equipment,
- design criteria for stationary LNG storage containers,
- materials of construction,
- safety, relief, fire protection and security systems,
- Instrumentation systems and material transfer systems.

4.6.3.3 Project Air Requirements

World Bank Guidelines and United States Environmental Protection Agency (US EPA) regulations were used to develop air emission standards for the project. For the purpose of evaluating potential impacts from the proposed project, technical guidance and procedures published by the US EPA were consulted. World Bank and US EPA air emission standards used for the project are summarized below.

The US EPA and state environmental regulatory agencies review new and modified sources of air pollution by evaluating both stack emission rates or concentrations and ambient concentrations of pollutants in comparison to established stack and ambient standards, respectively. For the primary sources of air pollution associated with the AES project, the gas turbines, US EPA has established Standards of Performance for Stationary Gas Turbines (40 CFR Part 60 – Subpart GG), which are applicable to stationary gas turbines with heat inputs greater than 100 MMBtu/hr. Subpart GG regulates emissions of nitrogen oxides (NO_2) and sulfur dioxide (SO_2) by limiting stack concentrations of these pollutants as a function of heat rate and fuel nitrogen and sulfur content. The maximum NO_2 and SO_2 emissions from the proposed AES gas turbines will be designed to meet the Subpart GG requirements as well as the recommended World Bank Guidelines for New Thermal Power Plants (stack emission guidelines for NO_2, SO_2 and PM_{10}, as discussed in Section 4.6.3.4). Projects in the US with similar levels of potential emissions to the AES project and located in areas meeting ambient air quality standards (attainment areas) also must perform Best Available Control Technology (BACT) evaluations to establish case-by-case emission limits for each pollutant emitted above EPA-defined significant emission rates. BACT evaluations take into account technical feasibility and the economic, energy and environmental impacts of alternative emissions controls in determining the required emission limits. A BACT analysis for the proposed emission sources has been performed and is provided in Appendix R.

Pursuant to US EPA New Source Review regulations, in order to be granted a permit to construct, new or modified major sources of air pollution must demonstrate that the source will operate without preventing or interfering with the attainment or maintenance of any applicable Ambient Air Quality Standards or Prevention of Significant Deterioration Increments. A summary of the National Ambient Air Quality Standards (NAAQS) and EPA-defined significant impact levels is presented in Table 4-22. In practice, sources of air pollution that result in air quality impacts that are less than significant impact levels are not considered to have the potential to cause adverse air quality impacts and, therefore, are not required to perform extensive impact analyses involving the interaction of impacts from multiple sources.

Table 4-23

US EPA National Ambient Air Quality Standards [(a)]

(Micrograms per cubic meter [$\mu g/m^3$])

Pollutant	Averaging Period	National AAQS		Significant Impact Level[(b)]
		Primary (mg/m^3)	Secondary (mg/m^3)	
SO_2	3-Hour	---	1300	25
	24-Hour	365	---	5
	Annual	80	---	1
NO_2	Annual	100	100	1
PM_{10}	24-Hour	150	150	5
	Annual	50	50	1
CO	1-Hour	40,000	40,000	2000
	8-Hour	10,000	10,000	500
Lead	3-Month	1.5	---	

(a) All short-term (24 hours or less) values are not to be exceeded more than once per year. All long-term values are not to be exceeded, except for PM_{10}, which is not to be exceeded by the average of the annual averages from three successive years. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

(b) In practice, EPA considers that those source of air pollution that result in air quality impacts less than these levels do not have the potential to cause adverse air quality impacts and, therefore, are not required to perform extensive impact analyses.

4.6.3.4 Global Warming Impacts

The Kyoto Protocol to the United Nations (UN) Framework Convention on Climate Change (the Kyoto Protocol) addresses the emission of greenhouse gases. Greenhouse gases are naturally occurring and man-made gases that absorb infrared radiation and thus may enhance atmospheric warming. The Kyoto Protocol aims to reduce emissions of six greenhouse gases, including CO_2, methane (CH_4), and nitrous oxide (N_2O) by 2008-2012. Article 2 of the Kyoto Protocol calls on the participating governments to implement policies that enhance energy efficiency and encourage measures to limit or reduce emissions of greenhouse gases. The Kyoto Protocol was opened for signatures on March 16, 1999, at the UN Headquarters in New York. After signing the agreement, each government must ratify it before it becomes officially adopted. As of July 24, 2002, 84 parties have signed the agreement, and 22 Annex I nations have ratified the agreement. The Kyoto Protocol will become effective 90 days after it has been ratified by at least 55 Annex I Parties to the United Nations Framework Convention. This will represent at least 55 percent of the total 1990 CO_2 emissions from developed countries. The Bahamas has signed and acceded to the agreement.

Like all industrial and utility combustion sources that use carbon-based fossil fuels (natural gas, oil, coal, etc.), the Project's combustion turbines will emit CO_2. There are no economical post-combustion control options for CO_2; therefore, existing options include replacement of old generating units with newer, more efficient units and increased reliance on natural gas. Combustion of natural gas emits approximately 60 percent of the CO_2 emitted by coal-firing and approximately 70 percent of the CO_2 emitted by oil-firing. The Project will utilize very efficient simple-cycle combustion turbines that produce more electricity while burning less fuel than older, existing utility plants. In addition, the Project will run mainly on natural gas, which produces less CO_2 emissions on a per MMBtu basis than oil, which will be used only as a backup fuel to natural gas.

The high efficiency of the Project's power generation coupled with the primary use of natural gas complies with the Kyoto Protocol's goals of enhanced energy efficiency and reduction in greenhouse gases.

4.6.3.5 World Bank Criteria

The World Bank has developed guidelines for a number of sector-wide environmental analysis topics. These are typically applied in the context of programs involving a number of sub-projects. Sectoral guidelines have been developed for both electric power transmission systems and thermoelectric projects.

The *Environmental Assessment Sourcebook* (World Bank 1991) identifies the Bank's policies, procedures, and sectoral and cross-sectoral issues involved in environmental assessment (EA) preparation. This document provides general guidance in the preparation of EA documents and has been utilized in the preparation of this EIA.

The Bank has also published several other documents and policy guidelines that are relevant to this project. The Pollution Prevention and Abatement Handbook includes specific pollutant discharge and ambient environmental quality protection standards.

Environmental Sourcebook Updates relevant to this project include:

- Public Consultation in the EA Process: A Strategic Approach (1999);
- Analysis of Alternatives in Environmental Assessment (1996);
- Biodiversity and Environmental Assessment (1997);
- Coastal Zone Management and Environmental Assessment (1994); and

- Environmental Management Plans (1999).

4.6.3.6 International Maritime Conventions

AES and its suppliers will comply with International Maritime Conventions in the import of LNG fuel and export of LPG. These will include the conventions of the International Maritime Organization, International Labor Organization, United Nations, World Health Organization, Organization of American States, and others as appropriate.

The Bahamas is a member organization of the International Maritime Organization (IMO). The primary IMO safety standard governing the marine transport of LNG is the "International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk," (IGC Code – 1993 Edition).

The Bahamas is a contracting state to MARPOL 73/78 (The International Convention for the Prevention of Pollution from Ships); however, The Bahamas has not agreed to Annex IV which deals with human sewage from ships. Nevertheless, pollution prevention practices consistent with MARPOL requirements will be adhered to during the project. The Society of International Gas Tankers and Terminal Operators (SIGTTO 1997) and The International Navigation Association (PIANC 1997) standards for LNG Docking facilities will be referred to during project design and construction.

5.0 Potential Environmental Impacts of the Proposed Project

5.1 Methodology for Impact Assessment

The environmental consequences of constructing and operating the proposed project facilities are analyzed in this section. The impacts on environmental resources from the proposed project will vary in duration and significance. Three types of impact duration were considered as part of the evaluation, including short term, long term, and permanent impacts. Short-term impacts are temporary in nature and will occur during the construction phase of the project. The construction phase will occur over 36 months as summarized on Figure 1.2. Short-term impacts will diminish to cessation as soon as the construction phase of the project is completed. Long-term impacts are those impacts that will be chronic in nature due to ongoing activities in the project area. Permanent impacts are those resulting in a permanent and irreversible change to existing environmental resources in the vicinity of the project. Impacts may be positive or negative, and will be identified as such. The specific criteria used for determining the significance of impacts are identified for each resource, and the following assumptions were used when evaluating the potential project impacts:

- AES Ocean LNG, Ltd. will comply with all applicable laws and regulations;
- The project will be constructed as described in Section 2; and
- AES Ocean LNG, Ltd. will implement the mitigation measures described in Section 6.

As described below, the construction and operational impacts consisted of an evaluation of the following:

- Island Expansion including:
  - Site Preparation
  - Dredging
  - Site Reclamation and Ground Improvement
  - Shore Protection
  - Support Vessel Harbor (SVH)
- LNG Terminal including:
  - Berthing
  - LNG Receiving
  - LNG/LPG Storage

- LNG Vaporization and Sendout
- LPG Stripping

- LNG Ancillaries including
  - Cooling Water Systems
  - Desalination Plant
  - Electric Generation
  - Site Stormwater
- Pipelines
  - 610 mm (24 in) Natural Gas Pipeline to Florida
  - 60 mm (2 in) Natural Gas and 219 mm (8 in) Potable Water, Pipelines to North Bimini
- Housing;
- Natural Hazards;
- Man Made Hazards;
- Air Quality;
- Noise Level;
- Social, Economic, and Institutional Resources;
- Visual Impacts; and,
- Cultural Resources.

A discussion of mitigation measures for the potential impacts described below is included in Section 6 of this EIA.

5.2 Construction & Operational Phase Impacts to Biological Resources

5.2.1 Island Expansion

Expansion of Ocean Cay to allow for development of the project will entail several distinct activities, each of which has the potential to impact the environmental resources in the area. The primary activities are: site preparation; dredging of the approach channel and turning basin; reclamation to expand the perimeter and raise surface elevations; performing ground improvement for facility foundations; adding shore protection structures; and upgrading the existing small boat harbor. Details of these activities are presented in Section 2, Project Description and Alternatives.

The results of the impact assessment are summarized below for each major island expansion activity.

5.2.1.1 Site Preparation

Site preparation activities have been defined in Section 2.3.1.1.A and 2.4.1.1 and will include mobilization to Ocean Cay of the temporary construction housing, sanitary services and other support vessels and equipment (i.e., barge mounted Reverse Osmosis (RO) System, Concrete Batch Plant, tugs, etc.) required during the construction phase of the project. Activities with the potential to impact the biological resources during the site preparation phase of work include the following:

- Anchorage or mooring of quarters barges or cruise ship for temporary housing on the eastside of Ocean Cay;
- Set up of the construction worker sanitary systems on Ocean Cay;
- Anchorage or mooring of the construction service vessels such as the fuel barge and vessel tender at the SVH;
- Anchorage or mooring and placement of intake and outfall structures for the portable RO desalination barge on the eastside of Ocean Cay;
- Placement of temporary sheetpile bulkheads at two locations on the east side of Ocean Cay for the barge mounted concrete batch plant and the barge loading location for the formed caissons;
- Anchorage or mooring of the barge mounted concrete batch plant and the aggregates barge adjacent to the batch plant; and
- Placement of the portable fuel storage tanks adjacent to the SVH.

Marine structures previously utilized by the mining operation will be removed prior to the initiation of dredge activities in the area south of Ocean Cay. The activities will be performed in conformance with Crown Lease #959 issued by The Department of Lands and Surveys. No additional impacts beyond those described in Section 5.2.1.2 are expected during the removal.

Quarters barges and/or a cruise ship for housing of construction personnel will be anchored or moored along the eastside of Ocean Cay. A gangway or temporary bridge will be installed between the temporary housing and the shore. The vessels and gangway will be located in an area that will have been previously dredged during the expansion of the approach channel and the turning basin, therefore no additional impact to biological habitat is expected from the anchoring and mooring activities. The impacts associated with the dredge operation on the east side of Ocean Cay are described in Section 5.2.1.2.

Sanitary systems required to support the construction workers while on Ocean Cay are described in Section 3.7. The incinerating toilets will be constructed on Ocean Cay at selected locations during the construction phase. The incinerating toilets will not discharge wastewater, and therefore no measurable impact is anticipated to the surrounding terrestrial or marine environment.

A barge mounted construction phase RO desalination unit, as described in Section 2.3.1.1.A, will supply potable water to the concrete batch plant, and other construction phase needs. The intake line will be placed on a floating pipeline extending a short distance from the RO barge. The reject brine discharge line from the barge will be anchored near the ocean bottom a short distance from the RO barge at the maximum possible distance from the intake pipeline. Both of these lines will be placed within dredged areas east of Ocean Cay; therefore, no additional impacts to biological systems are anticipated by the mooring and anchoring activities. Drinking water during construction will be provided from an offsite source or vendor.

The impacts associated with the operation of the barge mounted RO unit include potential impacts from the intake and discharge equipment. Filtration and/or a low velocity cap will be used to reduce flow velocity at the intake structure that will be positioned near the water's surface.

As discussed in Section 2.4.1.1, the barge mounted RO system will take in seawater through a manifold positioned approximately 1 m (3.3 ft) below the seawater surface. Intake velocity of the system will be restricted to 0.3 m/s (1 ft/s), with a flow rate of approximately 3.8 m^3/m (1000 gpm) to minimize the potential for entrainment of marine biota. The discharge from the RO system will be positioned near the seafloor in a previously dredged area of the SVH. The brine discharge from the RO system will have a salinity of approximately 57,000 ppm TDS, which will quickly defuse near the point of discharge. If it is determined that sodium hypochlorite addition is required to prevent biofouling, the discharge will be dechlorinated (if necessary) to meet Florida State, US Federal and World Bank Guidelines. Therefore no significant impacts are anticipated from the operation of the barge mounted RO system.

A concrete batch plant barge will be moored on the eastside of Ocean Cay to provide concrete for construction purposes. An aggregates barge will be placed adjacent to the concrete batch plant to supply the batch plant. As the aggregates barge empties, it will be replaced by a fully loaded barge as required by the concrete production schedule. Temporary sheetpile bulkheads will be placed as shown on Figure 2.21. The concrete batch production materials will be controlled through implementation of the management practices identified in the Environmental Management Plan, Appendix U. Impacts from dust will be controlled by wetting, and stormwater runoff will be confined to the barge or directed to Ocean Cay. No additional impacts are anticipated from the construction of the two bulkheads due to the previous dredging in that area.

Temporary fuel storage tanks with integral secondary containment systems will be placed onshore and adjacent to the SVH as shown on Figure 1.4. These tanks will be delivered new and empty to the site and placed by crane operators. No biological impacts are expected from installation of these tanks or associated dispensing systems. They will be placed in an area that is currently disturbed ground where mining facilities are located. Management of the tanks will follow procedures in the Integrated Spill Control Response, Pollution Prevention, and Stormwater Management Plan, discussed in Section 10, Environmental Management Plan.

5.2.1.2 Dredging

In order to accommodate ship traffic associated with the LNG/LPG terminal, the existing approach channel and turning basin at Ocean Cay will be widened and deepened. Dredging will be accomplished using a Cutterhead Suction Dredge (CSD) and a Backhoe Dredge. Approximately 6.8 million cubic meters of material will be dredged and deposited directly to the reclamation and stockpile areas in the vicinity of Ocean Cay via temporary pipelines. Details of the equipment to be used and the dredging process are described in Sections 2.3.1.1.B and 2.4.1.1.A.

A. Potential Construction Impacts

Dredging was previously conducted in the early 1970's to create the existing approach channel and turning basin. Over the past 30 years, new habitats have become established within the existing approach channel and turning basin. Figure 4.16 illustrates the biological communities within the existing approach channel and turning basin.

An area of approximately 1.3 million m^2 (14.0 million ft^2) will be impacted by the dredging proposed to expand the channel and turning basin. The proposed dredge limits are shown on Figure 2.2. Areas planned to be dredged outside the existing channel and turning basin are composed of primarily soft bottom/sand or soft rock bottom with very low diversity of benthic macrofauna. The existing approach channel and turning basin contain small patches of seagrass and algae as well as some patchy distribution of soft corals in areas where rubble has accumulated. At the entrance of the approach channel, west of Ocean Cay, is a small area of rubble and patch reef.

The dredging will result in loss of the biota located within the dredge area (see Figure 5.1). As described below, the other impacts resulting from dredging will be short-term, occurring only during construction. The project area to be impacted includes 220,000 m^2 (2.4 million ft^2) of seagrasses or 17 percent of the total dredged area, 350,000 m^2 (3.8 million ft^2) of patchy soft bottom soft coral community with <50 percent cover (27 percent of total dredged area), and 22,000 m^2 (240,000 ft^2) of hard bottom with patch reef structure or 2 percent of the total dredged area. Most of the area to be dredged, 700,000 m^2 (7.5 million ft^2) (57 percent), consists of barren sand/soft bottom or soft bottom/rubble with little or no observed epifaunal communities. Once construction is completed, habitats and associated organisms will reestablish themselves within the newly constructed approach channel and turning basin. Soft corals, sponges and tunicates are likely to reestablish on hard bottom and rubble areas. Seagrass will reestablish in soft bottom areas of appropriate depth and temperature with the most successful reestablishment occurring in shallower, warmer waters. Given appropriate conditions of sediment type, temperature and light penetration, reestablishment of seagrasses can occur within 3 to 5 years.

Siltation and sedimentation impacts at the dredging site are expected to be localized and short-term in duration. Potential impacts will be further reduced through the use of the cutterhead suction dredge technique described in Section 2.4.1.2.A. The increases in local water turbidity levels produced by a CSD operation are directly related to the type and quantity of material that is being cut, but not picked up, by the suction. In addition, sloughing of the material along the side slopes of the cut and prop wash from operational tug boats operating in shallow waters alongside the channel can add to localized increases in water turbidity. According to the U.S. Army Corps of Engineers Engineer Manual entitled Engineering and Design – Dredging and Dredged Material Disposal (ACOE 1983), the increase in the level of suspended material appears to be concentrated in the immediate vicinity of the cutter. Within 5 m (16 ft) of the cutterhead, suspended solids concentrations can reach levels on the order of tens of milligrams per liter (mg/l) above background. However, these concentrations decrease exponentially away from the cutter towards the water surface, as well as laterally and in the downstream direction. Typically, near seabed concentrations are reduced to a few tenths of a mg/l within a lateral distance of 300 m (984 ft) from the cutterhead, although these may extend farther in the downstream direction in the presence of a significant mean current to a distance of 1000 m (3280 ft) (Hayes 2000). Other variables, such as particle size, may affect the distribution of suspended materials, but overall the turbidity effects of CSD are expected to be both short-term and localized in nature.

For dredge projects similar to Ocean Cay, the typical adopted effluent concentration in the water column is in the order of 30 NTU (Nephelometric Turbidity Unit) above background. To ensure that the effluent concentration does not exceed this value during this project, daily turbidity measurements will be carried out and operational procedures modified accordingly. A turbidity monitoring program is described in Section 10, Environmental Management Plan.

Excess dredged material (in the order of 3 million cubic meters) will be temporarily placed on the shoal located south of the approach channel as indicated on Figure 5.1. Deposition of this material will impact an area in which the benthic habitat is characterized by soft bottom/sand with patches of sparse seagrass and soft corals. Although existing benthic habitat will be lost by placement of dredged material on the bottom, the excess spoils shoal itself will form a foundation for a new benthic habitat until such time as the excess spoils shoal is harvested by the mining operation.

Most dredged material will be pumped and deposited directly to reclamation and stockpile areas on Ocean Cay via enclosed floating pipelines. Therefore, it is anticipated that potential siltation and sedimentation impacts within the water column as a direct result of the dredging procedure will be greatly reduced as compared to alternative dredging techniques. Some sedimentation and temporary turbidity could potentially occur due to transport of fine material into marine habitats during dewatering of dredged material. In order to minimize the impact of sedimentation resulting from dewatering, all dredged material will be deposited within dikes equipped with control weirs. The dikes will contain the discharged dredged material and prevent redeposition of the material due to waves or overflow. The weirs, used to discharge excess water, will be designed to reduce the discharge of fine sediment back into the water column and to moderate the discharge velocity and volume.

In cases where the compressive strength of the rock to be dredged exceeds 34,00 kPa (5,000 psi), blasting techniques may be employed to increase dredging rates. Should blasting be necessary, procedures to minimize environmental impacts will follow those successfully employed in other parts of the Bahamas such as Freeport Harbor and Gorda Cay. The potential impacts associated with blasting are very low and short-term in duration and include potential localized fish kills, seismically induced damage to surrounding man-made structures, and underwater noise. Seismically induced damage is not likely to be an issue as existing structures will have been removed prior to construction activities and new structures will not yet have been constructed. If there is a need to minimize the seismic impact of the blasting operations, additional holes can be drilled in which no charges will be placed. The function of these additional holes is to reduce the strength of the shock waves produced by blasting. Most fish and mobile species will be disturbed by construction activities and noise and will move to locations away from the construction area; however, some fish and marine life may be more acutely impacted by blasting noise or shock waves. If there is evidence at-risk species, such as marine mammals, may be present in the region during blasting, appropriate mitigation measures (up to and including postponement of blasting activities) will be taken to minimize or prevent impacts, as described in Section 6, Mitigation.

An additional issue related to the dredging operation is the fueling of dredge barges and associated vessels. A fuel barge will be used to transport fuel (no. 2 diesel) to the dredge. The fuel barge will be filled at the SVH located on the eastern side of Ocean Cay and transported by tug to the dredge. The location of the SVH is shown on Figure 1.4. Measures to avoid or minimize potential impacts associated with fueling operations are discussed in the Construction Spill Control Plan and Section 10, Environmental Management Plan.

B. Potential Operational Impacts

Upon completion of dredging operations, long-term operational impacts to the benthic communities within the approach channel and turning basin will be minimal. Although existing biological habitats will be permanently altered in the short-term, new habitats and organisms are able to rapidly reestablish themselves in previously disturbed areas. For example, it is anticipated that sessile organisms with planktonic larval stages will begin to reestablish themselves in the approach channel and turning basin within one year of completion of dredging. Studies have shown that recolonization of seagrass beds can occur in as few as 3-5 years provided appropriate sediment, temperature, and light conditions are available. In addition, dredging can also alter the bottom in ways that actually aid in establishing seagrass beds in areas where they did not previously exist. If additional dredging of the approach channel and turning basin is avoided or minimized during the course of operations on Ocean Cay, new benthic communities will develop and thrive in this area over the long term.

Due to natural current movements through the approach channel and turning basin, it is not anticipated that there will be any long-term sedimentation impacts in the approach channel and turning basin during operations on Ocean Cay. Historically, sediments have not accumulated in the existing approach channel. Natural currents and tides should serve to minimize or avoid potential sediment impacts to developing biological communities as well as prevent or minimize the need for additional dredging in this area.

5.2.1.3 Site Reclamation and Ground Improvement

Ocean Cay will be expanded from an areal footprint of approximately 38 hectares (95 acres) to 112 hectares (276 acres), including the shore protection beaches, to create sufficient land area to support the LNG and LPG facilities planned for the project. Site elevations will also be increased in certain locations, and ground improvement will be required for proper foundations. Details of the fill areas and ground improvement techniques are provided in sections 2.3.1.1.C and 2.4.1.3.C, and site elevation changes are shown on Figure 2.1.

A. Potential Construction Impacts

Land reclamation will occur by placing dredge spoils from the approach channel and turning basin expansion directly into designated fill and stockpile areas. Placing most dredged material directly into planned reclaim areas avoids the need to rehandle the material, thus minimizing the potential sedimentation impacts from stormwater run-off and redeposition of material. Some sedimentation could potentially occur due to transport of fine material into marine habitats during dewatering of dredged material. It will be minimized using dikes equipped with control weirs, as discussed above in section 5.2.1.2.A and shown on Figure 2.26.

The area impacted by the reclamation and island expansion is a total of 1,430,150 m^2 (15,394,500 ft^2) around the perimeter of the existing limits of Ocean Cay. This area consists of 51% barren sand, 24% sand and seagrass patches with less than 50% cover, 22% of variable cover and greater than 50% cover seagrasses, and 3% of low to high relief hard bottom. These designations and the areas used for calculations of the impacted area are shown on Figure 5.1.

As described in section 2.4.1.3, dredge spoils not directly placed in areas to be reclaimed will be pumped into settlement/dewatering basins on the island and sediment particles will be allowed to settle prior to discharge of effluent water. Permanent retaining structures are proposed along the approach channel and will serve as part of one settlement basin. Once drained, dredge spoils will be placed using conventional fill placement techniques. Turbidity control booms will be placed around any fill areas not permanently contained. As with the dredging operation, it is expected that these control procedures will minimize adverse impacts on marine resources due to short-term sedimentation and turbidity effects.

Deep Dynamic Compaction (DDC) techniques will be used to improve the reclaimed soils on Ocean Cay by inducing consolidation with a weight dropped from a predetermined height by a crane. The duration of DDC at the various parts of the island requiring improvement is estimated to be approximately six months. DDC methods are described in Sections 2.3.1.1.C and 2.4.1.3.C. It is likely that shockwaves produced by DDC will dissipate to the nearby ocean floor, and unlikely that these vibrations will propagate beyond the immediate near shore region of Ocean Cay. Because many of the near shore habitats around Ocean Cay will be undergoing modification due to island expansion and construction of shoreline protection, and because new habitats will not yet have established themselves along the shoreline, the impact of DDC to existing and new habitats will be minimal. The DDC activities should be completed prior to the reestablishment of new near shore habitats around Ocean Cay.

Stone columns, a means of ground improvement, are not planned at this time, but may be proposed and developed during later stages of design. The primary purpose of stone columns is to densify soils and distribute the loading to deeper soils to permit support of proposed tanks, equipment, and structures on shallow foundations bearing on the improved ground. If stone columns were to be installed they will be used as an alternate to deep dynamic compaction in areas of heavy structure loading as described in Section 2.4.1.3.B.

If this technique is used and material native to the island does not meet the strength and durability requirements for the stone columns, stone will have to be imported. Water generated as part of stone column construction will be collected and disposed of through settling basins.

Installation of drilled piles will provide support for onshore as well as offshore structures. If determined to be necessary, the onshore piles will likely consist of 0.3 to 0.6 m (1 to 2 ft) diameter cast-in-place concrete piles advanced to a depth of approximately 7 m (23 ft) into bedrock. Typical spacing between piles is anticipated to be approximately 1.5 to 2.5 m (4.9 to 8.2 ft). Boreholes will be advanced using drill rigs equipped with augers or air-rotary drilling equipment. No marine impacts are expected from the potential installation of onshore piles.

B. Potential Operational Impacts

When island expansion efforts are complete, no anticipated adverse long-term operational impacts from site filling and soils improvement are expected. Installed pilings and shoreline retaining walls are expected to eventually serve as substrate for attachment of sessile invertebrates, thereby forming the basis for development of new communities in this area.

5.2.1.4 Shore Protection

A comprehensive shore protection system around the perimeter of the island is proposed to prevent coastal erosion and provide protection for project facilities against coastal flooding (see Figure 1.4). The shore protection system will be designed to withstand wave and surge conditions associated with the nominal 100-year frequency hurricane event. Details of shore protection systems are described in Sections 2.3.1.1.D and 2.4.1.4.B. Construction and operations impacts of the proposed shore protection system are described below and potential impacts from natural hazards such as storms and hurricanes are described in Section 5.3.

A. Potential Construction Impacts

Along the north and west coasts of Ocean Cay, shore protection will consist of installation of artificial gravel beaches with terminal headland structures and T-shaped groins, as shown on Figure 1.4 and described in Sections 2.3.1.1.D and 2.4.1.4.B. Headlands and T-groins will be designed and installed to prevent excessive erosion and movement of beach material due to persistent long-shore transport. T-groins and terminal structures will be constructed using conventional 3-layer methods consisting of core material, rock filter and single layer concrete armor. The external concrete armor will be constructed of accropodes which are bulky, complex-shaped units placed by crane in an interlocking pattern. The typical thickness of this armor layer is 1.6 to 1.9 m (5.2 to 6.2 ft) with a porosity of 49 percent. Beach fill material (rock gravel and cobble) will be obtained through dredging operations and hydraulically placed along the shoreline. Shore protection along the reclaimed south and southeast coasts of Ocean Cay will consist of concrete caissons, steel sheet pile cells or equivalent systems, which will be installed in areas that have already been impacted by prior dredging activities as described above in Section 5.2.1.2.

Impacts from construction of the shore protection features could result from related dredging and land reclamation, as well as the actual installation of the shore protection systems. Construction impacts related to land reclamation are described above in Section 5.2.1.3. Permanent impacts will result from gravel beach construction and the installation of headlands and T-groins such that the existing beach and shoreline habitats on Ocean Cay will be disturbed and permanently modified.

Existing shoreline habitats include sandy beach areas, vegetated dunes, scrub, limestone outcrops and a small mangrove marsh. Descriptions of these habitats, including approximate areal coverage, are included in Section 4.1.8. Of the shoreline habitats that will be impacted by shore protection system construction, the mangrove habitat is the most sensitive; however, the mangrove habitat on Ocean Cay is extremely small (0.6 acres, or less than 1 percent of total island area). Due to its isolation, small size, poor quality (the mangroves are small and poorly developed), and because no endangered or threatened species are known to directly rely on this habitat on Ocean Cay, the overall impact due to loss of the mangroves is minimal. Loss of sandy beach habitat will permanently prevent any potential nesting of sea turtles on Ocean Cay; however, there is no evidence to suggest that Ocean Cay is a known nesting area for sea turtles or other potentially endangered species. Therefore impacts related to loss of sandy beach habitat on Ocean Cay will be insignificant.

Shore protection along the reclaimed south and southeast coasts of Ocean Cay will consist primarily of concrete caissons or equivalent systems to be installed in the SVH area (described below in Section 5.2.1.5). These shore protection systems will be installed in areas that have already been impacted by prior dredging activities as described above in Section 5.2.1.2.

Therefore, no additional impacts are expected due to the installation of the shore protection structures. Construction impacts related to land reclamation and installation of these shore protection systems are described above in Section 5.2.1.4.

B. Potential Operational Impacts

Once installed, the artificial gravel beaches and related shore protection structures will have a permanent net positive impact. A new rocky shore habitat will be created along the shoreline of Ocean Cay and sessile organisms and plants will eventually establish themselves along these beaches thereby reestablishing, and in places where sand habitats existed, replacing, the original shoreline habitat. As a result, these newly constructed cobble beaches should form stable rocky shoreline habitats. The accropode armor of the constructed headlands and T-groins are designed to minimize erosion of beaches due to regular wave action and the accompanying discharge of sediment and loss of surface area. During storms and extreme weather events, beach habitats can be disturbed as a result of natural forces and some movement and loss of material will occur due to cross-shore and long-shore transport. These effects will be minimized by adjustments to the length and orientation of headland and groin structures during design and construction. The interlocking precast concrete retaining walls will eventually become encrusted with sessile organisms and form the foundation for development of a stable community of attached macroalgae and macroinvertebrates.

5.2.1.5 Support Vessel Harbor (SVH)

The support vessel harbor will be created by expanding and upgrading the existing small boat harbor on Ocean Cay by adding additional berthing capacity. This SVH will be used by tugs, barges, launches, and a ferry, and will be equipped with a diesel fueling system. During construction, this facility will serve as a berthing area for material delivery barges and construction vessels. Refer to Sections 2.3.1.1.E and 2.4.1.4 for descriptions of the construction and operational aspects of the SVH.

A. Potential Construction Impacts

Impacts related to construction of the SVH will be short term and include loss of benthic habitat due to dredging activities as described in Section 5.2.1.2 (above) as well as the loss of shoreline habitat due to land reclamation along the southeastern coast of Ocean Cay as described in Section 5.2.1.3 (above), and the installation of shore protection as described in Section 5.2.1.4 (above).

A concrete caisson retaining wall (or equivalent) will be installed in the SVH and will serve as a bulkhead for mooring of construction vessels. Concrete caisson construction techniques are described in Section 2.3.1.1. Once construction of the SVH is completed there are no anticipated long-term impacts as a result of construction.

B. Potential Operational Impacts

Onshore facilities at the SVH will include utilities to service support vessels, electrical power, and diesel fueling capability. There is a potential for minor long-term and cumulative impacts on marine resources resulting from the operation of the SVH, primarily from bilge discharges and vessel fueling operations. To minimize such potential adverse impacts, ballasting and bilge discharge procedures will follow accepted international standards and applicable regulations.

To minimize potential impacts of diesel releases during fueling operations, containment booms will be available for deployment and the facility will be equipped with skimmers and other spill response products (e.g., absorbents). In the event of a spill, emergency procedures will be followed as discussed in Section 5.4 and Section 10, which will be implemented to prevent or minimize adverse environmental impacts. The Integrated Spill Prevention Countermeasures and Control and Stormwater Pollution Prevention Plan (Appendix U) provides for standardized procedures, training of personnel, establishing a watch and communications system, preventative maintenance of equipment, spill response materials, inspections, and documentation of all fuel transfers. With these controls in place it is anticipated that long-term operational impacts will be consistent with those of other support vessel harbors in the Bahamas.

5.2.2 Liquefied Natural Gas (LNG) Terminal

The proposed LNG terminal will be constructed at the southern end of Ocean Cay, as shown on Figure 1.4. Construction of the terminal will involve dredging, island expansion, and installation of shore protection. Potential impacts related to these construction activities are discussed in Sections 5.2.1.2, 5.2.1.3, and 5.2.1.4 (above). Additional construction activities include installation of berths, storage facilities, vaporization and sendout facilities, and LPG removal system. Impacts related to construction and operation of each of these additional elements are discussed separately below.

5.2.2.1 Berthing

Marine facilities at the LNG terminal will include two berths for gas carriers, one to accommodate LNG tankers for receiving LNG and another to accommodate LPG tankers for shipping out LPG. The construction process will involve the installation of both the LNG and LPG berths as described in Sections 2.3.1.2.A and 2.4.2.1.

A. Potential Construction Impacts

Installation of both the LNG and LPG berths will involve construction of loading platforms, breasting dolphins, mooring points, access trestles, and walkways as described in Sections 2.3.1.2.A and 2.4.2.1. Construction of the loading platforms and breasting dolphins will require installation of drilled steel piles. Steel casings will be used to reduce spoil dispersal in the water column, and drilling spoils will be collected and disposed of on land. Boreholes drilled in bedrock may not be cased and synthetic drilling mud will be used to stabilize boreholes during drilling, as described in Section 2.4.1.3.C.

Because offshore pilings will be installed in previously dredged areas, no benthic habitats will be present at the time of borehole installation; therefore, no direct impact from pile installation is expected to benthic habitats. Potential impacts during pile installation will be further reduced due to the use of a non-toxic, clay free, biodegradable drilling fluid. The proposed drilling fluid will be Bio-Bore© or equivalent, a material safety data sheet and additional product literature is presented in Appendix F. Mitigation strategies for the potential impacts associated with sedimentation from drilling operations are discussed in Section 6, Mitigation.

Mooring points, access trestles and walkways will be installed above the water surface and direct impacts to marine communities as a result of these construction activities are not anticipated.

B. Potential Operational Impacts

Once construction activities are completed, there are no anticipated long-term impacts that will occur as a direct result of installation of berthing facilities. Given appropriate substrate, sunlight, and temperature, benthic communities will be able to reestablish within the vicinity of the LNG terminal. There is the potential for long-term impacts due to increased ship traffic, particularly as a result of accumulation of pollutants in the water column and sediment, which is known to adversely effect biological communities. In order to minimize and avoid impacts related to introduction of pollutants and invasive species all bilge discharge procedures will follow standard MARPOL regulations as described in Section 6, Mitigation. Ballasting procedures will follow standard practices consistent with other Bahamian ports and in accordance with all applicable regulations.

Potential impacts, such as spills or related impacts resulting from natural or man-made hazards are discussed below in sections 5.3 and 5.4, and will be mitigated using hazard protection and control systems as described in Section 10.

5.2.2.2 LNG/LPG Storage

Storage facilities for LNG and LPG will be located within secondary containment berms on the southwest portion of Ocean Cay. Construction of the LNG and LPG storage facility will involve site preparation, tank construction, testing, inspection and corrosion protection.

A. Potential Construction Impacts

Potential impacts related to site preparation for tank installation involves site fill and soils improvements discussed above in Section 5.2.1.3. Tank construction will occur on Ocean Cay and no impacts to marine environments are anticipated as a direct result of construction of the LNG and LPG tanks.

The inner tanks of both LNG tanks and the LPG tank will be hydrostatically tested prior to commissioning using seawater which will be pumped from the seawater intake on the west side of Ocean Cay. Prior to hydrostatic testing all tanks will be swept clean to remove any resident construction debris and to avoid discharge of debris with the hydrostatic test water. Each LNG tank will be filled with 95,000 m^3 (25,096,340 gal) of seawater and the LPG tank will be filled with 40,000 m^3 (10,566,880 gal) of seawater. Hydrotest waters will be filtered and discharged through Outfall 001. Following the hydrotest, a freshwater rinse of each tank will follow utilizing a substantially smaller volume of water (estimated at less than 378.4 m^3 (100,000 gal) per tank) to spray rinse the interior surfaces. Waters used in the hydrotest will be filtered and discharged through Outfall 001 into the turning basin. Proposed intake and discharge rates for the test waters are described in Section 2.4.2.2.B.

The discharge of hydrostatic testing wastewater (seawater) into the turning basin is unlikely to impact nearby marine communities as there will be no change in salinity, only very modest alteration in temperature, and little or no discharge of sediment or other pollutants. The small volume of freshwater discharged into the turning basin will have a very minor localized effect due to a short-lived change in salinity, which will be quickly modified through mixing by local currents. Any potential impacts due to influx of freshwater will be minimized by the fact that it is unlikely that a large number of habitats and organisms will have reestablished themselves within the turning basin or approach channel by the time this singular event takes place (i.e. during or just after completion of major construction activities around Ocean Cay). Additionally, it is anticipated that this short-term impact will be insignificant to existing marine populations because many organisms are tolerant of small changes in salinity.

Preparation of the tanks will occur prior to filling with LNG or LPG and will involve both visual inspection and a nitrogen purge procedure as described in Section 2.4.2.2.A. Corrosion protection will consist of painting or galvanizing all metal structures. This procedure will take place on Ocean Cay and standard practices for any waste removal will be followed. No impacts to marine environments are anticipated as a result of the inspection or corrosion protection procedure.

B. Potential Operational Impacts

Once the tanks have been installed, cleaned, and tested there are no anticipated long-term impacts to marine habitats. Periodic maintenance and pumping of the tank containment areas will occur; however, potential impacts related to discharge of accumulated stormwater from the containment areas will be minimized through monitoring for temperature depression. If the temperature of the stormwater collected in the containment area is significantly below ambient temperature it may be indicative of a leak in the supercooled LNG or LPG tanks or piping. Potential impacts will also be mitigated through adherence to the procedures described in Section 10. In the unlikely event of an emergency, appropriate measures will be taken to avoid and mitigate impacts as described below in Sections 5.3 and 5.4.

5.2.2.3 LNG Regasification and Sendout

The proposed LNG regasification and sendout system is described in Section 2.3.1.2.D. The system will be constructed on reclaimed land that has been improved. The impacts associated with land reclamation and improvement are discussed above in Section 5.2.1.3. During operation of the system, seawater will be withdrawn from the ocean via the intake structure and used to regasify LNG to natural gas for use in the gas turbine generators and for transport via pipeline. The resultant cooled seawater will then be discharged back to the sea through Outfall 001 (refer to Section 3.4). Impacts associated with the process water intake and discharge system are discussed below in Section 5.2.3.1. No additional impacts to marine or terrestrial resources are anticipated during either the construction or operational phases of this the LNG regasification and sendout systems.

5.2.2.4 LPG Removal

The proposed LPG removal system described in Section 2.3.1.2.E will be constructed on reclaimed and improved land. The impacts associated with land reclamation and improvement are discussed in above in Section 5.2.1.3. No additional impacts to marine or terrestrial resources are anticipated during construction or operation of this system.

5.2.3 LNG Ancillaries

5.2.3.1 Facility Process Water System/Desalination

Operation of the LNG facility will be dependent on three main ancillary systems, including the LNG cooling water system, desalination plant, and electrical generation system. Design and construction of these ancillary structures is described in Sections 2.3.1.3 and 2.4.3. Seawater will be used for heating the LNG, providing feed water to the desalination plant and auxiliary cooling for the ancillary systems. These streams constitute the facility process water. A description of facilities and construction techniques for the seawater intake and facility process water discharge Outfall 001 are included in Sections 2.3.1.3 and 2.4.3, respectively. Marine impacts related to the construction and long-term operation of the intake and discharge system for facility process water are described below.

A. Potential Construction Impacts

The terminal end of the intake pipe will be located 250 m (830 ft) west of Ocean Cay and will extend vertically from the buried pipeline to an intake structure including a velocity cap. The top of the intake structure will be located approximately 4.9 m (16 ft) below the water surface. Offshore installation of the 1.8 m (6 ft) diameter intake pipeline will involve dredging a trench and burial of the pipeline. Details of the velocity cap and intake pipe are described in Section 2.4.3.1 and are shown on Figure 2.12.

Excavation of the pipeline trench will begin with dredging a sufficient channel for placement of the pipe using the cutter suction dredge. The impacts to biological resources from dredge operations will be similar to those described in Section 5.2.1.2. The dredged materials removed from the trench will be pumped to the onshore settling areas established for the fill operation. Spoil material will be used to backfill the pipe installation and any excess will be used for island reclamation as described in section 5.2.1.3. If necessary, bedding material (gravel) will be placed in the trench prior to laying the pipeline. Gravel and concrete mats will be placed around the pipeline to secure the vertical portion of the structure in place.

Installation of the intake pipeline will impact benthic habitats west of Ocean Cay for 56 m (184 ft) west of the area impacted by the island expansion as described in Section 5.2.1.3. The approximate impact area will be an offshore corridor 56 m (184 ft) long and 12 m (40 feet) wide. The benthic habitat in this region is thin layer of soft bottom sand, overlying rock, with patches of seagrass and mixed seagrass and algae beds of $<$50 percent cover. Seagrass and algae located in the narrow area to be trenched will be removed through the dredging operations. Potential sedimentation impacts from trenching to areas on either side of the trench will likely occur due to the sediment disturbed during the dredge operation. Anchorages for construction vessels will be placed to minimize impact to areas outside of the dredging and pipe installation construction corridor. The intake line installation corridor will be refilled with native materials and will present the opportunity for reestablishment of localized seagrass beds. Installation of gravel and concrete mats around the intake structure will permanently alter the soft bottom habitat; however, these will serve as new hard bottom substrate for the establishment of new benthic communities near the intake structure.

The discharge pipe will be terminated at the wall of the turning basin (Outfall 001). The final discharge pipe (5.5 m (18 ft) diameter) will pass below the concrete caisson wall at the LNG berths to a discharge point in the turning basin located approximately 10 m (32 ft) below the water surface. An excavation to accommodate the discharge line will be dredged from the turning basin north onto the island using the cutter suction dredge. Marine impacts associated with dredge operations are discussed in Section 5.2.1.2.

Installation of the discharge outfall in the turning basin will be accomplished by offshore dredge. Impacts to biological resources from dredging, land reclamation, and installation of shore protection features in this region are described above in Sections 5.2.1.2, 5.2.1.3, and 5.2.1.4. No additional impacts related to construction of the discharge pipeline are anticipated.

B. Potential Operational Impacts

The seawater intake structure is designed for smooth uniform flow with entrance velocities of less than 0.15 m/s (0.5 ft/s) at the intake velocity cap. This rate of flow is less than the average ambient current monitored at Ocean Cay during the MetOcean Study (Appendix A). Entrainment of suspended solids and marine life at the intake structure will be minimized by the low velocity draw of the intake. However, it is likely that some marine life will become entrained and removed at the screens located onshore prior to the intake pumps. Screen washes will be directed to Outfall 002 and some portion of the entrained organisms are expected to be returned live to the sea. Disinfection of the incoming seawater with sodium hypochlorite will be instituted at a position following the intake screens to prevent biofouling to critical mechanical systems. Depending on maintenance requirements observed during the initial stages of operation, sodium hypochlorite may potentially also be injected into the intake stream prior to the intake screens to prevent biofouling and potential reduced capacity. While the volume of entrained biological material is expected to be minimal, if dosing with sodium hypochlorite becomes necessary at a point preceding the screens, mortality of any entrained marine life will result.

Flow from the discharge Outfall 001 will be a combination of facility process water and pretreated contact stormwater. Maximum flow rates at the outfall (not including variable flow from stormwater) will be 151.4 m^3/m (40,000 gpm). Long-term operational impacts of this discharge will be due to changes in temperature of the water in the vicinity of the discharge plume. Potential short and long-term impacts due to oil or other contaminants in the process water will be avoided and minimized by pretreatment of contact stormwater and floor washes through an oil/water separator as well as adherence to the Integrated Spill Control, Response, Pollution Prevention and Stormwater Management Plan, as discussed in Section 10.

The diluted discharge of facility process water is anticipated to have a salinity of approximately 37,000 ppm measured as TDS. The increase in salinity from the discharge of brine generated by the desalination plant is anticipated to be negligible due to dilution in the cooling water discharge (diluted more than 30 times). Many marine organisms can accommodate small changes in salinity, and salinity in waters around Ocean Cay, particularly to the east of Ocean Cay on the Bahamas Bank are naturally high (between 36,100 ppm and 36,500 ppm TDS); therefore, any long-term impact due to a small rise in salinity at the outfall is anticipated to be negligible.

Water temperature at the point of discharge during the operational phase of the LNG facility is modeled at 15.6 ^{o}C (28 ^{o}F) below the intake temperature. The discharge water is cooler than the intake due to the chilling from regasification of the LNG. The shape and volume of the thermal plume caused by the discharge and the anticipated water temperature differential within the plume is discussed in the Technical Report – Thermal and Cold Discharge Modeling, included in Appendix H. The results of the modeling conducted on the discharge show that the maximum temperature decrease in the immediate vicinity of the discharge is 1.59 ^{o}C (2.86 ^{o}F) at the bottom of the turning basin and 0.17 ^{o}C (0.31 ^{o}F) at the surface. The plume dimensions comply with Florida State, US Federal and World Bank Guidelines, in that there is 95 percent probability that the temperature increase at the edge of the mixing zone is less than 3 ^{o}C (5.4 ^{o}F) at the surface, sub-surface or bottom (In this case, the temperature *decrease* is less than 3^{o}C (5.4 ^{o}F) at the edge of the mixing zone). The area of maximum temperature differential is contained within the turning basin. Since the thermal plume generated will be colder than the ambient seawater, the plume will be more significant at depth than at the surface. Marine habitats in the area of the discharge will have been previously disturbed during the dredging of the turning basin and approach channel (refer to Section 5.2.1.2), therefore no short term additional impacts are expected to occur. Over the longer term, there may be occasional short-term impacts during storm events which may temporarily change the distribution of the thermal plume or cause an upwelling of the cooler water at the bottom of the channel. Potential long term impacts from the discharge of the cooling water are limited to the localized area of the thermal plume, however some species that have lower tolerance to temperature variations (corals, plankton, and seagrasses) may be affected. Such potential impacts are expected to be limited to the immediate area close to the ship berthing facilities within the turning basin which will have been previously disturbed by dredging actiities.

In addition to the temperature differential, the discharge of facility process waters will contain a residual chlorine concentration of no more than 0.2 ppm due to the addition of sodium hypochorite to the intake water. This concentration meets Florida State, US Federal, and World Bank Guidelines criteria of 0.2 ppm for residual chlorine and, further, is expected to dissipate rapidly near the point of discharge due to mixing with the ambient seawater in the turning basin.

5.2.3.2 Electric Generation

The proposed electric generation facilities will include three approximately 15 MW gas turbine generators as described in section 2.3.1.3. The facilities will be constructed on reclaimed and improved land. The impacts associated with land reclamation and improvement are discussed in Section 5.2.1.3. The potential impacts associated with the process water from the electric generation facilities are discussed in Section 5.2.3.1. No additional impacts to terrestrial or marine biological resources are anticipated from the construction of the electric generation equipment. Potential impacts to air resources are discussed below in Section 5.5.

5.2.3.3 Site Stormwater

Stormwater will be discharged from the south side of Ocean Cay into the turning basin and approach channel from three outfall locations (shown on Figure 1.4). Water that may be contaminated with oil will pass through an oil/water separator before its is discharged to Outfall 001 (e.g., floor drainage or equipment wash waters). All other stormwater collected from plant surfaces and the LNG/LPG dikes will be directed into a drainage culvert that will drain to Outfalls 002 and 003. Discharge of all collected rainwater will be into the turning basin and approach channel. Material cleaned from screens at the intake pump house will be directed to either Outfall 002 or 003 along with screen wash water (seawater).

A. Potential Construction Impacts

Construction of the stormwater and wastewater management system will occur simultaneously with site fill and improvement and installation of shore protection along the south and southwestern coasts of Ocean Cay. Potential impacts related to construction of the discharge system are similar to the construction activities described above in Sections 5.2.1.3 and 5.2.1.4.

B. Potential Operational Impacts

Potential short-term and long-term impacts to marine communities from stormwater and wastewater discharges will be minimized by strict adherence to the Integrated Spill Control Response, Pollution Prevention, and Stormwater Management Plan, discussed in Section 10. This management plan is designed to prevent introduction of contaminants into the waters around Ocean Cay, thereby avoiding or minimizing potential impacts. The segregation and treatment of stormwater potentially containing oil prior to discharge will significantly minimize potential impacts to water quality in the vicinity of Ocean Cay.

Contract air services will be utilized so that aircraft maintenance and refueling will not occur at the airstrip located on the northern portion of Ocean Cay. Use of oil and chemicals is not anticipated in the vicinity of the airstrip. The Integrated Spill Control Response, Pollution Prevention, and Stormwater Management Plan described further in Section 10, Environmental Management Plan, illustrates the oil and chemical management practices at the project facilities. Since oil and chemicals will not be used in the vicinity of the airstrip, environmental impacts resulting from sheet flow drainage of stormwater from this area is not anticipated.

5.2.4 Pipelines

5.2.4.1 610 mm (24 in) Pipeline to the EEZ Boundary

A 610 mm (24 in) natural gas pipeline will be installed offshore extending westward from Ocean Cay for 64.6 km (40.4 miles) to the Exclusive Economic Zone (EEZ) boundary. In shallow water, from the shoreline to depths of approximately 30 m (100 ft), the pipeline will be installed by post-lay trenching. In areas where bottom conditions are not suitable for trenching and burial, the pipeline will be installed by direct lay and covered with articulated concrete mats. In deep water, depths greater than 30 m (100 ft), the pipeline will be installed by direct lay techniques. Pipeline construction and installation methods are described in Sections 2.3.1.4 and 2.4.4.

A. Potential Construction Impacts

Pipeline installation in shallow waters, to approximately 30 m (100 ft) depth, will directly impact biota in an area of the bottom approximately 4.1 km (2.5 miles) in length and 30 m (100 ft) in width. The pipeline will be installed in a trench constructed by jetting, approximately 1.5 m (5 ft) deep with respect to the surrounding seabed. Two jetting systems are proposed for burial. Jetting by fluidizing soils will displace soil without creating a large plume of suspended sediment, thereby minimizing potential impacts to adjacent habitats due to sedimentation. The second jetting method, the Venturi Method, draws fluidized soils into an intake and disperses the soil laterally across the seabed by discharge through jets pointed away from the trench, creating a plume of suspended material. The impact of this sediment plume is discussed further below. Burial of the pipeline will be achieved by natural backfill.

The benthic habitats along the proposed 610 mm (24 in) pipeline route in the survey area are primarily soft bottom/sand habitats with low diversity of benthic macrofauna. In a few places there are some small, isolated patches of seagrass and a few isolated patches of soft corals. A small area of patchy reef and rubble occurs at the western most extent of the area examined (water depth 18.3 to 30.5 m (60 to 100 ft)) near the edge of the Bahama platform. Shallow water marine habitats within the survey area shown on Figure 4.17 impacted by installation of the 610 mm (24 in) pipeline include the following: 140 m (450 ft) of seagrasses with >50 percent cover (3.1 percent of the transect line), 600 m (2000 ft) of seagrasses <50 percent (13.2 percent of the transect line) and 211 m (700 ft) of hard bottom (4.7 percent of the transect line). The predominant habitat type (59.4 percent of the transect line) is barren sand/soft bottom or sand/rubble bottom. Existing benthic habitats are shown on Figure 4.16.

Trenching will directly impact seagrass and algae habitats through damage to plants located in the trench. Nearby biota will also be impacted to a lesser extent by associated impacts related to trenching, such as sedimentation, which can cover photosynthetic surfaces and epifaunal organisms on the plants. The impact of this sediment plume will vary depending on the soil type and prevailing currents. Based on sediment analysis and modeling studies for shallow water installation (Appendix S), it is expected that material will drop out of suspension in the vicinity of the excavation area. The zone of deposition was predicted to extend from 25 to 120 m (80 to 400 ft) on either side of the pipeline, depending on the direction and velocity of the ocean current. The extent of the area of sedimentation is smaller for smaller current velocities.

The sedimentation study concluded that the average depth of sedimentation would range from 500 mm (20 in) for a low velocity current (0.2 m/s [0.6 ft/s]) to 110 mm (4 in) for a high velocity current (1.0 m/s [3.2 ft/s]).

Currents may aid in moving sediment off of the photosynthetic blades of seagrass and other plants, and heavier sediment particles are likely to settle at the base of the plants rather than on the blades. Sedimentation impacts are most likely to be greater closest to the trench where the largest of the particles will settle, and decrease moving away from the trenched area. Once the pipeline is buried, the soft bottom habitat will be restored and seagrasses as well as other benthic fauna will reestablish in areas previously disturbed by trenching. Thus, impacts related to construction are anticipated to be relatively short-term in duration with recovery of habitats and reestablishment of seagrasses and other macrofauna occurring within a few years. Seagrasses are known to reestablish within 3 - 5 years given appropriate growing conditions. If only the blades above the surface are damaged, and rhizomes are kept intact, a situation likely to occur in regions adjacent to the trenched area, regrowth can occur more rapidly. Minimizing impacts to habitats and biota adjacent to areas directly impacted by pipeline construction will potentially enable more rapid reestablishment of disturbed areas.

Installation in shallow waters will require that construction vessels be anchored. Anchors will be placed in position by anchor-handling tugs. As much as possible, anchors will be placed to avoid or minimize impact to live bottom habitats. Impact to habitats, particularly seagrasses and some soft corals, will occur. Direct impacts to these habitats will occur in the localized area of the anchor point and damage to plants and macrofauna will occur. These impacts will be short-term, occurring only during construction, and will be localized at the area of the anchorage as shown on Figure 3.1.

At the shoreline approach to Ocean Cay, where bedrock is covered with less than 1 m (3.2 ft) with sand, a length of approximately 400 m (1300 ft), the pipeline will be covered by a double layer of articulated concrete mats (approximately 300 mats). Installation of articulated concrete mats will cover the existing bottom habitat, thus making it unavailable for colonization; however, the concrete mats also provide hard bottom benthic habitat which will serve as new hard bottom substrate that will become recolonized.

In deep water (below 30 m (100 ft) depth) the pipeline will be installed by direct lay using dynamically positioned vessels and will impact an area of approximately 66 km (41 mi) in length and 30 m (100 ft) wide. Pipeline installation will be optimized to avoid or minimize any potential damage to deepwater live bottom habitats.

A deepwater marine survey is planned for the proposed 610 mm (24 in) pipeline corridor to assess the locations and extent of marine communities including seagrasses, coral reefs, hard and soft bottom communities and sandy non-vegetative areas. Upon completion the deepwater assessment of the project area, a general description and characterization of communities with dominant species identified will be submitted as an addendum to this EIA.

Hydrostatic testing of the pipeline will be conducted in accordance with accepted standard practices as described in Section 2.4.4.1. The proposed testing fluid is freshwater, which will be obtained from the desalination plant. A volume of 35,000 m^3 (9.3 million gal) of test water will be required. Upon completion of hydrostatic testing, water will be filtered, treated as necessary, and discharged through Outfall 001 into the turning basin at Ocean Cay as shown on Figure 1.4. Discharge of a large volume of freshwater will have an immediate, very short-term impact on biological communities within the vicinity of the discharge plume. Many organisms, such as soft corals and seagrass are sensitive to large fluctuations in salinity, while others, are more resilient and can survive dramatic short-term changes in salinity. However, due to the timing of this singular test event, just after completion of the major construction activities around Ocean Cay with discharge into an already impacted area, it is unlikely that many new habitats and organisms will have reestablished themselves; therefore, anticipated impacts to nearby marine communities due to influx of freshwater are likely to be minimal.

B. Potential Operational Impacts

Once the pipeline is installed, there are no anticipated long-term impacts due to operation. In shallow water, burial of the pipeline subsequent to installation will restore soft bottom habitats and recolonization is likely to occur within a few years. Pelagic organisms are unlikely to be impacted by the presence or operation of the pipeline as its location on the sea floor will not obstruct migratory waterways or otherwise prevent travel throughout the water column. Implemented safety procedures and pipeline inspections are designed to avoid or minimize any potential impacts once the pipeline is operational. The pipeline safety features are discussed below in Sections 5.3 and 5.4.

5.2.4.2 60 mm (2 in) & 219 mm (8 in) Pipelines to Bimini

A 60 mm (2 in) natural gas pipeline and 219 mm (8 in) potable water pipeline will be installed within one offshore trench extending approximately 38 km (24 miles) from Ocean Cay to North Bimini. The preferred route for installation of the 60 mm (2 in) and 219 mm (8 in) pipelines is on the Bahamas Bank extending along an approximately south-north route to the east of the cays between Ocean Cay and North Bimini. The pipelines will make landfall on the west shore of North Bimini and extend approximately 265 m (870 ft) to an interconnection point on Bahamas Electricity Corporation (BEC) property. Details of construction and installation methods for the 60 mm (2 in) and 219 mm (8 in) pipelines are provided in Sections 2.3.1.4 and 2.4.4.

A. Potential Construction Impacts

Most of the pipeline route from Ocean Cay to North Bimini Island lies in water depth of approximately 5 m (16.4 ft) or less, with one location reaching a depth of 12 m (40 ft). For most of its length, the pipeline will be installed in a trench constructed by jetting, approximately 1.2 m (4 feet) deep with respect to the surrounding seabed. Two jetting systems are proposed for burial. Jetting by fluidizing soils will displace soil without creating a large plume of suspended sediment, thereby minimizing potential impacts to adjacent habitats due to sedimentation. The second jetting method, the Venturi Method, draws fluidized soils into an intake and disperses soil laterally across the seabed by discharge through jets pointed away from the trench, creating a plume of suspended material.

The impact of this sediment plume will vary depending on the soil type and prevailing currents. Analysis of sediments along the proposed pipeline corridor from Ocean Cay to Bimini indicate very little variation in sediment composition along the route with <10 percent of the sediment consisting of silt-sized particles. Based on sediment analysis and modeling studies (Appendix S), it is expected that material will drop out of suspension in the vicinity of the excavation area. The zone of deposition was predicted to extend from 20 to 180 m (65 to 590 ft) on either side of the pipeline, depending on the direction and velocity of ocean current and type of bottom sediment. The extent of the area of sedimentation is smaller for smaller current velocities. The sedimentation study concluded that the average depth of sedimentation would range from 350 mm (14 in) for a low velocity current (0.2 m/s [0.6 ft/s]) to 40 mm (2 in) for a high velocity current (1.0 m/s [3.2 ft/s]). Potential impacts to benthic organisms from sedimentation related to pipeline installation were discussed in section 5.2.4.1A.

Installation of the pipeline will require that construction vessels be anchored. Anchors will be placed in position by anchor-handling tugs. In shallower waters (2 to 3 m (7 to 10 ft) depth), spuds will be used to stabilize the barge. As much as possible, anchors will be placed to avoid or minimize impact to live bottom habitats. Impact to habitats, particularly seagrasses and some soft corals, will occur. Direct impacts to these habitats will occur in the localized area of the anchor point and damage to plants and macrofauna will occur. These impacts will be short-term, occurring only during construction, and will be localized at the area of the anchorage.

Existing benthic habitats observed along the eastern and the alternative western routes are shown on Figure 4.17. Marine habitats impacted by installation of the pipelines to North Bimini include the following: 14.1 km (8.8 mi) (37.3%) seagrasses of variable cover, 13.4 km (8.3 mi) (35.3%) of seagrasses <50 percent, and 27.3% of barren sand bottom. Impacts to sensitive hard coral and reef communities between Ocean Cay and the Biminis will be avoided or minimized during pipeline installation by selecting the eastern route over the western route (where coral communities were noted in field studies). Seagrass and alga communities within this corridor will be temporarily impacted due to construction and installation of the pipeline. Direct impacts will include damage to plants located in the trench. Nearby biota will also be impacted to a lesser extent by associated impacts related to trenching, such as sedimentation, which can cover photosynthetic surfaces and epifaunal organisms on the plants. Currents may aid in moving sediment off of the photosynthetic blades, and heavier sediment particles are likely to settle at the base of the plants rather than on the blades. Sedimentation impacts are most likely to be greatest closest to the trench where the largest particles will settle, and decrease moving away from the trenched area.

Once the pipeline is buried the soft bottom habitat will be naturally restored and seagrasses as well as other benthic fauna can reestablish in areas previously disturbed by trenching. Thus, impacts related to construction are anticipated to be relatively short-term in duration with recovery of habitats and reestablishment of seagrasses and other macrofauna occurring within a few years. Seagrasses are known to reestablish within 3 - 5 years given appropriate growing conditions. If only the blades above the surface are damaged, and rhizomes are kept intact, a situation likely to occur in regions adjacent to the trenched area, regrowth can occur more rapidly. Minimizing impacts to habitats and biota adjacent to areas directly impacted by pipeline construction will potentially enable more rapid reestablishment of disturbed areas.

The pipeline will be covered by articulated concrete mats for a distance of approximately 400 m at the near shore approach to Ocean Cay where bedrock is exposed. Installation of articulated concrete mats will cover the existing bottom habitat, thus making it unavailable for colonization; however, the concrete mats also provide hard bottom benthic habitat which will serve as new hard bottom substrate that will become recolonized.

At the near shore approach at North Bimini, a distance of approximately 300 m (1000 ft), a typical trench and pull or trench and plow pull method will be employed using either a backhoe or pulled plow, respectively. The precise method utilized will depend on equipment available. For a distance of 300 m (1000 ft) beyond the shore trench the pipeline will be laid on bedrock and covered by articulated concrete mats. Potential impacts from trenching in this area include direct disturbance to habitats located in the trenched area as well as impact to areas adjacent to the trench due to sedimentation. Sedimentation impacts will depend on the type of sediment and currents; however, it is anticipated that impact from sedimentation will be short-term in duration and occur within only a localized region around the trench. Impacts related to installation of articulated concrete mats are described above.

No significant impacts will result from the onshore installation of the pipelines. The construction work associated with the installation of the onshore portion of the pipeline will be restricted to within the limits of an existing roadway (Queen's Highway). The work within the roadway will be performed over a duration of less than one week and disturbed areas will be restored to their original condition. Due to the limited number of vehicles on North Bimini, no significant impacts to traffic are anticipated.

Hydrostatic testing of the pipeline will be conducted in accordance with accepted standard practices as described in Section 2.4.4.2. The proposed testing fluid is fresh water that will be devoid of additives. Test water will be obtained from the desalination plant. Approximately 700 m^3 (190,000 gal) of test water will be required for the water pipeline and 80 m^3 (22,000 gal) of test water will be required for the gas pipeline. Upon completion of hydrostatic testing, water will be filtered, treated as required, and discharged through Outfall 001 into the turning basin at Ocean Cay as shown on Figure 1.4. Due to the timing of this singular test event, just after completion of the major construction activities around Ocean Cay with discharge into an already impacted area, it is unlikely that many new habitats and organisms will have reestablished themselves; therefore, anticipated impacts to nearby marine communities due to influx of freshwater are likely to be minimal.

B. Potential Operational Impacts

Once the pipeline is installed there are no anticipated long-term impacts due to operation. Burial of the pipeline subsequent to installation will restore soft bottom habitats and recolonization is likely to occur within a few years. In particular, seagrass communities are able to reestablish themselves within several years of bottom disturbance, and sometimes will develop in disturbed areas where seagrass beds did not previously exist. Pelagic organisms are unlikely to be impacted by the presence or operation of the pipelines as the location on the sea floor will not obstruct migratory waterways or otherwise prevent travel throughout the water column. There is evidence to suggest that juvenile Queen Conch migrate from soft bottom/sand habitats on the Bahamas Bank to adult habitats, both rocky and sandy, on the Bahamas Platform. Since the pipeline will be buried, the potential migration routes of Queen Conch between the Biminis and Ocean Cay are not expected to be impacted. Safety procedures and pipeline inspections, described in Section 10, Environmental Management Plan, are designed to avoid or minimize any potential impacts once the pipeline is operational. The pipeline safety features are discussed below in Section 5.4.

5.2.5 Housing

Both temporary construction worker housing and permanent employee housing will be provided by the project as described in Section 2.3.1.5. The temporary construction housing will consist of a quarters barge or cruise ship anchored off the east side of Ocean Cay. A gangway or temporary bridge will be constructed to allow access between the vessel and the island. Permanent housing will be provided at a location in South Bimini (Figure 2.19) as described in Section 2.3.1.5. In addition, a hostel will be constructed on Ocean Cay at the location shown on Figure 1.4 to house the permanent workers during their shifts on Ocean Cay.

During construction, the workers will be housed on either a quarters barge or a cruise ship. The impacts of anchoring or mooring the vessel are described in Section 5.2.1.1. Sanitary sewage and “gray water” including shower water, cooking water and laundry water will be collected in the onboard tanks provided on the housing vessel. This material will be offloaded to barges and transported a minimum of 4.8 km (3 mi) offshore for disposal. This procedure of disposal is routinely utilized by other ships in the Bahamas and is the accepted means of disposal for these wastewaters. The impacts to biological resources from this temporary operation are expected to be negligible.

Solid waste generated by the construction workers while on the housing vessel will also be collected, loaded to a barge and transported to a landfill operation with the capacity and proper permits to accept the waste. Combustible waste will be incinerated on Ocean Cay as described in Section 3.7.

Supervisory personnel will be housed in hotels and apartments on the Biminis during the period of construction. Because existing facilities will be utilized no impacts to environmental resources will occur during the construction phase by this housing activity.

Permanent housing units will be constructed on South Bimini following commonly accepted construction techniques in the Bahamas. The construction of the housing units will require minimal ground improvements for foundations, roadways and recreational facilities; therefore, no specialized equipment will be required. The sewer system will consist of a Bahamas Building Code approved cesspit tank and soakaway system. No other sewer system will be necessary. Use of a cesspit is common practice on Bimini and is therefore not expected to create significant biological impacts.

During the period of shift work, anticipated to be 4 days, the permanent workers will be housed on Ocean Cay in the hostel units. Wastewater from sanitary facilities, showers, cooking and laundry associated with the hostel will be directed to a septic system with infiltration field. No direct discharge to surface waters from the hostel will occur. Adverse impacts to surface water quality, groundwater quality, and biological resources are not anticipated due to the small volumes of the discharges. Solid waste generated at the hostel will be managed as described in Section 3.4.3.

5.3 Natural Hazards

Natural disasters in the vicinity of the project area can occur from severe storms, tropical hurricanes, earthquakes, and floods. To evaluate potential natural hazards, a Meteorological and Oceanographic Study (MetOcean Study) and a Seismic Hazard Analysis were conducted for the project area. The reports summarizing these studies are included in Appendix A and H, respectively. The results of these studies were used to analyze potential impacts in the project area and to design project facilities to withstand potential worst case scenarios involving natural hazards.

Based upon the MetOcean Study, Ocean Cay is generally vulnerable to flooding because of offshore bathymetry and low tides. There are no historical records of tsunamis occurring or causing damage in the vicinity of the project area. However, hurricane flooding does occur and would represent the worst-case meteorological event in the project area. Thus, such flooding is the basis for determining the volume and velocity of flood control design efforts. The LNG Terminal site will incorporate appropriate flood control design elements, including establishment of a finished grade elevation of 6 m (19.7 ft) above MSL. Shore protection will be installed to protect against flooding and storm surges resulting from hurricanes, tsunami and severe weather. Also, the site drainage system will be designed for the rainfall conditions up to and including that associated with 10-year, 24-hour rainfall condition based on data from Miami, Florida. The potential impacts from natural hazards are discussed below.

5.3.1 Hurricanes and Flooding

Natural hazards arising from storm events include those associated with storm waves/surges, high winds, and torrential rainfall, all of which can affect ongoing operations at Ocean Cay. Storm waves in the project area are mainly due to the passage of tropical cyclones that generally form in the tropics from June to November. These cyclones are accompanied by thunderstorms and a counterclockwise circulation of winds near the earth's surface and are classified as tropical depressions, tropical storms or hurricanes, depending on maximum sustained wind speed.

As discussed in Section 4.1, Ocean Cay is exposed to a tropical cyclone approximately once every two years and exposed to a hurricane approximately once every 3 years. Review of the hurricane tracks also reveals that most tropical storms and hurricanes affect the project area between the months of August and October (inclusive), with the bulk of the systems passing within relative proximity of the project area during the months of September and October.

According to the MetOcean analysis discussed in Section 4.1, the deepwater significant wave heights associated with the 100, 200, and 500 year events are 12 m (40 ft), 14 m (46 ft), and

16.5 m (54 ft), respectively, west of Ocean Cay and 5.5 m (18 ft) to 7.0 m (23 ft) on the east side of Ocean Cay. However, the deepwater waves undergo wave transformation processes as they propagate into shallow water, resulting in changes in their significant heights, propagation directions, and potentially wave period. These wave transformation processes reduce the storm waves as they travel from offshore over the western and eastern boundaries of the Great Bahama Bank. At Ocean Cay, the near shore wave heights are much lower, less than 1.5 m (4.9 ft) in 99.7 percent of the occurrences, with the largest recorded wave height (1.7 m (5.6 ft)) during the period of the MetOcean Study occurring during Hurricane Michelle.

Because the near shore waves are depth-limited, the influence of storm surge is also an important aspect of hurricane hazard analysis. In fact, during large storms and hurricanes, storm surge impacts are expected to be more important than wave heights at Ocean Cay. Preliminary assessment of storm surge levels associated with the 100-year hurricane event range from 2.7 to 3.3 m (8.9 to 10.8 ft). Because of the current low elevations of Ocean Cay (1.8 m to 4.5 m (5.9 to 14.8 ft), with a nominal elevation of 3.5 m (11.5 ft)), Ocean Cay is susceptible to flooding in the event of a direct hurricane hit. Flooding of the LNG/LPG terminal, the power generation area, oil and chemical storage areas, and other operations that will be sited on Ocean Cay could have a direct and immediate adverse impact on surrounding marine resources as a result of releases due to damage or catastrophic failure unless the structures are designed to withstand such effects.

Thus, the project area containing the LNG tanks, LPG tank and associated equipment will be elevated to 6 m (19.7 ft) above MSL. For protection against wave run-up and splash over, a perimeter dike will be constructed to protect this entire area. The dike will be constructed approximately 3 m (10 ft) above grade, bringing the dike to approximately 9 m (24 ft) above MSL, as discussed in Section 2.3.1. The LNG and LPG tanks will be designed to withstand a Category 5 hurricane and the plant will be designed for a Category 4 hurricane, which will protect against high winds as well as storm surge and wave effects. Based on design evaluations, shore protection features will be incorporated into design to further stabilize the island and its operational features. These include T-groins, artificial beaches, rock revetments, steel sheet pile cells, and concrete caissons, which will be installed as part of the Ocean Cay island expansion discussed in Section 2.3.1.1.D. Stormwater runoff during storm events will be managed as described in Section 3.5, and should not be an issue given the island's small size and short times of travel for sheet flow discharges to its perimeter.

5.3.2 Earthquakes

Ocean Cay is situated in a tectonically stable area in the western North Atlantic Ocean, on a geologic structure called the Bahama Platform. The Bahama Platform lies atop either old oceanic crust that formed during the initial opening of the Atlantic Ocean about 170 million years ago or continental crust that was separated from Africa during Atlantic Ocean rifting. Since the initiation of Atlantic rifting, the northern Bahama Islands have been situated on stable crust adjacent to a passive continental margin. Very little earthquake activity has been documented historically or recorded instrumentally from the Bahama Platform, and no evidence of active faulting has been reported in the scientific literature.

Both a probabilistic seismic hazard analysis and a deterministic seismic hazard analysis were carried out for the project area (Appendix I). The analyses conducted in this study, combined with previously published seismic hazard analyses that include the northern Bahama Islands, suggest that only minor ground shaking with a mean repeat time of 4,975 years is likely to be experienced at Ocean Cay. Based on these analyses, maximum horizontal component peak ground accelerations at the top of bedrock of 0.012 g and 0.023 g were recommended for the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE), respectively. These values were determined for design of the LNG facility in accordance with requirements of NFPA 59A (2001). Using these values, engineering analyses are being performed to estimate response spectra for peak accelerators at the ground surface. The LNG tanks and piping will be designed for seismic loading based on the response spectra. Adverse impacts to the surrounding environment resulting from catastrophic failures of project elements during a seismic event are not expected.

5.3.3 Tsunami

Tsunamis are generated by earthquake faulting that moves the seafloor vertically or by offshore slumping of sediments caused most often by earthquake shaking. Tsunami heights can vary greatly along a coast since local tsunami height is controlled by the strength of the earthquake, the distance of the site to the earthquake fault rupture, and the shape of the near-shore bathymetry and the onshore topography.

According to Heck (1947), a number of earthquakes centered in the Caribbean region have caused local tsunamis with heights of as much as 3 m (10 ft). However, there are no reports in the scientific literature of tsunamis in the northern Bahama Islands. Small tsunamis (probably less than about a few feet) from distant earthquakes may be possible in the Bahamas. For example, Doxsee (1948) reported that a "sea wave" (presumably a tsunami) was reported at the Azores from the 1929 Grand Banks earthquake off Newfoundland. No indication of the height of this sea wave at the Azores is given, but no damage was mentioned in the report. This report indicates that tsunamis from strong earthquakes can travel across the Atlantic Ocean basin. However, the lack of reports of strong tsunamis at significant distances (more than about 100 km) from the past centers of strong earthquakes in the Atlantic Ocean or Caribbean region suggests that the potential for any significant tsunami in the northern Bahama Islands is extremely remote. If a very large, offshore earthquake, like the 1929 Grand Banks earthquake, occurs along the passive continental margin of the southeastern U.S. near the northern Bahama Islands, there could be a significant tsunami experienced in the vicinity of the project area; however, its likelihood is low.

Because the likelihood of a tsunami occurring at Ocean Cay is very remote, the potential for adverse impacts to the environment from the Project due to this natural hazard is extremely low.

5.4 Man-Made Hazards

The manmade hazards that may potentially occur during the construction and operation of the AES Ocean LNG, Ltd. project will be minimized to the extent practically possible through the use of automated systems and controls, environmental management system plans for spill and fire response, as well as worker health and safety, and designated work practices required during construction and operation. The manmade hazards considered for impact include the following:

- Spills
  - fuel oil - both temporary and permanent systems failures
  - LNG/LPG - both tank and piping failures
  - Leaks from ships during fuel loading and offloading
- Fire and explosion
- Marine safety
  - ship traffic

- Worker safety
  - construction safety
  - operational safety systems

The potential impacts of the aforementioned man-made hazards are discussed below.

5.4.1 Spills

Spills of fuel oil can have a potential impact on soil, groundwater and particularly surface water during both the construction and operational phases of the project. During construction fuel will be distributed over water to several types of vessels, including the dredge barges, the pipelay barges, the water treatment barge, the concrete batch plant barge, and the quarters barges or cruise ship. Fueling will be conducted in a manner consistent with the spill prevention and response plan prepared by the construction contractor under the guidelines set forth by AES, as described in Section 10, Environmental Management Plan. In addition to construction barge fueling operations, fuel oil will be transferred from oil delivery barges to onshore tanks during both the construction and operational phases. The fuel barge will be berthed in the SVH at the fuel station, as shown on Figure 1.4. These operations will be managed in a manner consistent with the requirements of both the construction phase spill plan and the operational phase spill/stormwater plan, described in Section 10, Environmental Management Plan.

During construction, fuel oil will be dispensed from the onshore tanks to construction vehicles and equipment by fuel trucks. During operation of the plant, dispensing will be accomplished primarily by using installed piping systems. The dispensing stations at the tanks will be provided with an impervious area for staging the trucks during loading. The impact of any release during loading operations will be minimized by containing the release within the impervious area until the fuel can be cleaned up. Spill response materials will be maintained at the fuel dispensing stations for this purpose.

Fuel deliveries to the various onshore locations of construction will be performed by the fuel truck drivers who will be required to receive spill plan training prior to beginning work. The trucks will be equipped with oil spill response materials. The truck driver will check the capacity of the receiving tank and then monitor the transfer to heavy equipment or day tanks. Each transfer will be documented. The potential for adverse impacts due to spills during these operations will be greatly minimized by implementing these management controls, as described in Section 10, Environmental Management Plan.

Impacts of a very limited nature are anticipated from occasional equipment leaks from fuel and hydraulic systems. The potential area of impact will be minimized by implementing a schedule of mechanical preventative maintenance for equipment and by instructing construction personnel of the importance of controlling the area potentially impacted by a release and providing immediate spill response and cleanup measures, described in Section 6, Mitigation.

5.4.2 Fire and Explosion

Fire and explosion hazard impacts to surrounding islands, inhabitants, workers, and marine resources are not expected during the construction phase due to the limited quantities of flammable and combustible materials to be imported to the site. The availability and use of portable extinguishing systems would limit the impacts of small fires, and personnel will receive training on the proper use and locations of this equipment.

Fire and explosion hazards at Ocean Cay from the receiving, storage, separation, and sendout of LNG, LPG and natural gas are detailed in the document entitled "LNG Terminal Hazards and Safety Considerations, Ocean Cay, Bahamas" (Hazard Analysis), provided in Appendix C. Mitigation controls are described in Section 6, Mitigation. The Hazard Analysis considers the various hazards and potential effects on public safety that could occur in the operation of the LNG Import Terminal on Ocean Cay, Bahamas with respect to siting and the operating procedures at the terminal. Potential impacts due to fire and explosion will be minimized through use of gas detection systems and a fire suppression system consistent with the guidance of NFPA 59A.

5.4.3 Marine Safety

Shipments of LNG received at the LNG facility will transit to Ocean Cay through the approach channel from the deeper waters of the Florida Straits. Vessels transporting LPG loaded at the island for export will leave Ocean Cay through the same channel. Ships contracted for the movement of the LNG and LPG will be equipped with the latest safety devices and the crews will be trained in safe handling and emergency response procedures. Shipments of LNG and LPG will comply with International Code for the Construction and Equipment of Ships

Carrying Liquefied Gases in Bulk (IGC Code), International Maritime Organization 1993. Coordination of ship arrivals and departures will be controlled by the Ocean Cay operation. By implementing the management controls specified in the Marine Safety Plan, discussed in Section 6 and provided as Appendix U, AES expects no marine safety-related impacts to the Bahamas due to the shipments of LNG and LPG.

Shipping traffic to the Bahamas will increase during the construction phase and to a lesser degree during the operation of the plant. A LNG Shipping Study has been prepared and is included as Appendix T. In the waters surrounding Ocean Cay, dredge operations will occupy water space as the approach channel and turning basin expansion proceeds. The increased traffic to Ocean Cay for delivery of equipment, personnel and supplies required during construction will be directed to Ocean Cay through the approach channel from the deeper waters west of the island. Since the island is industrial in nature, the impact to local boat traffic for pleasure and commercial purposes is expected to be minimal.

During the placement of the pipelines both to North Bimini and to the EEZ and Florida, an area of approximately 8.4 km^2 (3.3 mi^2) over water will be affected by the installation barges and support vessels as shown on Figure 3.1. These vessels and related equipment will be marked to avoid hazards to local navigation in accordance with the Marine Safety Plan discussed in Section 10, Environmental Management Plan.

5.4.4 Worker Safety

There are potential impacts to worker safety during the construction and operation phase due to the increased activities on the island and over water, the higher risk associated with handling LNG and LPG, and the higher population of workers. During construction, the potential impacts to worker safety include construction related hazards from working at elevation, within confined spaces, and near hydraulic and heavy equipment. A Health and Safety Plan for construction operations is included as Appendix U. The potential impacts to worker safety during operation include extremely low temperature material exposure and oxygen depletion hazards, increased fire hazards, and hazards associated with high-pressure systems. The LNG Terminal Hazard Assessment, Appendix C, includes further information regarding these hazards. Mitigation strategies for potential impacts are discussed in Section 6.

5.5 Air Quality Impacts

This section presents the approach, procedures and results of the air quality modeling analysis performed to assess the impacts associated with air pollutant emissions from the proposed AES project. Due to the absence of specific air quality regulations or guidance in the Bahamas for evaluating air quality impacts, emissions from the project were evaluated using US EPA procedures applicable to new major sources. US EPA-recommended air quality dispersion models were used, following procedures outlined in EPA's "Guideline on Air Quality Models" (40 CFR Part 51, Appendix W, 2001 and proposed amendments), for the purpose of demonstrating compliance with National and Florida State Ambient Air Quality Standards (AAQS). In addition, an analysis of stack plume visibility was performed, as discussed in Section 5.8.

Results of the air quality impact analysis indicate that the proposed project will have an insignificant impact on the surrounding air quality (i.e., the maximum modeled impacts for all pollutants were less than US EPA-defined significant impact levels [SILs]). Therefore, no further analyses were required as the AAQS and Prevention of Significant Deterioration (PSD) increment levels will not be threatened by the proposed project. Additionally, the plume visibility analysis demonstrated that the impact on surrounding visibility will also be insignificant, as described in Section 5.8.1.

5.5.1 Air Dispersion Model Selection

5.5.1.1 Land Use and Topography

Land use and topography are important for selection of appropriate dispersion models and dispersion coefficients used in the modeling analysis. As presented in Section 4.1, the proposed project site is on Ocean Cay, a small island surrounded by water. The area within the immediate vicinity of the proposed facility on Ocean Cay is either undeveloped or consists of existing industrial use as an aragonite mining operation. The mean elevation of the site after reclamation will be 4.5 m (14.8 ft) above MSL. Topography on Ocean Cay is flat with no locations where terrain rises above the proposed stack height.

A land use classification analysis was performed to determine whether urban or rural dispersion parameters should be used to quantify ground-level concentrations. The analysis followed the procedures recommended by the US EPA (EPA, 2001) and the typing scheme developed by Auer (Auer, 1978). This procedure involves visually determining the uses of various industrial, commercial, residential, and agricultural/natural areas within a three kilometer radius circle centered on the proposed site. Industrial, commercial, and compact residential areas are classified as urban, while agricultural, natural and common residential areas are considered rural. For air quality modeling purposes, an area is defined as urban if more than 50 percent of the surface within this area falls under an urban land use type. Otherwise, the area is determined to be rural.

The proposed expanded island on which the project will be located will have an approximate 112 hectares (276 acre) land area. There are no other islands located within the 3 km (1.9 mi) radius (28.3 km^2 (10.9 mi^2)) of the project site. Therefore, approximately 96 percent of the area surrounding the project site is water, which is considered rural according to the Auer classification technique. Therefore, the rural dispersion coefficients were used for the air quality modeling analysis.

The air quality modeling analysis used both screening and refined dispersion models to predict ambient air impacts from the proposed project. Based on the flat, mostly sea-level topography of the surrounding area, the SCREEN3 dispersion model was selected for the screening modeling analysis and the Industrial Source Complex (ISC3) model, incorporating the PRIME (Plume Rise Model Enhancements) downwash algorithm, was selected for the refined analysis. Descriptions of these models, inputs and other considerations, including justification for use of the PRIME downwash algorithms, are provided in the following sections.

5.5.1.2 SCREEN3 Model

The primary purpose of screening modeling is to identify the worst-case operating load conditions and stack parameters associated with the proposed facility for use in the refined modeling analysis. The results of the screening modeling are compared to significant air quality impact levels to conservatively estimate the significant impact area for each pollutant and averaging period. For those pollutants predicted to have significant impacts, more refined modeling is performed in order to demonstrate compliance with AAQS and PSD increments.

The screening modeling was performed using EPA's SCREEN3 (Version 96043) air dispersion model, which is recommended by EPA for screening-level applications. SCREEN3 is designed to provide conservative estimates of air quality impacts in simple terrain areas (terrain below stack-top elevation) and in complex terrain areas (terrain above stack-top elevation). In addition, SCREEN3 contains algorithms that enable aerodynamic downwash effects to be evaluated and is currently the only regulatory model recommended for the evaluation of cavity impacts. SCREEN3 calculates the dimensions of the cavity region caused by nearby structures and maximum concentrations of pollutants within the region.

The SCREEN3 default regulatory mixing height option and an anemometer height of 10 meters were used in the analyses. The EPA-recommended scaling factors of 0.9, 0.7, 0.4, and 0.08 were used to extrapolate SCREEN3 modeled 1-hour concentrations in simple terrain to the 3-hour, 8-hour, 24-hour, and annual averaging periods, respectively. The full range of meteorological conditions (all stability's and wind speeds) were selected to be evaluated with the SCREEN3 model.

5.5.1.3 Industrial Source Complex Model with Plume Rise Model Enhancements (ISC3-PRIME)

Appendix A of EPA's Guideline on Air Quality Models (EPA, 2001) currently identifies the ISC3 model as a refined model recommended for use in regulatory applications involving industrial source complexes; rural or urban areas; flat or rolling terrain; transport distances less than 50 km; and 1-hour to annual averaging times. However, the current building downwash algorithms in the ISC3 model contain several deficiencies, including: 1) over predictions under light wind, stable conditions; 2) discontinuities in the vertical, alongwind, and crosswind directions; and 3) the assumption that the source is always collocated with the structure causing the down washing (EPA, 1998). To address these deficiencies, the Electric Power Research Institute (EPRI) funded field and wind tunnel experiments from which a new downwash algorithm was developed, called PRIME, Plume Rise Model Enhancements. After evaluating the PRIME algorithm in a number of field measurement, tracer, and wind tunnel studies, EPA proposed changes to the Guideline on Air Quality Models that would revise ISC3, by incorporating the PRIME downwash algorithm and renaming the model ISC-PRIME (EPA, 2000). EPA's proposed rule, published in the April 21, 2000 Federal Register, proposes to revise the Guideline on Air Quality Models to recommend use of ISC-PRIME in cases involving aerodynamic downwash. Although not yet adopted as a final rule, communication with Tikvart, head of the EPA's modeling section, indicates that the only issue delaying adoption is the present moratorium on new regulations implemented by the Bush administration.

The use of ISC-PRIME, instead of ISC3, is warranted in this modeling analysis due to the distant location of the gas turbine stacks relative to the predominant structure causing downwash. This structure is one of the LNG storage tanks, which are located about 123 meters from the closest gas turbine stack and which have a height of 55 meters. One of the limitations with the ISC3 model, as listed above, is that the location of a stack relative to a building or structure causing downwash is not considered. If the stack is determined to be within the general region of influence of the building, the stack is always treated as though it were at the center of the lee wall of the building. As a result, in the case of the AES project, the ISC3 model assumes the plume is entirely captured in the cavity of the tanks, while in actuality only a small portion of the plume may be captured in the cavity, due to the relatively large distance between the LNG tank and the stacks. This treatment in ISC3 of building downwash can lead to severe over prediction of the impacts in cases where the stack is located a significant distance away from the building. ISC-PRIME corrects for this deficiency in ISC3 by considering the actual location of the stacks relative to the structure causing downwash. Because EPA considers the use of ISC-PRIME in downwash situations to have significant improvements over the existing ISC3 model and has already proposed incorporation of ISC-PRIME into the Guideline as a recommended model, ISC-PRIME is justified for use in the AES modeling analysis.

Based on the above discussion, ISC-PRIME (version 99020) was used to perform the refined air quality modeling analysis. The ISC-PRIME model can predict short-term and long-term concentrations from multiple stacks in rural or urban areas. The ISC-PRIME model accepts hourly meteorological data to define the conditions for plume rise, transport, and dispersion. The model estimates the concentration for each source and receptor combination for each hour, which is then used to estimate concentrations for other averaging periods for direct comparison with significant impact levels and NAAQS.

The ISC-PRIME model has various input options to simulate a variety of dispersion conditions for emissions from stacks, area sources or volume sources. The following EPA-recommended default options for use in dispersion modeling analyses for regulatory purposes were used in this analysis:

- Use stack-tip downwash (except for Schulman-Scire downwash);
- Use buoyancy-induced dispersion (except for Schulman-Scire downwash);
- Do not use gradual plume rise (except for building downwash);
- Use the calms processing routines;
- Use upper-bound concentration estimates for sources influenced by building downwash from super-squat buildings;
- Use default wind speed profile exponents; and,
- Use default vertical potential temperature gradients.

5.5.2 Receptor Grid

5.5.2.1 SCREEN3 Model

The SCREEN3 receptor grid consisted of an array of receptors placed at the following intervals from the reference point of the facility (gas turbine unit 2 stack):

- 100 m (328 ft) out to 3 km (1.86 mi);
- 500 m (1640.4 ft) between 3 and 5 km (1.86 and 3.1 mi); and,
- 1,000 m (3280.8 ft) between 5 and 10 km (3.1 and 6.2 mi).

These intervals resulted in a total of 39 rings. Flat terrain (0 terrain height above stack base) was assumed for each receptor ring.

5.5.2.2 ISC-PRIME Model

A polar receptor grid was developed that extended from the proposed unit 2 gas turbine stack out to a distance of 10 km. Receptors were placed on radials every 10 degrees from 10 degrees to 360 degrees. The receptors were spaced every 100 m (328 ft) out to 1 km (0.62 mi), every 200 m (656.2 ft) from 1 km (0.62 mi) to 2 km (1.24 mi), every 500 m (1640.4 ft) from 2 km (1.24 mi) to 5 km (3.1 mi), and every 1 km (0.62 mi) from 5 km (3.1 mi) to 10 km (6.2 mi) along the radials. Because the proposed project on Ocean Cay is not considered publicly accessible, additional discrete receptors spaced every 100 meters (328 ft) were placed along the plant boundary and receptors inside the plant boundary were removed. An additional two tiers of receptors were placed outside of the plant boundary at 100 meter (328 ft) intervals and with a 50 meter (164 ft) tier spacing to provide further refinement to the receptor grid outside of the plant boundary. As discussed later in Section 5.5.7.2 C, the refined modeling analysis performed using this receptor network resulted in maximum predicted impacts for all short-term averaging periods (< 24-hour) occurring within the 100 m (328 ft) spaced receptors and the maximum annual average impacts were predicted to occur at 3500 m (2.17 mi). Therefore, a dense Cartesian grid with 100 m (328 ft) receptor spacing centered on the initial maximum annual average impact location was used to ensure the maximum annual impacts had been located. The refined receptor grid is shown on Figure 5.2. Figure 5.3 is a close-up of the receptor grid immediately surrounding the proposed gas turbines, which also depicts the Ocean Cay boundary and significant nearby structures.

Because of the lack of surrounding terrain features on Ocean Cay and the fact that all of the area surrounding Ocean Cay is water, the flat terrain height option was selected and the simple terrain calculation algorithm was used for all refined modeling.

5.5.3 Meteorological Data

Representative hourly meteorological data (surface and upper air) are required for input in the ISC-PRIME model. Refined data must be representative of the dispersion characteristics of the area around the proposed facility, be reliable, be of sufficient quantity and meet EPA quality assurance requirements. The site meteorological data set described in Section 4.1.1 does not represent a sufficiently long period and does not contain all of the required input parameters to perform the air quality dispersion modeling analysis. However, it is useful in evaluating whether other available and sufficiently detailed meteorological data sets are representative of the project site for use in the dispersion modeling. US EPA criteria for determining representative meteorological data for air quality impact analyses were used to evaluate available data sets. These criteria include proximity to the project site, similarity in terrain features, similarity in wind direction and speed frequency distribution, and the quantity and quality of the available data.

Based on these criteria, sources of meteorological data potentially suitable for dispersion modeling on Ocean Cay were preliminarily identified and data were obtained from monitoring stations located at Settlement Point and Nassau Airport in The Bahamas and from Key West, Miami and West Palm Beach in Florida. After review of these data sets based on the US EPA criteria, upper air data from National Weather Service (NWS) Station #12844 - West Palm Beach International Airport, Florida and surface data from NWS Station #12836 - Key West

International Airport, Florida were selected for input in the ISC-PRIME modeling analysis. The most recent 5 years of concurrent meteorological data available from these stations was obtained from EPA's Technology Transfer Network - Support Center for Regulatory Air Models.

These upper air and surface data sources are judged to be the most meteorologically representative of available data for refined dispersion modeling purposes based on proximity to Ocean Cay and the similarity of climatological and terrain features and maritime influences. The West Palm Beach upper air data is the closest meteorological monitoring station with upper air data that are both sufficiently complete and in the appropriate format for input in ISC-PRIME (upper air data is available from the Nassau Airport, but the data set is incomplete). Although there are closer monitoring stations with surface data (e.g., Miami and West Palm Beach airports – within 105 and 162 km (65.2 and 100.7 mi) of Ocean Cay, respectively), the location of the Key West monitoring station is judged to be the most representative with respect to similarity in lack of complex terrain, and the similarity in wind speed and wind direction frequency distributions. Key West is located 285 km (177.1 mi) southwest of Ocean Cay, near the southern end of a narrow line of small islands or reefs, more than 80.5 km (50 mi) from the Florida mainland. The location of Key West is considered more representative than the locations of the Nassau and Settlement Point monitoring stations, which have more influences from larger landmasses than Key West. A wind rose plot for the Key West NWS station for the five years modeled (1986 to 1990) is presented in Figure 5.4.

Appendix G provides further substantiation of the Key West surface wind data. Wind speed and direction frequency distributions from the identified surface wind data sets are compared. This comparison shows a high correlation between all of the data sets with respect to wind direction and wind speed distribution.

The US EPA meteorological preprocessor, PCRAMMET (Version 99169) was used to prepare the NWS surface and upper air data for use in the ISC-PRIME dispersion model. The surface meteorological data were combined with coincident mixing heights derived by merging surface temperatures with the concurrent twice-daily data obtained from the West Palm Beach Airport NWS station. All surface meteorological data files have missing data filled as prescribed in "Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models".

5.5.4 Good Engineering Practice Stack Height Analysis

Following EPA procedures contained in the "Guideline for Determination of Good Engineering Practice (GEP) Stack Height (Revised)" (EPA, 1985), a GEP analysis was performed to evaluate the potential for building downwash on the gas turbine stacks. The GEP height is a function of the dimensions of nearby building tiers and structures and is defined by the following formula:

$$Hg = H + 1.5L$$

where:
- Hg = the GEP stack height
- H = the height of the nearby structure
- L = the lesser dimension (height or maximum projected width) of the structure

The GEP stack height for a given stack is defined as the highest formula height calculated for any of the structures located nearby (defined as within a distance of 5L of the stack). The following procedures were used to analyze the stacks for downwash effects.

The stacks and influencing structures (those located within 5L) were identified on scale CAD drawings of the proposed project site and geographical coordinates were determined. The stack heights, relevant building dimensions, and locations relative to the stacks and property lines are summarized in Table 5-1 in Appendix G. The data was preliminarily evaluated (see Tables 5-2 and 5-3 located in Appendix G for the gas turbines and LPG removal hot oil system heater stacks) to identify which structures were located within 5L of the stacks and, therefore, capable of causing downwash on the stacks. The dimensions of those structures meeting the 5L criteria (e.g., one of the LNG tanks, the fuel oil storage tank and the gas turbine enclosures for the gas turbine stacks) were then evaluated using the EPA Building Profile Input Program (BPIP, dated 95086). The LNG tanks and berm were evaluated as a single building with multiple tiers. BPIP determines, in each of the 36 wind directions (10° sectors), which building may produce the greatest downwash effects on a stack.

The direction-specific dimensions produced by the BPIP model were included in the ISC-PRIME refined modeling analysis. The dimensions of the structure producing the maximum GEP height (the LNG tank nearest to the stacks) were also used in the SCREEN3 modeling analyses to determine worst-case operating loads and to conduct the cavity region analysis.

The BPIP analysis indicated that the GEP height for each of the three gas turbine stacks and the LPG removal hot oil system heater stack is 137.5 m (451.1 ft), based on the dimensions of the LNG tanks. All stacks are located within 275 m (902 ft) (5L) of the nearest LNG tank, so the LNG tank is the controlling GEP height for all sources. The proposed stack heights for the AES gas turbines (15.2 m (49.9 ft)) and the LPG removal hot oil system heater stack are below the GEP height of 137.5 m (451.1 ft), which is the height required to avoid building downwash effects. Therefore, direction-specific downwash dimensions were included in the ISC-PRIME dispersion modeling analyses. The BPIP output files are provided in Appendix G.

5.5.5 Emission Characteristics and Stack Parameters

As discussed in Section 3.3, the gas turbine generators and LPG removal hot oil system heater oil heater are the primary components associated with the operating phase of the project with the potential to impact air quality in the vicinity of Ocean Cay. Other minor and intermittent emission sources, which will only operate in the event of an emergency or outage of the gas turbine facility, include several small diesel reciprocating engines used for emergency fire water pumping and standby electricity generation and a flare system, which will be used to combust natural gas from the LNG facility if a power failure renders the vapor handling systems inoperable. Because these emissions sources are not part of the normal operating scenario and would operate infrequently only during emergency or test conditions, they are not included in the air quality impact dispersion modeling analysis.

AES is currently evaluating two different gas turbine configurations and several different vendors for each configuration. In order to provide AES the flexibility to develop either configuration, the air quality impacts representative of both configurations have been evaluated in the screening modeling analysis to determine the worst-case operating conditions for refined modeling.

One configuration would consist of a maximum of three simple cycle gas turbine generators each sized at approximately 15 MW generating capacity to support the LNG and LPG facilities. Two gas turbine generators operating simultaneously would be sized to handle 100 percent of the operating load of the LNG/LPG facilities and one gas turbine will be used for standby capacity as a spare. Furthermore, two of the gas turbines will operate exclusively with natural gas and one will have dual-fuel capability to operate either firing natural gas or diesel fuel. It is anticipated that the gas turbines would operate primarily on natural gas and that the diesel fuel would only be used as a backup fuel.

The other gas turbine configuration would consist of two simple cycle gas turbine generators each sized at approximately 30 MW generating capacity. In this configuration, one gas turbine would be sized to handle 100 percent of the operating load and one would be used for standby capacity as a spare. One gas turbine would be designed for exclusive natural gas combustion and the other would have dual-fuel capability.

For the purposes of evaluating air quality impacts from operation of the gas turbines, two sets of operating scenarios were developed, one for each gas turbine configuration. Each operating scenario was modeled with SCREEN3 to determine the worst-case configuration and scenario for each pollutant. For the three gas turbine configuration, the operating scenarios assume two gas turbines operating simultaneously, both firing natural gas or one firing natural gas and the other firing diesel fuel. For the two gas turbine configuration, the operating scenarios assume one gas turbine operating at a time and firing either natural gas or diesel fuel. A total of 10 operating scenarios for each gas turbine configuration were evaluated with the SCREEN3 model covering the range of fuels (natural gas and/or diesel fuel), operating loads (50 percent, 75 percent and 100 percent) and combustion air inlet conditions (8.9°C, 23.9°C and 37.8°C (48°F, 75°F and 100°F)). The operating scenarios, stack parameters and emission rates, based on gas turbine vendor data, are summarized in Tables 5-4 and 5-5 located in Appendix G for the three gas turbine and two gas turbine configurations, respectively. The stack parameters and emission rates representative of the stack are summarized in Table 5-6 located in Appendix G. The data used to develop these estimates are provided in Appendix G.

5.5.6 Background Ambient Concentrations

As discussed in Section 4.2.1.1, there are no major existing stationary sources identified within 30 km (19 mi) of Ocean Cay. The closest major air pollution sources are diesel engine generators located in Alice Town in North Bimini, about 35 km (22 miles) to the north. Because there are no major stationary sources of air pollution within 10 km (6.2 mi) of the project site, the pollutant concentrations from background sources are not expected to have significant interaction with those from the project. Moreover, as discussed below in Section 5.5.7.2, because modeled impacts from the AES project were determined to be insignificant at all locations for each regulated pollutant, EPA modeling guidance does not require inclusion of other background sources in the modeling analysis.

The only existing air pollution sources on Ocean Cay are the aragonite and calcite mining operations, which involve material transfer, screening and stockpiling operations and several small diesel engine generators. Due to the predominantly wet nature of the minerals, as they are pumped from offshore locations, fugitive particulate matter emissions from this operation are minimal. Moreover, after the AES gas turbines are installed, the small diesel generators used to power the mining operations will be relegated to emergency backup use, and therefore the pollutant emissions from the small diesel generators are not expected to contribute significantly to background concentrations. In fact, pollutant concentrations in the immediate vicinity of Ocean Cay may actually improve when the AES gas turbines are providing power to the mining operations. As shown in Table 5-7 in Appendix G, the combined emissions from the existing mining operations diesel engines have the same order of magnitude emission rates as the proposed AES gas turbines. In addition, the gas turbines will have much better dispersion characteristics (higher stacks and much higher stack gas exit velocities) than the existing diesel engines, resulting in lower ambient concentrations.

Based on evaluation of existing Ocean Cay emission sources and the lack of other sources within 30 km of the site, other air emission sources were not directly modeled in the air quality impact analysis. However, to conservatively account for the potential contribution of background sources, non-modeled background concentrations were added to maximum pollutant concentrations predicted for the AES gas turbines to estimate total air quality concentrations. The total air quality concentrations were then compared to AAQS.

In order to provide an estimate of existing air quality in the region representative of Ocean Cay for use in the air quality impact dispersion modeling analysis, ambient air monitoring data were reviewed from monitoring stations located in similar climates and geographical locations with similar or greater levels of industrial activity and vehicular operations to create synthetic baseline conditions. While use of ambient pollutant concentration data from such sources overstates the actual conditions on Ocean Cay, it provides a conservatively high estimate of total impacts when modeled results representative of the new emission sources are added to the conservatively high background concentrations.

US EPA guidance (Ambient Monitoring Guidelines for Prevention of Significant Deterioration, EPA-450/4-87-007) was used to develop representative synthetic baseline conditions, which allows the use of monitoring data from regional sites as representative background data if the proposed source will be constructed in an area that is generally free from the impact of other point sources. EPA ambient monitoring data were first identified and obtained from monitoring stations in the Virgin Islands, Puerto Rico, and in Monroe, Dade and Broward Counties, FL. A composite set of representative background air quality data was then compiled based on the availability of data (not all monitoring stations monitor for all pollutants) and evaluation of the similarity of the geography, meteorology, and population/industrial density of the monitoring sites compared to Ocean Cay. (Figures 4.20 and 4.21 depict the location of the monitoring sites in southeastern FL, Puerto Rico and the Virgin Islands.) In general, once the most representative monitoring station was identified, the maximum ambient concentration for each regulated pollutant and averaging period was selected from the most recent four years of available data. The following items summarize the rationale used for selection of the representative monitoring stations for each of the regulated pollutants:

- Ambient particulate matter (PM_{10}) data are available from monitoring stations located in Monroe County, FL (Marathon and Key West in the Florida Keys); 12 different counties in Puerto Rico; and St. Croix and St. Thomas in the Virgin Islands. The monitoring station located in Marathon in Monroe County in the FL Keys was judged to be the most representative of Ocean Cay with respect to geography, meteorological influences and population/industrial density. As shown on Figure 4.20, Marathon is located in the Florida Keys approximately 250 km (155 miles) southwest of Ocean Cay, near the center of a narrow line of small islands or reefs and more than 80 km (50 miles) south of the Florida mainland. As discussed in Section 5.5.3, the location of the Florida Keys is considered meteorologically representative of Ocean Cay, with its lack of terrain features, lack of large nearby landmasses and similar maritime influences. The predominant easterly wind direction and lack of upwind emission sources approximates conditions on Ocean Cay. Finally, the Marathon monitoring data was considered more representative than the Key West data due to its lower population/industrial density, which results in less emission sources.

- Ambient nitrogen dioxide (NO_2) data are available from monitoring stations located in Broward County, FL (Hollywood and Fort Lauderdale); Dade County, FL (Key

Biscayne and Miami); and in Catano and San Juan, Puerto Rico. Ambient NO_2 data is not monitored at either of the monitoring stations in Monroe County, FL or in the Virgin Islands. The monitoring station located in Key Biscayne, FL was judged to be the most representative of Ocean Cay with respect to geography, meteorological influences and population/industrial density. As shown on Figure 4.20, Key Biscayne is located the furthest east of any of the monitoring stations in Florida on a narrow landmass in Biscayne Bay. As such, it is less influenced by upwind (easterly) air emission sources than any of the other available NO_2 monitoring sites. All of the other NO_2 monitoring sites are located further inland or have much larger numbers of upwind emission sources and have significantly higher upwind population/industrial densities.

- Ambient sulfur dioxide (SO_2) data are available from monitoring stations located in Broward County, FL (Fort Lauderdale); Dade County, FL (Miami); Puerto Rico (Barceloneta, Bayamon, Catano, and Yabucoa); and the Virgin Islands (St. Croix). Ambient SO_2 data is not monitored at either of the monitoring stations in Monroe County, FL. The monitoring station located in Yabucoa, PR was judged to be the most representative of Ocean Cay with respect to geography, meteorological influences and population/industrial density. As shown on Figure 4.21,Yabucoa is located in southeastern Puerto Rico, near the coast, where it is less influenced by upwind (easterly) air emission sources than any of the other available SO_2 monitoring sites. All of the other SO_2 monitoring sites are located further inland or have much larger numbers of upwind emission sources and have significantly higher upwind population/industrial densities.

- Ambient carbon monoxide (CO) data are available from monitoring stations located in Broward County, FL (Hollywood, Fort Lauderdale, Pampano Beach and Lauderdale Lakes); Dade County, FL (Miami); and Puerto Rico (San Juan). Ambient CO data is not monitored at either of the monitoring stations in Monroe County, FL or in the Virgin Islands. The monitoring station located in Pampano Beach, FL was judged to be the most representative of Ocean Cay with respect to geography, meteorological influences and population/industrial density. As shown on Figure 4.20, Pampano Beach is located closest to the coast in southeastern FL, where it is less influenced by upwind (easterly) air emission sources than any of the other available CO monitoring sites.

- Ambient lead (Pb) data are available from monitoring stations located in Broward County, FL; Dade County, FL (suburban Miami); and Puerto Rico (San Juan). Ambient Pb data is not monitored at either of the monitoring stations in Monroe County, FL or in the Virgin Islands. The monitoring station located in Dade County was judged to be the most representative of Ocean Cay with respect to population/industrial density. The Dade County monitoring location, located in a suburban/residential area about 11 km (7 miles) west of Miami, has a lower population/industrial density that the other available data sets.

The synthetic ambient background data based on the selection methodology discussed above and used in the dispersion modeling analysis is summarized in Table 5-8 in Appendix G. The 5-year summary of ambient data from each of the identified monitoring stations is presented in Appendix O.

5.5.7 Air Quality Modeling Results

5.5.7.1 Construction Impacts to Air Quality

The use of equipment to construct the onshore and offshore segments of the Project will result in temporary, short-term emissions of certain air pollutants. These emissions will be restricted to the construction period for the Project, will vary depending on the types of work being conducted at any given time, and will not be concentrated within any particular location. The project will utilize state-of-the-art engineering design and construction procedures to minimize air emissions during the construction phase. The principal sources of emissions will be combustion emissions from stationary and mobile equipment powered by diesel internal combustion engines. Fugitive dust emissions may also occur from earthwork, movement of construction vehicles and wind erosion of exposed soil on the site. These emissions will not result in significant adverse impacts to the air quality within the vicinity of the project area. Due to the variable and temporary nature of air pollutant emissions from construction activities associated with this type of project, a quantitative air quality impact analysis of construction emissions is not typically performed and has not been performed for this Project.

As discussed in Section 2.4, the major construction activities include:

- Dredging and pumping of materials from offshore to stockpiles and reclamation areas on the project site;
- Site preparation, including filling, grading, and excavation;
- Shoreline protection and ground improvements;
- Concrete pouring;
- Erection of steel, tanks, shore protection features, and mooring/docking facilities;
- Machinery installation;
- Pipeline installation; and
- Finishing and cleanup.

A. Stationary and Mobile Source Air Quality Impacts During Construction Phase

Stationary source diesel engines used throughout the construction period include portable electricity generators, pumps, compressors, etc. Diesel engines will also be used to power mobile construction equipment and marine vessels. Diesel engine-powered land-based mobile construction equipment will include cranes, dozers, backhoes, graders, etc. Marine vessels powered by diesel engines and used for pipeline installation will include dredges, pipe-lay barges, trenching equipment, survey vessels, anchor handling tugs, pipe supply barges, escort boat, personnel carriers, and a housing barge or cruise ship.

Use of stationary diesel engine-powered equipment, such as generators, pumps and compressors will vary throughout the construction phase, will be intermittent and will cease at the conclusion of construction activities. These sources will generally be small (less than 1 MW or 1600 hp) portable units that are moved as necessary.

Portable and mobile source diesel engines will emit criteria pollutant emissions (NO_X, SO_2, CO, VOC, PM_{10} and Pb). However, ambient air quality impacts are expected to be minimal for several reasons. During the site preparation activities, demolition activities will be minor as the site is relatively clear of existing structures and debris. Although a significant island expansion is proposed during the early construction phase, the fill materials will be pumped in slurry form from offshore dredging activities via a pipeline directly into stockpiles in the reclamation areas, thus minimizing the transfer of dredged fill materials by marine vessels or on-site construction vehicles. Minimal grading will be required because the project site is nearly level and close to the proposed project grade level. Therefore, heavy construction activity during the site preparation phase will occur during a short period, conservatively estimated to be 18 months of the 36-month total construction period. The EPC contracts will also require that construction equipment used on-site be well maintained, which will result in efficient fuel combustion and minimize criteria pollutant emissions.

Impacts from criteria pollutant emissions from diesel engine-powered marine vessels used for pipeline installation are not expected to adversely affect air local and regional air quality. Emissions from these sources will not be concentrated within any particular location within the offshore or onshore segments of the project area. Therefore, while the total construction period for the Project will be approximately 36 months, the period during which air pollutant emissions will occur within any particular location within the project area will be substantially less than the total construction period.

B. Fugitive Dust Emissions

Fugitive dust emissions during construction will result from earthwork (excavation, grading, landscaping, etc.), movement of vehicles on-site, roadways and wind erosion. As stated above, heavy construction activities will be minimal, as demolition and grading activities will not be significant. Moreover, the dredged fill material will be pumped in a slurry form via pipeline into dewatering basins located near the final reclamation areas and construction equipment used for any final grading will handle fill material with high moisture content and minimal potential to generate fugitive dust. In addition, as discussed in Section 6.3, mitigation measures to minimize emissions of airborne particulate will be implemented, as necessary, including the use of water or other wetting agents on areas of exposed soils and completing final grading and landscaping of exposed areas as soon as possible. It also should be noted that any impacts on the coral reefs and under-sea grasses due to deposition from fugitive dust would be insignificant in comparison to impacts from dredging activities.

5.5.7.2 Operational Impacts to Air Quality

A. Worst-Case Scenario Analysis (SCREEN3)

To determine the worst-case operating scenarios for the proposed gas turbines, a screening modeling analysis, using the SCREEN3 model, was conducted for each of the gas turbine configurations and operating scenarios described in Section 5.5.1.2. A total of 20 different scenarios were modeled, covering the various possible combinations of fuels, operating loads, and inlet temperature conditions for the two gas turbine configurations. For the scenarios involving two gas turbines operating simultaneously, the SCREEN3 simulations assumed a single stack, with the total emission rate from the two turbines and the minimum stack velocity and temperature from a single turbine.

The results of the worst-case scenario analysis are presented in Table 5-9 in Appendix G. Based on this analysis, the worst-case operating scenario for NO_2, PM_{10}, SO_2 and Pb is Case #10, which is the three gas turbine configuration with one turbine firing natural gas and the other firing diesel fuel, both at 100 percent load and at a chilled inlet air temperature of 8.9°C (48°F). The worst-case operating scenario for CO was determined to be case #19, which is also the three gas turbine configuration, with one turbine firing natural gas, one turbine firing oil, both at 75 percent load and 8.9°C (48°F) inlet air. This scenario was determined to be worst-case for CO primarily due to the higher emission rate at 75 percent load than at 100 percent load.

The worst-case screening analysis indicated that ambient impacts for all pollutants and averaging periods (except for the 1-hour average CO concentration) may be above the EPA-defined significant impact levels. Therefore, refined modeling with ISC-PRIME was performed for all pollutants.

For purposes of the modeling analysis, the LPG removal hot oil system heater was assumed to operate continuously at maximum load. The results of the screening modeling analysis for the LPG removal hot oil system heater stack, summarized in Table 5-10 in Appendix G, indicate insignificant impacts for all pollutants except for the annual average NO_2 impacts. The LPG removal hot oil system heater was included in the refined modeling analysis along with the gas turbine stacks and the modeling was performed for all pollutants.

B. Cavity Zone Analysis

Although the ISC-PRIME model predicts concentrations within the cavity zone, the currently recommended screening procedures for performing a cavity analysis with the SCREEN3 model were also used. The SCREEN3 model was used to determine the maximum dimensions and concentrations (if applicable) of the cavity regions created by all nearby structures (located within 5L) for which the proposed stack heights are not GEP.

All of the buildings and structures included in the GEP analysis (see Section 5.5.4) were evaluated to determine if a cavity zone for a particular structure would affect the stacks and, if so, the concentrations of pollutants in the cavity. If necessary, the predicted cavity lengths are compared to distances to property lines to determine if any offsite cavity impacts will occur. For each structure located within 5L of the stacks for which the stacks are not GEP (e.g., one of the LNG tanks and the fuel oil storage tank for the gas turbine stacks), the SCREEN3 model predicted the cavity lengths for each of the two primary building orientations (i.e., along the longer and shorter sides of the building, which are the same for circular tanks).

The results of the cavity analysis are presented in Table 5-11 in Appendix G. The SCREEN3-predicted cavity zone lengths are 86.5 m (283.8 ft) for the LNG tank and 12.7 m (41.7 ft) for the fuel oil tank. All three gas turbine stacks and the LPG removal hot oil system heater stack are located a distance farther than the cavity lengths from these structures. Therefore, no cavity regions were determined to affect emissions from the stacks and no further analysis of cavity impacts was required. Moreover, the results of the cavity analysis provide further justification for the use of the ISC-PRIME model for the refined modeling analysis. In contrast to ISC-PRIME, which allows for modeling of the stacks at their actual orientations and locations relative to the LNG tanks (where the plumes are not captured by the cavity), ISC3 models the stacks as collocated with the LNG tank, resulting in complete capture of the emissions within the cavity.

C. Refined Modeling Analysis (ISC-PRIME)

As discussed in Section 5.5.7.2, based on the results of the SCREEN3 modeling analysis to determine worst-case operating scenarios, two scenarios were evaluated in the refined modeling analysis for the gas turbine stacks (Case #10 for NO_2, PM_{10}, SO_2 and Pb and Case #19 for CO). The refined modeling input parameters for the gas turbines and the LPG removal hot oil system heater stack are summarized in Table 5-12 in Appendix G. Refined modeling was performed with ISC-PRIME for each of the worst-case operating scenarios using the regulatory default options and five years of meteorological data as described in Sections 5.5.1.3 and 5.5.3. ISC-PRIME was run initially for each pollutant and averaging period with the non-uniform polar receptor grid described in Section 5.5.2.2.

The results from the polar receptor grid network indicated that the peak model-predicted concentrations for all short-term averaging periods ($<$24-hour) occur within the 100 m (328 ft) spaced receptors and the maximum annual average impacts for SO_2 and PM_{10} were predicted to occur at 3000 m to 3500 m (1.86 mi to 2.17 mi). Therefore, a dense Cartesian grid with 100 m (328 ft) receptor spacing centered on the initial maximum annual average impact location was used for subsequent model runs to ensure the maximum annual impacts had been located.

The results of the refined grid analysis modeling with ISC-PRIME are summarized in Table 5-13 in Appendix G. The refined modeling analysis predicts that maximum ambient concentrations due to the combined emissions from the proposed AES gas turbines and the LPG removal hot oil system heater will be less than the applicable significant impact levels for all pollutants and all averaging periods. Based on these results and in accordance with Florida State and EPA modeling guidance, no further impact analyses are required and compliance with the AAQS and PSD increments is demonstrated. However, estimates of total ambient concentrations for each pollutant and applicable averaging period were developed by adding the maximum modeled concentrations to the conservatively estimated background concentrations that were derived by the methodology discussed in Section 5.5.6. The total estimated ambient concentrations are demonstrated to be in compliance with the AAQS.

5.6 Noise Impacts

5.6.1 Construction Phase Noise Impacts

The assessment of noise emissions from Ocean Cay during the construction phase of the project is based on baseline calculations made for the existing aragonite and calcite mining operation, as described in Section 4.2.2. The rational for the approach stems from the fact that the types of equipment currently used for the mining operation are very similar to the equipment planned for the construction phase activities, which include diesel engine driven electric generators and earthmoving equipment. The individual source noise signatures for each piece of the construction phase equipment are expected to be very similar to the source noise signatures for the baseline (current) equipment. Thus, it is valid to extrapolate the expected noise emissions for the construction phase of the project from the previously calculated baseline noise assessment.

The dominant baseline operation source noise signatures are those for the three pieces of earthmoving equipment currently used for mining activities. The resulting noise level at South Cat Cay, the inhabited island nearest Ocean Cay, was calculated to be 7 dB(A). It is expected that during peak construction activity, as a worst case scenario, not more than 100 individual pieces of equipment (a highly conservative number), with engines similar to the baseline excavator and wheel loader, would be employed. These pieces of diesel engine driven equipment will comprise most of the construction tools needed for this project. These include the dredging barges and pumps, winches for cranes and pipe shore pulling, power for deep dynamic compaction (DDC) and pile driving, concrete batching, sand pumping, jetting equipment, pipe compression test equipment, welding generators, power for the temporary fuel, water and sewer systems, and the engines for the tugs, launches and ferries.

Thus, the noise calculation resulting from the baseline assessment was extrapolated to account for the increase in activity due to construction by a factor of about 33 times (3,300 percent). The resultant maximum noise level that may be expected at South Cat Cay due to construction phase operations then equals the noise level calculated for the baseline operation plus the additional noise level resulting from the 97 additional pieces (worst case) of construction equipment.

The increase in noise level due to the increased number of equipment pieces operating during the construction phase is accounted for by the following equation:

dB increase = 10 * log (pieces construction equipment / pieces baseline equipment)

or, dB increase = 10 * log (100 / 3) = 15.2 dB

That is, the increase in diesel driven equipment noise for the construction equipment is expected to be 15 dB over the noise for the existing operations on Ocean Cay. Although it is not expected to occur, this worst case scenario assumes that all of the construction equipment will be operated simultaneously.

Therefore, the total noise level that may be expected at South Cat Cay due to diesel engine driven construction phase operations is 7 dB(A) + 15 dB = 22 dB(A). This is subjectively a low sound level, and is likely to be below the existing background ambient sound level on South Cat Cay due to wind, waves on the beach, insects, birds and other sources. Therefore, it is unlikely that noise from the construction phase activity would be noticed audibly at South Cat Cay.

It is also noted that the expected noise level of 22 dB(A) is well below both the daytime limit of 55 dB(A) and the nighttime limit of 45 dB(A) required by Florida State and World Bank Guidelines.

Other construction operations that could impact noise levels include compression test vents and rock drills. Compression test vents are of temporary use, and if properly muffled with an appropriate blow down silencer should not pose a noise problem. Source noise levels for compression blow down can be quite low with the properly sized silencer. Rock drills are potentially the loudest pieces of equipment on a construction project. Furthermore, pneumatically driven drills produce higher noise levels than do hydraulically actuated drills.

Calculations were made of the expected noise level at South Cat Cay, due to the noise emissions of a pneumatically driven rock drill. For these calculations, measured source noise data from an older model rock drill, untreated for noise, were used as a worst case scenario. Furthermore, it was assumed that as many as three older, untreated rock drills may be operating simultaneously. This is likely the maximum number of drills that will be used if concurrent drilling is needed for pile and/or stone column installation. Although these drills would operate intermittently when used, and for a limited period of time during the project, it was considered important to evaluate their noise impact, as drill operation could potentially determine the maximum emitted noise levels of the total construction operations.

The worst case expected noise level at South Cat Cay due to all construction activities, including all of the diesel driven engine operations discussed above, and also including the maximum, untreated, intermittent drilling operations is 28 dB(A). A detailed description of the calculation method is given in Appendix P. It is noted that the level of 28 dB(A) is well below both the daytime limit of 55 dB(A) and the nighttime limit of 45 dB(A) required by the World Bank Guidelines. Noise limits in Florida (Broward County) are 55 dB(A) at all times for residential receiving land uses.

The calculated noise level of 28 dB(A) is for a worst case scenario. This calculation was made assuming that all of the construction equipment for the project is operated simultaneously, and also assuming that the equipment used is not specially treated for noise control. If less than all of the construction equipment operates simultaneously, or if even a modicum of noise control is applied, then this worst case noise level may be reduced significantly.

Another noise source that was considered for potential impact on South Cat Cay was the occasional blasting that may be required during construction. Blasting is a noise source that may have considerable variation in noise output, depending on the method of setting the explosive charge. Variables include the size of the charge, the timing of the charge, the depth of the charge, if a covering blanket is used, and if the charge is placed near an open rock face.

It is expected for this project to utilize modern blasting methods, which reduce noise and vibration levels through the use of smaller charges with extended timing, will be employed if blasting is required as part of the proposed project. In this case, noise levels on the order of those produced by a rock drill, or less, may be expected. It is expected that the sound of blasting will not even be noticed at the closest inhabited island South Cat Cay.

If unusually high levels of blasting noise are produced, then the sound of blasting may be briefly noticeable on South Cat Cay. Any noticeable blasting sound will be of very short duration, on the order of a few seconds. Also, it is very unlikely that such a blast would exceed the World Bank daytime noise limit of 55 dB(A), even momentarily. Further, the World Bank Guidelines specify that 1-hour averages be used to evaluate sound levels. A short duration blast would have almost no influence on the 1-hour average sound level. Therefore, it is highly unlikely that noise from blasting would have a measurable impact at South Cat Cay.

The assessment of the noise emissions on North Bimini during the construction phase of the project is based on the calculations that were made for the construction phase of the project on Ocean Cay, as described previously. Similar types of equipment will be used for these construction phase activities. These include pipe pullers, jetting operations and material stockpile maintenance. The individual source noise signatures for each piece of construction equipment on North Bimini are expected to be very similar to the source noise signatures for the corresponding equipment on Ocean Cay.

The dominant noise emissions are those for two pieces of earthmoving equipment and for the pipe pulling operation, followed by the jetting operation and the use of an air compressor, as needed. It was assumed for a worst-case scenario, that during peak construction activity all of these operations would be conducted simultaneously. The construction activity on North Bimini is not expected to have a duration of more than 1 week. This activity will be conducted during daytime hours only. The resulting noise level for the construction activity at the nearest residences was calculated to be 54.3 dB(A). The noise calculation for this case is summarized in Appendix P.

It is noted that the worst case expected noise level of 54.3 dB(A) is below the daytime limit of 55 dB(A), as required by the World Bank Guidelines. Also, this expected construction noise level is consistent with the existing background noise level due to the continuing operation of the Bahamas Electricity Corporation Alice Town power plant.

If the noise emitted from construction operations on North Bimini or housing construction on South Bimini reaches levels which exceed the World Bank Guidelines or similar requirements in Florida, then modest noise control measures can be employed that will reduce the noise levels at the nearest residences by 5 to 10 dB. These measures could include the construction of temporary noise barriers around the pipe pulling operation.

5.6.2 Operational Phase Noise Impacts

The assessment of the noise emissions from Ocean Cay during operation of the LNG/LPG facility is based on the noise calculation model that was developed for the existing aragonite and calcite mining operation, as described in Section 4.2.2. The operational phase noise assessment takes into account the noise emissions resulting from the 30 MW power generation facilities, the LNG and LPG terminal operations and the existing aragonite mining operations, which are expected to continue as part of the overall project. Note that it is expected that the existing mining operation powerhouse will be decommissioned after the new gas turbine power generation facility is on-line. Therefore, the mining power generator which will be used for emergency back-up only source noise signatures were not included in this assessment.

The source noise signature for the proposed 30 MW power plant facility was extrapolated for the purposes of this assessment from recent noise measurements of a similar gas turbine facility. The source noise signature for the LNG/LPG facility was scaled from measurements of a similar gas blower and pump operation. The noise projection calculations to South Cat Cay that were used for this noise assessment are discussed in detail in Appendix P.

Based on these noise projection calculations, the total noise level that may be expected at South Cat Cay due to the power generation and LNG/LPG operations is about 18 dB(A). This is a subjectively low sound level, and is likely to be below the existing background ambient sound level on South Cat Cay due to wind, waves on the beach, insects, birds and other sources. Therefore it is unlikely that the noise from operational activities would be noticed audibly at South Cat Cay.

Additionally, the expected noise level of 18 dB(A) is well below both the daytime limit of 55 dB(A) and the nighttime limit of 45 dB(A) required by the World Bank Guidelines. Noise limits in Florida (Broward County) are 55 dB(A) at all times for residential receiving land uses.

On infrequent occasions, an airplane may use the Ocean Cay airstrip. Although an aircraft event would not be considered a routine or necessary part of the operations, an assessment of the potential for noise impact of such an event was made.

The aircraft source noise signature used for the calculation was derived from NASA test data of a general aviation type, propeller driven airplane. This source noise signature was then included in the noise projection model for the Ocean Cay operation. The noise projection calculations indicate that the aircraft noise emissions from a takeoff at Ocean Cay will yield a maximum noise level at South Cat Cay of 29.4 dB(A). Therefore, the aircraft would be the dominant noise source on Ocean Cay as compared to operational noise sources.

Based on these noise projection calculations, the maximum combined total noise level that may be expected at South Cat Cay due to power generation, LNG/LPG operations, and an infrequent aircraft takeoff is about 30 dB(A). This noise level is below both the daytime limit of 55 dB(A) and the nighttime limit of 45 dB(A) required by the World Bank Guidelines.

5.7 Social, Economic and Institutional Resources Impacts

The potential social, economic, and institutional impacts of the project were assessed with particular consideration being given to those impacts related to economic benefit or loss, direct displacement of residents and/or businesses, induced development (particularly on the Biminis), loss of access to the project site or sites proposed for housing on South Bimini, increased traffic, and infrastructure requirements. The scope and nature of the potential impacts varies significantly between the construction phase as compared to the operational phase of the project. Thus, potential impacts related to these two phases of the project are discussed separately below. Additional information regarding the socioeconomic impacts to Bimini will be submitted as an addendum to this EIA, pending response to a letter submitted to the Bimini Administrator.

5.7.1 Construction Phase Impacts

Assessment of the potential socioeconomic impacts during construction focused primarily on work force requirements, acquisition of supplies, increases in marine vessel and other traffic, and the temporary increased demand for services related to the construction project (food, housing, communications, law enforcement, medical care, local transportation)

5.7.1.1 Jobs Creation

It is estimated that a maximum of 450 full-time construction jobs will be created during the construction phase of the project. AES will use good faith efforts to employ qualified Bahamian citizens in the construction and operation of the proposed project. A training program will also be established by AES to recruit and train suitable Bahamian citizens with the skills required during the project's construction and operational phases. AES will donate to the training program 50 US cents per man-hour worked by every non-Bahamian involved in the construction phase of the project. Based on local populations and the potential number of available workers it is expected that up to 20 percent of the construction work force personnel will be hired from the nearby Family Islands. The remainder of the construction and supervisory positions will be filled with experienced workers that will temporarily relocate to the area. Thus, construction activities will provide numerous new, although temporary, work opportunities for both skilled and unskilled labor, as well as contribute significantly to the Bahamian economy. Because of the available labor pool, particularly of unskilled workers, and the diminishing needs of other large construction projects currently underway in the Bahamas, the demand for labor for this project is not expected to compete with or impede other ongoing development projects in the area.

In addition to creating construction jobs for an extended period (estimated at 3 years), job training will be made available to provide the appropriate personnel for civil, mechanical and other positions required by the construction. This action is consistent with the Bahamian government's goal of advancing both training and employment of its citizens in the high technology sector, and is particularly important to the young population of the Family Islands as they emerge from school into the workforce.

An added benefit to the Bahamian economy arising from employment during the construction phase will be the revenues realized from work permits for non-Bahamian workers involved with development of the project.

5.7.1.2 Construction Materials/Supplies

The majority of the raw materials to be used during construction are expected to be purchased outside the Bahamas, although a significant amount of cement, aggregate or ready mix concrete, and miscellaneous fabricated material may be sourced in the Bahamas if commercially available. Other required materials may also be purchased locally, and include such items as food, housing materials, ferries and other small marine vessels, household and office supplies, oils, chemicals and cleaning supplies. These purchases are projected to infuse the local economy with additional revenues over the estimated 3-year construction period, estimated at $12 million.

5.7.1.3 Transportation

Marine traffic in the immediate vicinity of Ocean Cay and the Biminis will increase over current levels during the construction period. Such traffic will result primarily from barges delivering construction materials and equipment, vessels removing waste materials from Ocean Cay, ferries and other commuter vessels to and from the island. These increases in marine traffic are not expected to have a significant impact on existing marine traffic because Ocean Cay is located several miles from the nearest inhabited island and shipping lanes to be utilized by larger vessels have more than adequate additional capacity. Most barges brought to the area during the construction phase will be received at the SVH at Ocean Cay.

Pipeline laybarges and their supporting vessels will be positioned at different locations along the pipeline route based on the progress of the construction. These vessels will require a restricted access area surrounding the vessels to provide adequate area for the installation techniques. The restricted area will be adequately marked for navigation hazards. Impacts due to restricted access are expected to be temporary and minimized to the extent possible. Potential impacts to navigation may occur as the pipeline construction progresses around the west coast of the Biminis.

Commuter vessels, such as ferries, bringing employees and supplies to and from Ocean Cay will result in increased use of existing docks and marinas on the Biminis. However, it is not anticipated that this will significantly interfere with tourism, fishing and other current activities reliant on docking services because the vast majority of construction workers will be housed at Ocean Cay and will not be commuting between Bimini and Ocean Cay.

Increased vessel traffic could cause direct physical disturbance to marine life from the presence of vessels, increase the risk of collision between vessels and listed species, and adversely affect the listed species from increased levels of underwater noise. It is likely that whales react primarily to the noise generated by vessels, and not to their physical presence. Most whales will respond to the presence of vessels in the area and move away; however, their behavior is not always predictable and strikes are known to occur. Because most sightings of whales occur in deeper waters, away from the areas where most construction activities will take place, collisions are unlikely. Sea turtles do not appear to be disturbed by the physical presence of and noises produced by vessels and vessel traffic; they may simply dive when approached by a vessel and avoid areas of intensive human activity. Mitigation to avoid interaction between marine animals and vessels is discussed in Sections 6.0 and a mitigation plan is presented in Section 10.

Acoustic disturbance from the increased vessel traffic and construction operations may cause minor short-term disturbance to cetaceans and sea turtles, but the same management actions proposed to minimize potential collisions during the project will also minimize potential acoustic disturbance. Mitigation for possible blasting activities that may take place during construction is discussed in Sections 6 and 10.

In addition to marine traffic, modest increases in air traffic to the Biminis and localized vehicle traffic can be expected. This is not anticipated to be a negative impact, as such traffic will result from infrequent visitors and the few temporarily housed supervisory personnel not residing on the cruise ship or quarters barges at Ocean Cay. In fact, such travel will likely provide additional revenues to transportation related businesses on the Biminis.

5.7.1.4 Services and Infrastructure Requirements

Construction of the project will bring an influx of workers to the Ocean Cay area on a temporary basis, which will create a demand for certain services. Significant fees have and will be spent during the development phase on local professional services such as architects and surveyors as well as professionals working in the legal, real estate, banking and scientific fields. In addition, professionals traveling to the Bahamas during project development require lodging, meals, supplies, communications services, and local transportation, all of which infuses the local economy with considerable added revenue.

During actual construction, service requirements expand to include housing, meals, transportation, and other services for the numerous construction personnel and supervisors. The potential for 'pop-up' or 'boom town' settlements and businesses, which could have an adverse impact on the Biminis and other nearby islands, will be minimized by housing construction personnel on vessels (cruise ships, quarter barges) moored at Ocean Cay. These temporary quarters will provide for all needed services while the workers are on duty. Nevertheless, it is expected that some small businesses in the immediate vicinity of Ocean Cay (i.e., Bimini), particularly those providing food, housing, entertainment, and local transportation, may experience an unavoidable but gradual drop in business as the construction period wanes.

Impacts on existing infrastructure or institutions, particularly on the Biminis, are expected to be minimal during the construction period with the possible exceptions of law enforcement, emergency medical care, and work permit processing. Because the majority of workers will be housed at Ocean Cay, there should be no need for additional roads, schools, sanitary facilities, or other related infrastructure on the Biminis.

It is anticipated that emergency medical services of a first aid nature will be provided on Ocean Cay during construction. More significant injuries may be transported to Bimini or to Florida facilities depending on the severity of the injury. Although entertainment and other required services will be provided to the construction workers at the housing arrangements on Ocean Cay, some workers may visit the Biminis during work breaks which may impact the needs for law enforcement personnel on the Biminis. Work permit processing and customs needs at Ocean Cay will require additional immigration personnel to be stationed at Ocean Cay during the construction period.

5.7.2 Operational Phase Impacts

The operational phase of the project is expected to have a considerable net positive economic impact, on the Bahamas in general and on the Biminis and other "Family Islands," in particular, over the long term (30-year project life span). Key areas of economic benefit are:

- revenues to the Bahamian government resulting from business license fees;
- diversification of the economy in a non-tourism related and technical industry;
- improved balance of trade between the Bahamas and the U.S.;
- creation of skilled permanent jobs;
- investment in the local economies of Bimini and the Family Islands;
- development of affordable housing on Bimini; and
- expansion of water and energy supplies and systems.

5.7.2.1 Government Revenues, Diversification, Balance of Trade

With potential turnover of $700 million per year, AES anticipates paying up to $7 million each year in business license fees to the Bahamian Government. Over the 30-year life span of the project, revenues from license fees could total more than $200 million. Additional fees from work permits for permanent non-Bahamian employees will add to that figure.

Completion of this project will provide diversification to the Bahamian economy. At present, the industrial and technical business sector accounts for only 5 percent of the labor force, with the economy focused very strongly on tourism and financial services. Yet, siting the LNG/LPG terminal on Ocean Cay will not interfere with ongoing tourism and financial markets, with no adverse impact to either business sector. This is largely due to Ocean Cay's solely industrial nature and its lack of inhabitants, as well as its remoteness from tourism-based local economies such as that on Bimini.

The export of natural gas to South Florida from Ocean Cay will significantly improve the balance of trade between the United States and the Bahamas. Currently, the Bahamas has an import-oriented economy heavily dependent on imports of food and manufactured goods from the United States.

5.7.2.2 Permanent Employment

It is estimated that 25 to 35 permanent full time jobs will result from on-going operations and maintenance of the facility with a permanent annual payroll estimated at over $1 million. In addition, the aragonite mining operation, which is owned and operated by an affiliate of the project, is expected to continue. The gross annual payroll of the Bahamian employees working at the mining operation is approximately $700,000 per year.

5.7.2.3 Permanent Housing

AES intends to construct needed affordable housing in the Bimini Islands for employees associated with operations of the LNG/LPG terminal. It is estimated that approximately 10 to 20 permanent employees and their families will require housing, with Bimini being the nearest feasible location. Assuming each employee's family has an average of four members, this would represent an increase in the Biminis permanent population of approximately 5 to 8 percent. Undeveloped land is available on South Bimini for creation of adequate housing without the need for resettlement of existing residents. Furthermore, creation of this housing will not take away land currently used for industry, farming, tourism or other businesses. The housing will be affordable, attractive, and well built and should have a positive social impact on the existing community. The proposed development layout, typical housing unit floor plan, and typical housing unit exterior are shown on Figure 2.20.

5.7.2.4 Services and Infrastructure

The projected increase in the Biminis permanent population will induce a modest demand for additional services and infrastructure. The new housing developments for Ocean Cay employees will be constructed by AES to include associated roads, sanitary waste facilities (septic systems), and recreational facilities. Additional water supply needs will be provided by the potable water pipeline between Ocean Cay and the Biminis. The electricity demands for the housing development will require evaluation by BEC to determine which upgrades, if any, are required to the existing electrical infrastructure. The availability of natural gas will allow the BEC an alternative fuel source for either repowering or a future expansion of their existing facilities in Bimini. Nevertheless, there will be an added need for schooling for employee's family members, as well as medical care, law enforcement, and emergency response personnel. It is expected that such demand will have a net positive impact by increasing job opportunities for Bimini and Family Island residents in professions that provide good salaries and long-term job stability.

A ferry service will be established to transport permanent employees from housing located on South Bimini to Ocean Cay for their work shift. The ferry service may also transport supplies such as food to the LNG Terminal operation. It is anticipated that the ferry operation would be run from existing marinas and would not impact current recreational and fishing boat traffic. The ferry operator and the workers associated with the service would be provided with additional permanent positions for Bahamians in the Biminis.

The impacts of additional ship traffic to the area are discussed in the Shipping Survey, Appendix T. During the year 2000, there were 57,140 trading vessel movements to and from ports in the vicinity of the project area (Florida Straits, western Bahamas). Operations at Ocean Cay will require approximately 150 LNG ships per year and 50 LPG shipments. These shipments will represent a 0.35 percent increase in ship traffic into the area. Additionally, other ships and smaller vessels will be received at Ocean Cay for worker transport and supply deliveries during operations. The impacts of this increase will be minimal to existing shipping lane capacity.

The project will provide natural gas via pipeline to the Biminis that, as mentioned above, will provide BEC an alternative fuel source for either repowering or a future expansion of their existing facilities to the Biminis future energy requirements. This will have a direct positive impact on the ability of the Biminis to grow and develop its business/commercial community, its residential community and its income base. At a minimum, the supply of natural gas directly to the Biminis will increase the reliability of the energy system currently in place, and will replace or augment the fuel oil based energy production with a cleaner fuel alternative. Reducing the Biminis use and/or reliance on fuel oil for power generation will also have an indirect positive impact on the environment by reducing the emission of air pollutants resulting from combustion of oil. There will be a need for expansion of the current electricity transmission system on the Biminis to provide power to new housing developments. This investment is consistent with the Bahamian government's long range plan for upgrades to the Family Islands infrastructure.

The desalination plant on Ocean Cay will supply potable water to the Bimini Islands via pipeline to augment its current capacity, which at present is insufficient to support growth on this island group. At a delivery cost expected to be in the range of $6 to $7 per thousand gallons, this additional source of water will allow Bimini to provide its citizens with an affordable and reliable supply of potable water to satisfy current and future needs in a manner consistent with its long term plan of development. Bimini currently plans to upgrade its supply and delivery system on North and South Bimini.

5.8 Visual Impacts

A visual assessment was performed to determine the visual effect of the proposed facilities on the receptors in the vicinity of the project area. The closest receptors to the project area are the residents of South Cat Cay, located approximately 11.35 km (7 mi) north-northwest of Ocean Cay. The results of the plume visibility analysis and visual impact analysis are discussed below.

5.8.1 Plume Visibility Impact Analysis

A stack plume visibility screening analysis was performed based upon the procedures described in EPA's Workbook for Plume Visual Impact Screening and Analysis (US EPA, 1992). The screening procedure involves calculation of plume color difference and contrast coefficients with the US EPA VISCREEN (Version 1.01) model, using as inputs emissions of NO_2, PM/PM_{10}, and sulfates (SO_4), worst-case meteorological dispersion conditions and other default parameters. The screening procedure determines the light scattering impacts of particulate, including sulfates and nitrates, with a mean diameter of two micrometers and a standard deviation of 2 micrometers. The VISCREEN model evaluates both plume/sky and plume/terrain color difference and contrast.

The VISCREEN analysis was performed for the worst-case gas turbine operating scenario that resulted in highest impacts for NO_2, SO_2 and PM_{10} (Case #10). The analysis was performed assuming that all emitted particulate from the gas turbine stacks would be PM_{10}, 10 percent of the emitted NO_X would be NO_2, and 5 percent of the emitted SO_2 would be SO_4, which result in a conservative assessment of visibility impacts.

The proposed project is predicted to have no area of significant visual impact and there are no EPA-defined Class I areas nor analogous designated areas within The Bahamas within 151 km (93.8 mi) of the project. Therefore, the visibility assessment was performed for an observer located at a minimum distance of 11.3 km (7 mi) from the project site (which is the approximate distance between Ocean Cay and Cat Cay). The maximum source to observer distance was assumed to be 18 km (11.2 mi), which would correspond to the northernmost extent of Cat Cay (the closest inhabited island). A conservative background visibility range of 20 km (12.4 mi) was also used in the VISCREEN analysis.

An atmospheric stability classification of F (based on the stability category classification system given by Turner [1970]) and a wind speed of 1 m/s (3.2 ft/s), which are representative of moderately stable atmospheric conditions, are the default meteorological conditions for a Level-1 screening analysis using the VISCREEN model. However, an evaluation of the representative meteorological data used in the refined ISC-PRIME modeling analysis indicated that F stability conditions do not occur at a 1 m/s (3.2 ft/s) wind speed when the wind is blowing from the south or south-southeast (the directions from which the plume could potentially be visible on Cat Cay). Based on EPA guidance for performing a Level-2 screening analysis, the most conservative meteorological condition was determined to be F stability at a 3 m/s (9.8 ft/s) wind speed. Therefore, these conditions were used in the VISCREEN analysis. It should be noted that due to the approximate south – north orientation between Ocean Cay and Cat Cay and the relatively small land area of Cat Cay, the worst-case meteorological conditions with the greatest potential to produce a visible stack plume to an observer on Cat Cay are estimated to occur less than only 1 percent of the time. In other words, based on the representative meteorological data used for the refined ISC-Prime dispersion modeling, F stability conditions at a 3 m/s (10 ft/s) wind speed occur less than 1 percent of the time when the wind is from the south or south-southeast. Therefore, even if a visible plume was predicted to occur on Cat Cay with the VISCREEN model run with the assumption of worst-case meteorology, it would occur infrequently.

The results of the analysis are presented in Table 5-14, which indicates that the gas turbine exhaust plumes will not impact visibility in the area surrounding the plant. The color difference and contrast parameters were below the EPA default criteria for a visibility screening analysis.

Table 5-14

VISCREEN Maximum Surrounding Area Visual Impacts[a] AES Ocean LNG, Ltd.

Background	Theta[b] (degrees)	Azimuth[c] (degrees)	Distance (km)	Alpha[d] (degrees)	Delta E[e]		Contrast[f]	
					Criteria	Plume	Criteria	Plume
Inside Surrounding Area								
Sky	10	130	13.8	39	2.00	0.748	0.05	0.002
Sky	140	130	13.8	39	2.00	0.273	0.05	-0.005
Terrain	10	84	11.3	84	2.00	0.608	0.05	0.007
Terrain	140	84	11.3	84	2.00	0.119	0.05	0.004
Outside Surrounding Area								
Sky	10	1	1.0	168	2.00	1.118	0.05	0.009
Sky	140	1	1.0	168	2.00	0.227	0.05	-0.010
Terrain	10	1	1.0	168	2.00	1.815	0.05	0.024
Terrain	140	1	1.0	168	2.00	0.468	0.05	0.022

[a] Based on the total project emissions
[b] Theta is the vertical angle subtended by the plume
[c] Azimuth is the angle between the line connecting the source, observer and the line of sight
[d] Alpha is the angle between the line of sight and the plume centerline
[e] Color difference parameter (dimensionless)
[f] Visual contrast against background parameter (dimensionless)

5.8.2 Visual Impacts of Project Facilities

Conceptual visual renderings of the proposed project facilities were developed based on the site layout (Figures 5.5, 5.6 and 5.7). The renderings for the Ocean Cay facilities are representative views, which incorporate the significant features of major systems and structures for presentation purposes. The layout shows Ocean Cay with the proposed island expansion, shore protection, ship berthing facilities, proposed LNG and LPG tanks, desalination plant and associated ancillary facilities. A three-dimensional (3D) model was developed from the site layout plans after adding height and profile information for each component and structure, as shown in Table 5-14. The 3D model was developed using AutoCAD 3D Accurender, assigning the appropriate materials, colors, lighting, and environmental factors (such as water and clouds). Each view of the proposed facilities was rendered by defining the viewer's location coordinates and the angle of sight.

The sizes, profiles and height information of the major components and structures were estimated based on preliminary project designs. The rendering incorporates typical LNG loading and unloading structures, LNG and LPG tanks, typical LNG/LPG ships, and ongoing mining operations. Shore protection and dock area representations were developed based on preliminary conceptual design drawings. The standard equipment, such as the simple cycle gas turbine plant, was based on typical plant equipment.

Based on scaled drawings of the project area, far field views of the proposed project facilities on Ocean Cay were generated from various locations in the direction of South Cat Cay. All renderings are calculated geometric objects in space and perspective. From approximately 1.6 km (1 mi) northwest of Ocean Cay, the facilities will be visible low on the horizon, as shown on Figure 5.8. From a distance of approximately 3.2 km (2 mi) the island is visible to the naked eye but the proposed project facilities are not discernable, as shown on Figure 5.9. Views of the proposed project facilities from a distance of approximately 6.4 km (4 mi) and 11.4 km (7 mi) away from Ocean Cay are also shown on Figure 5.9. As a conservative estimate of visual impacts the renderings, as compared to photographs, do not compensate for the curvature of the earth. Other factors including wave height and naturally occurring haze are also not accounted for in the artistic renderings. For these reasons, far field objects showing on a rendering may not in fact be seen by the naked eye. South Cat Cay represents the closest inhabited island and are located approximately 11.4 km (7 mi) north-northwest of Ocean Cay. Based upon the visual renderings performed, no significant visual impacts from the project facilities are anticipated on South Cat Cay. During pipeline construction, a short-term visual impact will occur at Cat Cay and South and North Bimini as the pipeline installation progresses north. The laybarge will travel at approximately 1 km (.3 mi) per day.

During construction, lighting will be utilized on and offshore of Ocean Cay for those activities requiring 24-hour shift work. Such activities are currently planned to include land reclamation and fill, deep dynamic compaction (DDC) ground improvements, and offshore dredge and pipelay activities. Onshore activities will be illuminated by the minimum number of portable lighting units required to support a safe work atmosphere. Offshore equipment, such as the dredge unit and the laybarges, will be equipped with their own lighting systems. Potential impacts from lighting will be minimized by limiting the number of lights to those necessary to the work activities being conducted, and positioning lights so that they are directed down towards the water or land where work is taking place. The impacts from lighting during construction will be temporary and limited to supporting specific 24-hour construction operations.

Permanent lighting associated with the operations of the Ocean Cay facility will be limited to the minimum amount of illumination required to support a safe and secure work atmosphere. Plant lighting will be installed between buildings and structures at a height not exceeding the height of buildings to minimize potential offsite impacts. Lighting for navigational aids, to support safe loading and unloading activities at the berthing location, at the airstrip and at the tops of the highest structures (tanks and flare stack) will also be installed. Lighting in open areas, or areas not utilized during nighttime hours, will be minimized to the extent possible. Security lighting will be installed as appropriate. Lights will be oriented to minimize potential impacts on inhabited islands in the area of Ocean Cay.

5.9 Cultural Resources Impacts

The potential impacts to cultural resources of construction and operation of the AES Ocean LNG project have been evaluated by conducting a remote sensing survey of the pipeline routes and construction right of way areas, performing an archival search, collecting underwater video and performing diver verification. The results of the work undertaken in the project areas are described in Section 4.4 and in Appendix Q. Based on fieldwork and research completed to date, there are not anticipated to be any impacts to cultural resources in the project area. The assessment of potential impacts to cultural resources on Ocean Cay, Bimini, and along the submerged pipeline routes is discussed below.

5.9.1 Terrestrial Ocean Cay

As concluded in Section 4.4, no cultural resources exist on Ocean Cay and in the area immediately offshore due to the man-made nature of the island and relatively short history of its existence. Although major modifications to Ocean Cay for island expansion, filling and construction are anticipated, no impacts to cultural resources will occur due the lack of these resources in this portion of the project area.

5.9.2 Terrestrial Bimini

Project areas on the Biminis include the pipeline landfall location to the BEC property on North Bimini and the development of permanent housing for workers and supervisors at a proposed location on South Bimini. Known cultural resources on the Biminis are described in Section 4.4.

The natural gas and potable water pipelines will be installed across the beach up Queen's Highway to the BEC property that currently houses the power generation equipment and water tanks for the Biminis. The BEC property has previously been developed and is currently a typical utility property without cultural resources present. No impacts to cultural resources are anticipated at the landfall point or along the previously developed roadway for the natural gas and potable water pipelines to the Biminis.

Although no impacts to cultural resources are expected at the potential locations of permanent housing construction on South Bimini, a survey for potential resources will be conducted and submitted as an addendum to this EIA. The report will summarize potential impacts to any identified cultural resources on the properties.

5.9.3 Submerged Pipeline Routes

The pipeline routes and the areas selected for the approach channel, turning basin, and island expansion were investigated by means of remote sensing, video surveys, and diver verifications. The remote sensing surveys included magnetometer surveys, side scan sonar surveys, subbottom profiling, and bathymetry measurements, as presented in Appendices D and E. Reconnaissance survey work was utilized to select the most appropriate pipeline route from the western and eastern proposed routes from Ocean Cay to the Biminis. Potential impacts to existing cultural resources were avoided by selection of the eastern route to the Biminis. The route east of the chain of islands stretching north towards the Biminis passes through much shallower water and as such is less likely to have been the site of navigational mishaps that contribute to submerged cultural resources. Factors supporting the selection of the eastern route are discussed in Section 8, Alternatives.

During the remote sensing survey and diver verification of the pipeline route to North Bimini, debris of modern manufacture was identified within the right-of-way for the pipeline construction. Specifically, debris was located as follows:

- S 528, M 822, M 852, M 866 - Anomaly was likely a pipe discarded during Ocean Cay dredge operations as shown on Figure 2.18.

- M 793, M 847, M 800, M 844, M 848, M 824 - Verified by diver to be a winch pulley and cable of modern manufacture and a concrete two-foot long iron bar, as shown on Figure 2.18.

- M 605, M 617, M 701, S 504, S 514 - Anomaly areas are possibly associated with the present Sapona site, which is located approximately 0.8 km (0.5 mi) west of the anomaly scatter documented on Figure 2.18. This anomaly area may also consist of wreckage of the barges and sailboats generated during the 1926 hurricane. An intensive area of ferrous scatter and debris in the immediate area is consistent with items that might have been on a vessel utilized for storage and includes automobile tires, bags of hardened cement, iron scatter, and possibly encrusted nails and other building materials as well as bits of cable and fasteners. Larger iron objects in this area, a winch and pulley mechanism, and large piece of joined superstructure material, possibly a stanchion, are pieces of modern iron shipwreck material.

The materials identified in the right-of-way of the construction were deemed to be of no cultural or historic value. Therefore there are no impacts expected to cultural resources during the construction or operation of the pipelines to North Bimini and the shallow water construction of the 610 mm (24 in) natural gas pipeline from Ocean Cay to the EEZ boundary and to Florida.

The construction right-of-way for the 610 mm (24 in) pipeline was investigated to a water depth of approximately 30 m (100 ft) by a shallow water geophysical survey. An additional geophysical survey including magnetometer and side scan sonar surveys was conducted from a water depth of 20 m (66 ft) to the EEZ. No anomalies associated with culturally significant resources were discovered during the survey. Deep water video will be collected at selected locations along the route from the 20 m (65.6 ft) line to the EEZ and this video will be reviewed for indications of cultural resources. Should items of cultural importance be identified, impacts to the resource will be minimized by approved methodologies up to and including modifying the route to avoid disturbance.

The near shore portions around Ocean Cay that are expected to be disturbed during the construction and operation of the project include the turning basin and approach channel to the south, areas to the west for island expansion and the water intake line, to the north for island expansion, and to the east for development of the SVH and staging of construction vessels. No resources of cultural significance were identified in these areas. The existing approach channel is of modern construction and debris identified in the near shore waters surrounding Ocean Cay is modern equipment associated with the current mining operation. No impacts to cultural resources are anticipated in the near shore Ocean Cay areas.

5.9.4 Unanticipated Discovery Plan

Over the course of project construction, remote sensing investigation and diver verification study, there is always the possibility of an unanticipated discovery. Based on the fieldwork completed during the fall and winter of 2001, no such discoveries have been made. To minimize potential impacts to as yet undiscovered resources, the project will implement an Unanticipated Discovery Plan. Under the plan, it is the responsibility of the principal archaeological investigator to make a preliminary assessment of such a discovery and relate the nature of the discovery to BEST. After discovery and assessment of the unanticipated resource, the protection of that resource would be of utmost importance. Protection may be undertaken in a number of ways. A protective buffer may be placed around the resource or the resource may be avoided by relocating the project element. Once an assessment has been made of the resource, the resource may be protected through the listing of the resource as a historic site or monument. If excavation, conservation, and curation is deemed necessary, that responsibility lies within the purview of the appropriate government agency or bureau.

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6.0 ENVIRONMENTAL MITIGATION PLAN

Mitigation measures where appropriate were developed to avoid and/or minimize potential impacts from the project. Potential environmental impacts are discussed in Section 5, and the proposed mitigation measures for the affected resources are discussed below. This section presents the project environmental mitigation plan for the affected resources and project hazards listed below:

- Marine Environment;
- Land Resources;
- Air Resources;
- Water Resources;
- Protected Areas;
- Plant and Wildlife Habitat;
- Geology and Soils;
- Natural Hazards;
- Fire and Hurricanes;
- Man Made Hazards;
- Social, Economic and Institutional Resources Impacts;
- Improvements to Infrastructure and Utilities;
- Visual Impacts; and
- Cultural Resources.

6.1 Marine Environment

Mitigation measures identified to avoid and/or minimize the potential construction and operational impacts of the proposed project to the marine environment are discussed in this section.

6.1.1 Commercial/Recreational Fisheries Resources

A variety of commercial and recreational fisheries resources occur in The Bahamas, as discussed in Section 4.1.7. The three primary commercial fisheries resources in The Bahamas are Spiny lobster, Queen conch, and Nassau grouper.

6.1.1.1 Commercial Fisheries

During the construction phase, potential impacts to commercial fisheries relate to loss of feeding and/or breeding habitats by disturbance of seagrass beds and coral reefs, or impacts due to construction activity and vessel traffic (e.g., noise and/or physical disturbance to the fisheries resources). Additionally, construction activities have the potential to interfere with the conduct of commercial fishing operations by temporarily obstructing access of fishermen to their fishing grounds.

Mitigation of impacts to seagrasses and coral reef habitats are discussed below in Sections 6.1.3 and 6.1.4. Since Spiny Lobster and Nassau Grouper are highly mobile and will likely avoid any marine construction areas, no mitigation is planned. Being less mobile, there is a potential for construction impacts to the Queen conch, however, this species was observed in limited areas of planned pipeline construction, as discussed in section 4.1.7. No habitat critical to Queen conch was identified in the areas to be dredged for the approach channel and turning basin.

There is no evidence to suggest that noise from boat traffic is detrimental to Spiny lobster, Queen conch, or Nassau grouper; therefore, no mitigation is planned. Advance notice of upcoming construction activities will be provided to local fishermen, in order to mitigate possible obstruction of potential fishing areas during construction. Additionally, the potential long-term operational impacts to commercial fisheries are discussed in Section 5. Potential impacts due to increased ship traffic will be mitigated by as the management plans described in Section 10, Environmental Management Plan.

6.1.1.2 Recreational Fisheries

Most recreationally fished species occur either on or near coral reefs, or in the deep waters of the Straits of Florida. Construction impacts to recreational fisheries, like commercial fisheries, may be related to impacts to critical feeding and/or breeding habitats including seagrass and coral reefs. During the construction phase, potential impacts to recreational fisheries relate to loss of feeding and/or breeding habitats by disturbance of seagrass beds and coral reefs, or impacts due to construction activity and vessel traffic (e.g., noise and/or physical disturbance to the fisheries resources). Additionally, construction activities have the potential to interfere with the conduct of recreational fishing operations by temporarily obstructing access of fishermen to their fishing grounds.

Mitigation of impacts to seagrass and coral reef habitats are described below in Sections 6.1.3 and 6.1.4. Based on the current data and as discussed in Sections 4 and 5, significant construction impacts to recreational fisheries are not anticipated. Since no construction impacts to recreational fisheries in deep water are anticipated, no mitigation measures are planned. In order to mitigate for temporary obstruction of fishing areas during construction, advance public notice will be provided to fishermen in the region so they can plan upcoming recreational trips accordingly. Once the facility is fully operational, there are no anticipated impacts to recreational fisheries and mitigation is not required.

Recreational boaters and fishers will not be significantly affected by construction because the area in which construction will occur is confined to a small area. Recreational boaters and fishers are highly mobile and will easily be able to avoid the small work area.

6.1.2 At Risk Species

At risk species, including endangered species, that may potentially occur in the project area are identified and discussed in Section 4.1.6.4. Several species of whales and dolphins are known to occur in waters around The Bahamas Islands, particularly in the Straits of Florida, a common passage for migration between southern breeding grounds and more northern feeding grounds. None of these species is known to reside year-round in The Bahamas, nor are critical breeding or feeding areas known to occur within the project area. Therefore, mitigation for possible disturbance to potential food resources or breeding habitat will not be necessary

Potential impacts to migrating whales and dolphins during construction are discussed in Section 5.7.1.3. Mitigation measures will be necessary during construction in deep water at times when migration events are anticipated to occur, primarily in the early spring and late fall. In order to mitigate for potential impacts to marine mammals due to vessel traffic or during possible blasting activities, a monitoring and deterrence program will be implemented as described in Section 10. There will be no anticipated impacts to marine mammals once the facility is operational; therefore, mitigation measures will not be required.

With the exception of marine mammals and turtles, no other at-risk marine species are known to occur or utilize habitats within the project area; therefore, mitigation measures are not necessary. Terrestrial based endangered species are discussed below in Section 6.2. Turtles are discussed below.

6.1.2.1 Turtles

Several species of sea turtles potentially occur within the project area and are identified in Section 4.1.6.4. In particular, the green turtle, *Chelonia mydas*, is an endangered species known to occur and nest on some beaches in The Bahamas. However, as described in section 4.1.6.4, sea turtles are not known to nest on any beaches on Ocean Cay. Therefore, there are no anticipated impacts related to construction activities. Sea turtles utilize a variety of habitats including seagrass beds and low relief reef areas, and impacts to these habitats will be minimized as described in Section 5, and through mitigation plans discussed below in Sections 6.1.3 and 6.1.4. Potential impacts to sea turtles include the potential for collisions with work vessels and disruption of nesting patterns due to induced lighting. Mitigation of potential impacts due to increased vessel traffic and to nesting grounds on nearby Cays due to lighting during construction will be implemented in accordance with the sea turtle mitigation plan described in Section 10. There are no anticipated long-term impacts to sea turtles once the project is operational; therefore, no additional mitigation measures will be implemented.

6.1.3 Seagrass Habitats

Seagrass habitats are common around Ocean Cay and along portions of the proposed pipeline routes. A description of the occurrence of these habitats within the project area is provided in Section 4.1.6 and observed seagrass habitats are shown in Figure 4.16. These habitats consist primarily of seagrasses, and may include a variety of macroalgae. Seagrass (and seagrass/algae) habitats will be impacted during construction by activities including dredging, anchoring, and jetting as described in Section 5. Natural reestablishment of seagrass habitats will occur given appropriate bottom conditions, temperature and light, with significant habitat recovery potentially occurring within 3-5 years. In order to ensure that seagrass recovery is occurring in areas impacted by construction activities, a 5-year seagrass monitoring program will be implemented. A proposed seagrass monitoring program is discussed in Section 10.

Once the facility is operational, no long-term impacts to seagrass areas are anticipated. Results from the seagrass monitoring program (described in Section 10) will provide an indication if unanticipated operational impacts occur that may influence the natural recovery of seagrasses. If unanticipated potential long-term operational impacts are detected, potential mitigation measures will be agreed upon and implemented at that time.

6.1.4 Coral Reef and Hardbottom Habitats

Coral reef habitats are described and discussed in Section 4.1.6. Potential impacts to coral reef areas are discussed in Section 5, and are anticipated to be minimal due to the small area of coral reef present within the project area. Where necessary, mitigation of impacts to coral reef areas will be done in two ways. First, selection of the eastern route for the 60 mm (2 in) and 219 mm (8 in) pipelines from Ocean Cay to North Bimini on the Bahamas Bank avoids known coral reef areas, as discussed in Section 8. Second, mitigation of impacts to coral reef areas at the western edge of the Bahamas platform, west of Ocean Cay, will involve implementation of specialized construction techniques during installation of the 610 mm (24 in) pipeline. These specialized techniques include installation of articulated concrete mats in hardbottom areas of less than 30 m (98.6 ft) water depth to avoid trenching impacts in hard bottom areas, for the 610 mm (24 in), 60 mm (2 in) and 219 mm (8 in) pipelines. Once the facility is fully operational, additional impacts to coral reefs are not anticipated and no mitigation measures are planned.

6.1.5 Other Benthic Habitats and Faunas

Other benthic marine habitats and faunas include sand/soft bottom/rubble bottom areas inhabited by sessile invertebrates such as soft corals, sponges, and/or tunicates, and soft bottom habitats supporting diverse infaunal communities that may include molluscs, crustaceans, and polychaetes. Distribution of benthic marine habitat types is discussed in Section 4.1.6.2 and shown in Figure 4.16 and 4.17. Construction impacts to benthic habitats are discussed in Section 5. Mitigation of potential impacts to benthic habitats, other than seagrass beds and coral reefs is anticipated to occur through natural reestablishment of bottom conditions and resettlement of associated faunas. Natural forces of currents and tides should restore the pre-construction distribution of soft bottom sediments that will be recolonized by infaunal organisms. Most invertebrates have planktonic larval stages and recruitment of new populations will occur relatively rapidly in areas where appropriate substrate for settlement is available. Organisms that can undergo asexual reproduction, such as sponges, have the ability to reestablish themselves from impacted populations.

Long-term impacts from installations, such as shore protection, cobble beaches, and concrete mats are discussed in Section 5. Loss of soft-bottom habitat due to installation of hard surface structures will be mitigated by the creation of new habitats. Hard surface installations will serve as substrate for settlement of a variety of sessile marine organisms, forming new communities that will replace the original soft-bottom benthic communities.

6.2 Land Resources

As described in Section 2.3.1.1 and 2.4.1, Ocean Cay will be expanded from an area of approximately 38 hectares (95 acres) to an area of 112 hectares (276 acres) (including shore protection structures). Due to the industrial nature of Ocean Cay, terrestrial resources are limited. Thus, no impacts to land resources are anticipated from the construction and operation of the facilities and no mitigation measures will be required. Threatened and endangered terrestrial species occurring in The Bahamas are listed in Table 4-16. These species were not observed (see section 4.1.8) and are not expected to be found in the vicinity of the project area therefore, mitigation will not be required.

Mitigation strategies for potential impacts to land resources on the Biminis will be created upon completion of the baseline evaluation of the Biminis, which will be submitted as an addendum to this EIA.

6.3 Air Resources

As discussed in Section 5.5, the AES project will have insignificant impacts on local and regional air quality. Construction impacts on air quality will be mitigated through construction management practices, including the use of appropriate dust suppression measures. Air quality impacts from operation of the project's gas turbines will be minimized by the combustion of clean natural gas as the primary fuel and low-sulfur distillate oil as the backup fuel. In addition, the gas turbines will be designed for high-efficiency with advanced combustion controls to further minimize fuel consumption and pollutant emissions. In addition to having insignificant air quality impacts, the proposed emissions from the gas turbines will comply with State of Florida and US Federal regulatory emission limits, Best Available Technology (BACT) requirements, and World Bank Guidelines. Other minor and infrequent sources of emissions from the project, including the LPG removal hot oil system heater, emergency diesel fire pump, emergency generator and fuel oil storage tank, will have appropriate controls as described in this section.

6.3.1 Gas Turbine Emissions Mitigation

The desalination plant and the LNG facilities will be provided with the required electrical power by either two gas turbines (each rated at 100%) or three gas turbines (each rated at 50%). One of the gas turbines will be designed for dual fuel operation with natural gas as primary fuel and distillate oil as the backup fuel.

The gas turbines that are being considered for the LNG facility power generation include the ABB GT 35C, or equivalent, for the 15 MW case and GE LM 2500, or equivalent, for the 30 MW case.

The gas turbines will be equipped with inlet coolers to maintain efficiency at high ambient temperatures. The proposed gas turbines represent one of the most efficient designs available, resulting in less fuel burned and lower emissions per megawatt hour of electricity produced compared to less efficient designs.

In the US, a proposed major stationary source located in an attainment area for all criteria pollutants (i.e., meeting Ambient Air Quality Standards) is required to demonstrate that Best Available Control Technology (BACT) will be used to control emissions of each pollutant subject to review. A BACT analysis is an assessment of technical, environmental and economic impacts of various emission control options. The BACT analysis is performed by application of a “top down” methodology to define the highest level of control possible and demonstrated in practice, which is both technically feasible and can be implemented at a reasonable cost. Control options are first evaluated for their technical feasibility. Options found to be technically feasible are ranked by control efficiency. In the event the most stringent level of control is ruled out due to cost, energy consumption, or environmental impacts, the next most stringent level of control is analyzed until BACT is determined. In no event shall application of BACT result in emissions of any pollutant that would exceed the emissions allowed by any applicable regulatory standard (e.g., the EPA New Source Performance Standards).

Although the proposed AES project is not under the jurisdiction of the State of Florida or the United States, a BACT analysis was performed and the summary report is provided in Appendix R. Based on the results of this control technology analysis, the controls summarized below in Table 6-1 were determined to be BACT in this case:

Table 6-1

BACT Controls

Pollutant	Control Technology
PM_{10}	• Natural gas primary fuel • Low sulfur No. 2 distillate fuel oil (infrequent backup fuel) • Inlet filters, and demineralized water injection
NO_x	• Dry low NOx combustor or water injection for natural gas primary fuel • Water injection for backup liquid fuel • Combustion controls
VOC	• Low molecular weight gaseous fuel • No. 2 distillate fuel oil backup fuel • Combustion controls
CO	• Natural gas or No. 2 distillate fuel oil for high combustion efficiency • Combustion controls
SO_2	• Natural gas primary fuel • Low sulfur No. 2 distillate oil backup fuel
H_2SO_4	• Natural gas primary fuel • Low sulfur No. 2 distillate oil backup fuel

The justifications for the proposed gas turbine emissions controls are provided in the BACT report in Appendix R. Due to the variability in gas turbine vendor emissions estimates/guarantees and the fact that a variety of different gas turbine manufacturers and two different configurations are still being evaluated by AES for use in the project, the maximum emissions representing the proposed control technologies are presented in the BACT analysis. The proposed emission rates were also compared to the respective EPA New Source Performance Standards for gas turbines (adopted by reference by the State of Florida) and World Bank Guidelines (see Table 6-2 in Appendix G). The comparison demonstrated compliance of the worst-case emissions with these regulatory limits and guidelines.

Stack testing will be performed on a biannual schedule on each of the gas turbines to determine emissions from the equipment. Stack testing will be conducted for the parameters specified in the manufacturer's performance specification. The results of the stack test will be compared against the results obtained in the initial commissioning stack test, and changes in performance will be noted. If performance of the units results in increased air emissions over that anticipated, appropriate mitigation will be proposed.

In addition, AES will install a continuous emission monitoring system (CEMS) to continuously monitor emissions of NO_X and CO from the gas turbines as well as opacity of the stacks. The CEMS for NO_X and CO will consist of one time-shared system that will monitor emissions from the maximum of two gas turbines that will be operated at the same time. A continuous opacity monitoring system (COMS) will be installed on each gas turbine stack to monitor for visual opacity due to particulate emissions. The CEMS and COMS will be designed, maintained and operated in general accordance with US EPA continuous monitoring performance specifications (40 CFR Part 60, Appendix B). NO_X and CO emissions will be monitored on a parts per million dry volume basis, corrected to 15 percent O_2 (ppmvd @ 15% O_2). Opacity will be monitored on a percent opacity basis. The monitored parameters will be compared to the proposed BACT-derived emissions limitations as summarized below.

Table 6-3

Emission Monitoring Parameters

Pollutant	Emission Limit[1]		Averaging Period
	Natural Gas	No. 2 Fuel Oil	
NO_2	25 ppmvd @ 15% O_2	60 ppmvd @ 15% O_2	24-hour rolling
CO	25 – 68 ppmvd @ 15% O_2 (depending on selected gas turbine vendor)	50 ppmvd @ 15% O_2	3-hour block
Opacity	20%	20%	6-minute block

[1] Listed emission limits are based on full load operations. CO emissions would be higher at part load (50 – 75% load) conditions.

6.3.2 LPG Removal Hot Oil System Heater Emissions Mitigation

The LPG Removal Hot Oil System heater is fired exclusively with natural gas. Exclusive use of clean burning natural gas will minimize emissions of SO_X and PM_{10}. Good combustor design and combustion control will be used to minimize NO_X, VOC and CO emissions. A low-NO_X burner design will further reduce NO_X emissions and is considered BACT.

6.3.3 Emergency Diesel Engine Fire Pump and Generator Emissions Mitigation

The diesel reciprocating engine-powered fire pump and backup generator will only be used in emergency situations and/or during an electrical power failure. It is estimated that each would operate typically only for 50 to 100 hours per year for engine exercising and maintenance purposes and at most for several hundred hours annually in the event of an emergency or power outage. The stationary diesel engines will be fueled exclusively with low-sulfur diesel fuel to minimize emissions of SO_2 and PM_{10}. The diesel engines will also use fuel injection timing retard, turbocharger after cooling, proper combustion controls and inlet air filtering to minimize emissions of NO_X, PM_{10}, CO and VOC.

6.3.4 Diesel Fuel Storage Tank Emissions Mitigation

Primary gas fuel supply will be provided by regasifying the LNG stored in tanks on-site. A liquid fuel tank will be provided for the low sulfur No. 2 distillate fuel oil, which will be used as backup fuel for one of the gas turbines. The storage of liquid fuels results in trace emissions of VOCs. EPA New Source Performance Standards applicable to large storage tanks do not require any emissions control if the stored material has a vapor pressure less than 5,200 Pa (0.75 psia). Distillate fuel oil has a vapor pressure of less than 340 Pa (0.05 psia) at the maximum temperature predicted for the project location. The proposed tanks will be equipped with conservation vents, which is the universal control for these tanks and fuel type.

6.3.5 Construction Air Quality Impact Mitigation

Project related air quality impacts during construction are expected to include fugitive dust emissions at the project site from ground excavation, fill operations, and removal of debris, as well as construction vehicle emissions, marine vessel emissions and portable generators. Electric incinerating toilets will also be used for sanitary facilities during construction. Typical practice for fugitive dust control is to treat land disturbed during construction and grading, if necessary, in a way that minimizes visible airborne particulates. Because the construction period is limited and activities change during the construction phases, these emissions are only temporary and vary throughout this period.

Potential emissions of fugitive dust will depend on such factors as soil properties (i.e., moisture content, volume of spoils, and soil silt content), meteorological variables (wind speed and precipitation), and construction practices employed. Fugitive dust emissions will be minimized through the use of dredged fill material, which will be pumped in a slurry form via pipeline into dewatering basins located near the final reclamation areas. In addition, construction equipment used for final grading will handle fill material with high moisture contents and minimal potential to generate fugitive dust. To further minimize emissions of airborne particulates, fugitive dust will be mitigated using the following measures, as necessary:

- The use of water on areas of exposed soils, if necessary; and
- Final grading and landscaping of exposed areas as soon as possible.

Emissions from vehicles and other engine-driven construction equipment will be temporary and cease once the project is completed. Nevertheless, mitigation measures will be implemented, as practical, including proper maintenance of construction equipment and controlling unnecessary idling of equipment.

The electric incinerating toilets include a venting system equipped with a catalyst for odor control. The combination of waste combustion temperatures and the catalyst will mitigate potential emissions from the use of the temporary sanitary facilities.

6.4 Water Resources

As described in Section 4.5.1, fresh water resources on Ocean Cay are extremely limited. There are no naturally occurring freshwater lakes, ponds, or streams. No impacts to fresh water resources are anticipated from the construction and operation of the facilities described in Section 2.3 and 2.4 and no mitigation will be required. However, stormwater runoff during construction and operation of the project may potentially become contaminated prior to discharging to the ocean. As a result of the potential impacts of stormwater, a stormwater management and emergency spill plan have been created for both construction and operation as discussed in Section 10, Environmental Management Plan.

Mitigation strategies for potential impacts to water resources on the Biminis will be created upon completion of the baseline evaluation of the Biminis, and will be submitted as an addendum to this EIA.

6.5 Protected Areas

As described in Section 4.1.9, there are no designated Protected Areas in the vicinity of the project area. Therefore, there will be no impacts from the construction and operation of the facilities described in Section 2.3 and 2.4; as such, no mitigation will be required.

6.6 Terrestrial Plant and Wildlife Habitats

No significant impacts to plant and wildlife habitats are anticipated on Ocean Cay as described in Section 5; therefore, no mitigation measures will be required. Mitigation strategies for potential impacts to plant and wildlife habitats on the Biminis will be prepared upon completion of the baseline evaluation of the Biminis.

6.7 Geology and Soils

Approximately 6.6 million cubic meters (8.6 million cubic yards) of earth material will be excavated from its current location and placed at some other location in the course of project construction, as described in section 2. To prevent loss due to erosion, exposed soil materials will be protected by surface treatments such as armoring, pavement and vegetation as described in Section 10 Environmental Management Plan. No further mitigation measures are proposed.

6.8 Natural Hazards

As discussed in Section 5.3, Natural Hazards, several types of natural disasters may occur in the vicinity of the project area including severe storms and tropical hurricanes, flooding, and earthquakes. The mitigation strategies for each of the aforementioned natural hazards are discussed below.

6.8.1 Hurricanes and Flooding

Natural hazards associated with storm events include those arising from storm waves/surges, high winds, and torrential rainfall as discussed in Section 5.3.1. For protection against wave run-up and over topping, shore protection features will be constructed to protect the proposed island footprint. The LNG and LPG tanks will be designed to withstand a Category 5 hurricane and the remaining components of the facility will be designed for a Category 3 hurricane. These design parameters will protect against high winds, as well as storm surge and wave effects, associated with these relatively infrequent meteorological events.

Shore protection structures will be designed to withstand the impacts from a 100-year storm as described in the MetOcean Report included in Appendix A. Based on design evaluations, shore protection features will be incorporated to further stabilize the island and its operational features. These include T-groins, cobble beaches, revetments, and concrete caissons, which will be installed as part of the Ocean Cay island expansion discussed in Section 2.3.1.1. Stormwater runoff during deluge storm events will be managed as described in Section 3.5, and should not be an issue given the island's small size and short times of travel for sheet flow discharges to its perimeter.

6.8.2 Earthquakes

As discussed in Section 5.3.2, seismic hazard analyses indicate that only minor ground shaking with a mean repeat time of 4,975 years is likely to be experienced at Ocean Cay. Based on these analyses, maximum horizontal component peak ground accelerations at the top of bedrock of 0.012g and 0.023g were recommended for the Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE), respectively. These values were determined for design of the LNG facility in accordance with requirements of NFPA 59A (2001). Using these values, engineering analyses are being performed to estimate response spectra for peak accelerations at the ground surface. The LNG tanks and piping will be designed for seismic loading based on the response spectra.

6.8.3 Tsunami

As discussed in Section 5.3.3, tsunamis are not expected to occur in the vicinity of the project area; therefore, mitigation strategies for tsunamis have not been developed.

6.9 Man Made Hazards

Man made hazards that may potentially occur during the construction and operation of the project are discussed in Section 5.4, Man Made Hazards. These man made hazards include but are not limited to the following:

- Spills;
    - Fuel Oil;
    - LNG/LPG;
- Fire and Explosion;
- Marine Safety; and,
- Worker Safety.

The potential impacts of each of the aforementioned hazards are discussed in Section 5.4 of this EIA. The mitigation strategy for each hazard is discussed below.

6.9.1 Spills

During construction, fuel will be distributed over water to several types of vessels, including the dredge barges, the pipelay barges, the water treatment barge, the concrete batch plant barge, and the quarters barges or cruise ship. The potential for equipment leaks from fuel and hydraulic systems will be avoided and/or reduced by implementing a scheduled mechanical preventive maintenance for equipment, as discussed in Section 5.4.1. Fueling will be conducted in a manner consistent with the spill prevention and response plan prepared by the construction contractor under the guidelines set forth by AES and contained in the plan discussed in Section 10, Environmental Management Plan. This plan will require booms to be deployed prior to beginning fuel transfer, and each transfer to be visually monitored for the potential of release. Furthermore, the plan will require fuel tender personnel to be instructed in the means of stopping, minimizing and responding all leaks and spills (if any) using spill containment/cleanup equipment maintained on each vessel. The construction contractor will be required to have active contracts in place with third party emergency response/cleanup companies to provide additional assistance if necessary.

Given these management controls, the potential impact from a fuel oil spill on water would be restricted to the small area within the deployed booms. Within this area, oil will be removed from the surface of the water, to the extent possible, using equipment and materials maintained adjacent to the location of fueling operations or supplied by the third party response contractor (depending in the size of the release). The potential biological impacts of such a release are discussed in Section 5.4.1.

In addition to construction barge fueling operations, fuel oil will be transferred from oil delivery barges to onshore tanks during both the construction and operational phases. The fuel barge will be berthed in the support vessel harbor at the fuel station, as shown on Figure 1.4. These operations will be managed in a manner consistent with the requirements of both the construction phase and operational phase spill plans, as discussed in Section 10, Environmental Management Plan.

As with barge refueling operations, barge to tank transfer procedures will require the barge and onshore crew to visually monitor every fuel transfer to the onshore tanks. Tank volumes, which will be monitored by level sensing devices, will be checked prior to the start of transfer to ensure that there is sufficient volume to receive the delivery. The spill plans discussed in Section 10 will require documentation of volume readings before and after the transfer, as well as other important control measures such as inspections of hoses and mooring lines, verification of communications equipment and signals, and pre-transfer conferences.

Spills at the support vessel harbor (if any occur) will be contained within the area by booms deployed prior to each transfer. To the extent practical, spilled oil will be recovered from the water surface using spill equipment maintained at the support vessel harbor.

Onshore fuel tanks will be provided with a secondary containment system that will limit the potential impact of releases due to tank failure. The area impacted by a worst case tank failure would be limited to the area of the secondary containment, which will be impervious to the fuel oil and sized to contain the entire contents of the tank. Piping provided to transfer the fuel oil from the point of delivery to the dispensing tanks will be constructed aboveground and inspected frequently to minimize the potential impacts of a pipe leak during transfer. Operators will be provided with spill response materials and training to adequately respond to a pipe leak and minimize the land area potentially impacted by the release. Following transfer, the lines will be blown through to the tanks to minimize potential releases from the piping system between delivery operations.

The potential impacts from spills of materials other than fuel oil will be minimized and controlled in a similar manner. Portable secondary containment will be used to the degree possible during construction to store drums of chemicals. During the operational phase, chemicals will be stored in a secure warehouse provided with secondary containment floors and dikes. The warehouse will be supplied with sorbent and other materials to minimize the area impacted during a release and clean up the spill.

6.9.2 Fire and Explosion

Fire and explosion hazards at Ocean Cay from the receiving, storage, separation, and sendout of LNG, LPG and natural gas are detailed in the document entitled "LNG Terminal Hazards and Safety Considerations, Ocean Cay, Bahamas" (Hazard Analysis), provided in Appendix C. Control systems and operational standards will be in place to minimize the potential for a fire or explosion and the resultant impacts to the operation, island and personnel.

The Hazard Analysis considers the various hazards and potential effects on public safety that could occur in the operation of the LNG Import Terminal on Ocean Cay, The Bahamas with respect to siting and the operating procedures at the terminal. The design and construction of LNG facilities required modeling of the hazard zones that could result from code-specified releases of LNG. The results of these calculations are used to determine if a LNG facility of a specific design and layout can be located on a site without causing an unacceptable impact to the safety of the public who live or work near the site. In this study the requirements of NFPA 59A (2001) and the provisions of U.S. Federal Regulations for LNG Facilities were followed. Because the hazard zones would lie within the property of Ocean Cay or over adjacent water, these requirements are met.

NFPA 59 “Utility LP-Gas Plant Code” has been applied to the LPG portion of the facility. This code does not require analysis of spill and fire scenarios as is done for LNG. However, spill control, leak detection and plant safety features will be equivalent for the LNG and the LPG portions of the plant.

Releases of cryogenic or low temperature liquid (e.g., LNG) due to spills, leaks, or intentional draining can expose facility personnel to several hazards. These hazards include oxygen deficiency, freezing injuries, fire hazards, and explosive air-gas mixtures.

As required by NFPA 59A and to minimize impacts to personnel and facilities, impoundment areas (secondary containment) will be provided for each of LNG/LPG Tank. Impoundments will be sized to handle credible size spills that could occur in any of these areas as described in the appropriate sections of this document. The liquid spilled from a flange leak or other source in these areas will flow into a channel or curbed area that will direct the flow into an impoundment area.

6.9.3 Marine Safety

Shipments of LNG and LPG will comply with the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), International Maritime Organization 1993. Coordination of ship arrivals and departures will be controlled by the Ocean Cay operation. Procedures for inspection and safety checks will be performed on each shipment, prior to the unloading/loading operations and before the vessel is released from Ocean Cay.

The Marine Safety Plan, included in Appendix U, discusses the safety procedures and recordkeeping requirements for LNG and LPG shipments. The AES project will adhere to this plan as well as other international standards and norms. Worldwide there has never been a serious incident involving a LNG or LPG ship involved in product transport as envisioned for the AES project. By implementing the management controls specified in the Marine Safety Plan, AES expects no marine safety-related impacts to The Bahamas due to the shipments of LNG and LPG.

A marine safety plan will be established and implemented in conjunction with the Bimini Port Authority to avoid or minimize potential hazards to navigation during installation of the pipeline.

6.9.4 Worker Safety

The potential for impacts to worker safety will be minimized to the extent possible through the use of a detailed construction health and safety plan, operating procedures prepared to safeguard workers, and a thorough and ongoing training program for the site workers. A construction health and safety plan for the construction phase of the project is included in Section 10. The selected construction contractor will be responsible for preparing the detailed health and safety plan in accordance with the minimum guidelines provided in Section 10 and specific to the activities planned at Ocean Cay.

6.10 Social, Economic and Institutional Resources

The proposed project will have a net positive impact on social, economic and institutional resources; therefore, mitigation measures are not required.

6.11 Improvements to Infrastructure and Utilities

The proposed project will have a net positive impact on infrastructure and utilities; therefore, mitigation measures are not required.

6.12 Noise Impacts

As described in Section 5.6, there will be no significant noise related impacts anticipated from the construction and operation of the facilities described in Section 2.3 and 2.4; therefore, no mitigation measures will be required.

6.13 Visual Impacts

As described in Section 5.8, there will be no significant impacts to visual resources from the construction and operation of the proposed project; therefore, no mitigation is planned.

6.14 Cultural Resources

As described in Section 5.9, there will be no significant impacts to cultural resources anticipated from the construction and operation of the proposed project; therefore, no mitigation is planned. In the event of the unanticipated discovery of significant cultural resources, the Unanticipated Discovery Plan included in Section 10, Environmental Management Plan, will be implemented.

7.0 CUMULATIVE IMPACTS

Cumulative impacts occur when impacts from the proposed project have an additive effect on the impacts resulting from existing major facilities, from reasonably foreseeable changes to existing facilities, or from reasonably foreseeable future projects within the project area. Cumulative impacts identified for the AES project are presented below for each scenario.

7.1 Cumulative Impacts from Existing Major Facilities

The aragonite mining operation is the primary existing major facility in the project area that presents the possibility for cumulative impacts in conjunction with the proposed development on Ocean Cay. These cumulative impacts primarily relate to emissions of airborne particulates and other air pollutants, sediment and other water pollutants, and noise. Marine traffic impacts, visual (aesthetic) impacts, and socioeconomic impacts (on The Biminis) will also be cumulative but minimal as described below.

7.1.1 Air Emissions

Although the mining operation typically manages mined aragonite sand with a high moisture content, there exists the potential for some dust emissions from the operation. The cumulative impact of the particulate emissions anticipated from the AES project added to the existing particulate emissions from the mining operation is expected to be well below ambient air criteria for emission of particulate matter. Cumulative particulate matter is assumed to be higher during the construction period than during operations.

The mining operation uses diesel-burning generators to produce electricity, which typically emit greater levels of air pollutants than natural gas powered generators. After the AES project gas turbines are installed, the small diesel generators used to power the mining operations will be relegated to emergency backup use and main power will be supplied to the mining operation by the AES generators. As a result, the cumulative impact on pollutant concentrations in the immediate vicinity of Ocean Cay will be a positive one. Not only will the emission rates from the proposed AES gas turbines be the same order of magnitude as the combined emissions from the existing mining operation’s diesel engines, but the gas turbines will also have much better dispersion characteristics (higher stacks and much higher stack gas exit velocities) than the existing diesel engines. This will result in lower ambient air pollutant concentrations.

7.1.2 Water Pollutants

There will be a cumulative, although temporary, impact on surrounding waters as a result of sediment discharge during island expansion, which will add to that currently released during mining operations. Such sediment discharges will be closely controlled, as described in Sections 2.4 and 5. After construction is completed, control structures will be installed as part of the mining operation relocation to minimize sediment discharge from onshore dewatering of the mined sand. Furthermore, sedimentation and erosion at the project facilities will be controlled through grading and stabilization, as described in Section 10. Therefore, no measurable cumulative impact from sediment discharge is anticipated after the new facilities become operational.

As for other water pollutants, cumulative impacts will result from the storage, use and disposal of industrial materials (fuels, chemicals, solid wastes). However, due to the improved storage and handling practices developed for the AES project, which will also be operated for the benefit of the mining operations, the cumulative impacts are expected to be positive. In particular, fuel storage and handling on Ocean Cay will be improved by replacing the current underground petroleum storage facilities used by the mining operation with aboveground storage tanks equipped with integral secondary containment and by replacing current fueling operations with procedures and facilities that minimize releases to either terrestrial or marine resources.

7.1.3 Marine Resources

Cumulative, but temporary, impacts on marine resources in the project area are expected as a result of dredging and pipeline installation in addition to the disturbance associated with current mining operations. Such cumulative impacts to the marine environment in the area include disturbance of developed seagrass areas and other bottom habitats, as well as temporary interruption of the movement of marine species in the immediate area. The cumulative impacts on the marine environment surrounding Ocean Cay are expected to be very minimal following the AES project construction period. Although further development of mining locations, as allowed under the terms of the Crown Lease, will be conducted in the future, areas proposed to be mined do not directly intersect areas associated with construction of the pipelines to the Biminis. In fact, a permanent right-of-way will be established for the pipeline installation that would prevent mining in the same locations. Furthermore, only minimal and infrequent maintenance dredging of the approach channel and turning basin will be required during operation of the proposed project. Thus, cumulative impacts are not expected at those locations after the project begins operations.

7.1.4 Noise

The noise impact assessment described in Section 5 was performed using the baseline assumption that noise impacts from constructing and operating the proposed project were additive to the noise sources already in existence on Ocean Cay (i.e., the mining operation). As described in Section 5, although the cumulative noise emissions during both construction and operation of the proposed project on Ocean Cay will be greater than currently exist, the resultant increase in noise will be inaudible at the nearest sensitive receptor (Cat Cay) and below established limits for noise emissions.

7.1.5 Marine Traffic

There will be additional ship and barge traffic around Ocean Cay during both construction and operational phases of the proposed project as compared to existing levels. During the construction period, the areas around Ocean Cay will be traversed with ship/barge traffic supporting the construction activities including dredging, equipment deliveries and temporary potable water generation and construction crew housing. There will be a cumulative impact due to construction barge traffic additive to the existing mining barge traffic; however, these impacts are expected to be minimal and short term.

During operations, it is anticipated the AES project will control the navigation through the approach channel and turning basin to minimize potential traffic-related impacts. Furthermore, interference with ongoing marine traffic as a result of the additional LNG terminal-related traffic will be minimal due to the excess capacity of shipping lanes in the Straights of Florida. Thus, although there will be additional marine traffic as a result of the proposed project, the impacts of the ship and barge traffic (including cumulative impacts) in the area will be minimal.

During Construction, a modest cumulative impact to marine traffic in the waters surrounding The Biminis will also be realized due to increased traffic from supply boats transporting goods from The Biminis to Ocean Cay and construction materials to The Biminis.

7.1.6 Socioeconomic Issues

Establishment of housing on the Biminis will create a modest increase in population that will generate a cumulative impact on the ability of the Biminis to provide adequate educational, medical, and other infrastructure-related services to its residents. Because the population growth associated with the proposed project is estimated at only 8% or less, this cumulative impact is expected to be minimal. Furthermore, other needed services (power (339,500 kWh/year), water supply (28.4 m^3/day (7,500 gpd)), sanitary waste management, housing and associated facilities) will be mostly provided for by the proposed project and will not create additional demand on existing resources. Due to the quantity of potable water the project will supply to the Biminis (1892.1 m^3/day (500,000 gpd)), the usage associated with the proposed permanent housing compared to the potable water provided by the project will yield a net positive result.

The cumulative impact on the Bahamian economy will be a strongly positive one. Significant additional resources will be realized by the nation as a result of this project, which is consistent with the government's long-term development plan. The additional licensing income, among other sources of additional income, will add to the already increasing government revenues and economic growth resulting from expanded and diversified business development in The Bahamas in recent years.

Specific data relative to infrastructure, social services and educational resources has been requested from the Biminis Administrator. When this information is received an addendum to this EIA will be submitted.

7.2 Cumulative Impacts from Foreseeable Changes to Existing Facilities

Current mining operations may increase their production rate over the next five years. Cumulative impacts from the AES project and the increased mining operation are expected to be limited to those discussed in the above.

Additional throughput at the mining operation will lead to increased barge traffic to the east of Ocean Cay. It is assumed that increased shipment of product will be made by vessels approaching and leaving Ocean Cay through the approach channel. The cumulative impacts of the increased traffic in the vicinity of Ocean Cay are consistent with those discussed above.

There will be a positive cumulative impact on Biminis future power generation facilities as a result of the AES project. The availability of natural gas to the Biminis via pipeline from Ocean Cay will allow conversion of the existing diesel combustion generators so that the cleaner alternative of natural gas can be combusted. In addition, if the existing generating engines are converted for natural gas combustion, or if BEC installs natural gas fired generators as part of its expansion plan, less fuel oil storage will be required to supply the generators, thereby decreasing the risk of release during delivery and storage.

7.3 Cumulative Impacts from Future Projects

AES has stated an interest in developing an electrical generating facility on Ocean Cay in conjunction with the LNG operation assessed in this EIA. The plant would potentially be capable of producing 1800 MW of electricity for delivery to Florida through an underwater cable. AES will complete an EIA for the electrical generating project at the time it is proposed for construction. The cumulative impacts to be considered in the power plant EIA will include impacts due to increased water intake and discharge rates, cable installation, air emissions from natural gas combustion to provide electricity, and the socio-economic impacts associated with providing jobs and housing for additional permanent positions at the plant.

8.0 EVALUATION OF ALTERNATIVES

Section 8.0 of this Environmental Impact Assessment (EIA), entitled "Evaluation of Alternatives," addresses the system alternatives to the proposed Ocean Cay LNG Project, including the siting alternatives evaluated for the proposed Liquefied Natural Gas (LNG) terminal and the alternative technologies considered for the proposed seawater desalination, electrical generating, and LNG regasification facilities. This section also addresses the major route alternatives to the proposed (1) Ocean Cay Pipeline, a new, 610 mm (24 in), undersea natural gas pipeline extending from Ocean Cay, an industrialized island in The Bahamas, to the Exclusive Economic Zone (EEZ) boundary between The Bahamas and the United States, and (2) the Cay Express Pipeline, a new, 219 mm (8 in) undersea fresh water supply pipeline and a new, 60 mm (2 in) undersea natural gas pipeline from Ocean Cay to North Bimini. Finally, this section addresses the alternatives to the proposed dredging technologies to be used at Ocean Cay.

As set forth in Section 1.0 of the EIA, the Ocean Cay LNG Project will involve the construction and operation at Ocean Cay of an LNG receiving, storage and regasification terminal, including ship berthing and LNG import facilities, storage tanks and regasification equipment; a Liquefied Petroleum Gas (LPG) removal plant and terminal, including ship berthing and export facilities; a seawater desalination plant and ancillary facilities; an approximately 30 Megawatt (MW) electrical generation station consisting of two or three natural gas-fired simple cycle combustion turbines (one of which will be capable of operating on fuel oil for back up-purposes). In addition, the existing approach channel and ship turning basin at Ocean Cay will be enlarged by dredging (see Section 2.3.1.1.B.) to accommodate the larger LNG ships for the proposed operations. The dredge spoil material will be used as fill material to expand Ocean Cay, as needed, to accommodate construction and operation of certain Project components and to enhance the island's existing storm protection capabilities.

The 24-inch Ocean Cay Pipeline will originate at Ocean Cay and interconnect at the EEZ boundary with a new, 24-inch, undersea natural gas pipeline extending to delivery points in Broward County, Florida (Ocean Express Pipeline). The Ocean Express Pipeline will be constructed and operated by AES Ocean Express LLC, a U.S. affiliate of AES Ocean LNG, Ltd.

At South Bimini, the Ocean Cay LNG Project will involve the construction and maintenance of employee housing and associated facilities.

Approximately 76,740 scmd (2.71 mmscfd) of natural gas will be supplied to the Bimini Islands via the 60 mm (2 in) undersea pipeline and, from that supply, The Bahamas Electricity Corporation (BEC) will have the option to purchase natural gas for use in repowering its existing diesel fuel-fired electrical generating units and for generating capacity expansions required to meet future demand growth. Natural gas also will be supplied to the proposed electrical generating station at Ocean Cay to operate the simple cycle combustion turbines. Power from the Ocean Cay electrical generating station will be used to operate the LNG/LPG terminal and ancillary facilities, the seawater desalination plant, and the existing mining facility. Fresh water from the desalination plant will be supplied to the Bimini Islands via a 219 mm (8 in) fresh water supply pipeline (one of two components of the Cay Express Pipeline). The eight-inch fresh water pipeline initially will provide, in a reliable and economical manner, up to 500,000 gallons per day (GPD) to Bimini's water system with future expansions in the system allowing up to 1,000,000 GPD of delivery. This source of water will augment the existing Bimini water system and provide needed capacity to allow future growth and expansion.

The Ocean Cay Pipeline, a significant component of the Project, is designed to serve the growing demand for natural gas in Florida, which is projected to increase by 2.39 Bcf/day by 2010, and by 4.54 Bcf/day by 2020. By accessing sources of natural gas other than the Gulf of Mexico, the Ocean Cay Pipeline will serve to diversify, through interconnection with the Ocean Express Pipeline, the source and supply of natural gas to Florida. The Ocean Cay Pipeline has a design capacity of 22.7 million m^3/day (800 million ft^3/day) and will be designed for a maximum allowable operating pressure of 2180 psig.

AES, through consultations with The Bahamas Environment, Science and Technology Commission (BEST) and other interested governmental and non-governmental stakeholders, has designed the Project to avoid or minimize impacts to natural resources and the environment, as well as to other potentially affected parties. The scope, configuration and location of the Project have been developed based on AES' assessment of a variety of system, route and technological alternatives. Provided below is an analysis of those alternatives. Specifically, Section 8.1 addresses a "No Action" alternative to the Project, Section 8.2 discusses the system (and certain sub-system) alternatives to the Project, Section 8.3 addresses the major offshore route alternatives for the Ocean Cay and Cay Express Pipelines, and Section 8.4 evaluates the dredging technology alternatives with respect to the dredging to be conducted at Ocean Cay.

As set forth below, AES believes the Project reflects the preferred approach to achieve, in an environmentally preferable manner, the primary objectives of the Bahamian Government, BEST and AES, with respect to the Ocean Cay LNG Project.

8.1 "No Action" Alternative

The "No Action" alternative to the Project would mean that the LNG and LPG terminals, the Ocean Cay Pipeline (natural gas), and the Cay Express Pipeline (natural gas and potable water) would not be constructed. The implications of this alternative to Ocean Cay, Bimini and, nationally, The Bahamas, as well as to the State of Florida, are significant. In The Bahamas, the "No Action" alternative would mean the loss of additional reliable and economical natural gas and fresh water supplies, and certain economic and socioeconomic benefits associated with the Project, such as permanent and temporary employment and training opportunities, tax and other revenue streams, and new housing and related facilities construction (Section 2.3.1.5).

Other implications associated with the "No Action" alternative include:

- The potential environmental impacts and economic benefits associated with the Project would not occur (see Section 5);
- Without the introduction of an affordable, reliable water supply to the Bimini Islands, water shortages likely would occur and future expansion of housing or tourist-related services that affect economic growth in the Biminis would be impacted;
- Without the introduction of an affordable, reliable natural gas supply to the Bimini Islands, reliance on fuel oil likely would increase to meet the projected growth in demand for electrical power, potentially resulting in greater air pollutant emissions and other environmental impacts as compared to cleaner burning natural gas-fired generation; and
- Most importantly, the stated objectives of the Project would remain unfulfilled (see Section 1.2).

8.2 System Alternatives

AES considered alternative means for providing natural gas, desalinized water, and additional electrical generating capacity to the anticipated market areas in The Bahamas and south Florida. Primarily, AES considered alternatives involving the expansion of natural gas supply by construction of new LNG terminals at alternate onshore and offshore locations within south Florida and onshore locations in The Bahamas. AES also considered certain sub-system alternatives, including the (1) the expansion of desalinized water supply to the Bimini Islands using a Seawater Reverse Osmosis (SWRO) system or a Mechanical Vapor Compression (MVC) system, (2) the production of electrical generating capacity to supply power to the LNG/LPG and ancillary facilities at Ocean Cay in an economical, reliable and environmentally preferable manner using either simple cycle or combined cycle technology, and (3) evaluation of alternative potential sources of thermal energy to support the LNG regasification plant. Each of these system and sub-system alternatives is discussed below.

8.2.1 LNG Terminal Siting Alternatives

Among the primary objectives of the Project are to provide, in a manner that minimizes potential environmental impacts, (1) improved competition and reliable alternatives to existing natural gas supplies in south Florida, by diversifying the gas supply sources in that region, and (2) an alternative supply of fuel, natural gas, to The Bahamas. While natural gas produced from the Gulf of Mexico is supplied to certain markets in Florida, non-Gulf sources of supply, such as LNG, must be tapped to serve the targeted need in south Florida. In The Bahamas, electrical generating facilities currently rely almost exclusively on fuel oil as the primary fuel source. The siting of an LNG receiving, storage and regasification facility at Ocean Cay, together with the installation of an intra-Bahamian natural gas supply pipeline, will enhance the ability of The Bahamas to meet, in an environmentally preferable manner, the anticipated growth in demand for electrical power generating capacity.

AES considered two primary groups of alternatives to siting the LNG terminal facilities at Ocean Cay, both of which were evaluated based on the ability to meet general facility siting criteria and avoid or minimize potential adverse environmental and socioeconomic impacts to the area affected by the Project. These two groups of alternatives included:

- Onshore and offshore LNG terminal facilities in southern Florida; and
- Onshore LNG terminal facilities in The Bahamas.

8.2.1.1 LNG Terminal Facilities in Southern Florida

In order to serve the need for alternative, reliable sources of natural gas supply in south Florida, AES examined several potential options for siting a new LNG facility in that region. Key criteria for LNG terminal facility siting included:

- Deep water port capability: AES assumed that the draft of typical LNG vessels would require a minimum port water depth of 43 feet at the LNG facility.

- Land area and safety buffer availability: U.S. federal and state regulatory requirements stipulate that a LNG facility be located on a site of suitable size and configuration to minimize adjacent landowners' potential exposure to site accidents or releases. AES assumed that a site of a minimum of 25 acres would be necessary to meet these requirements.

- Proximate access to existing gas transmission facilities: AES assumed that the location of a southern Florida LNG facility would need to be proximate to the existing Florida Gas Transmission Company (FGT) system (for FGT to re-deliver the gas to other points without incurring substantial upgrades, resulting in additional impacts, on their system) in order to avoid or minimize overland pipeline construction through densely populated communities.

Based on these criteria, AES evaluated both (1) onshore locations where LNG terminals could be sited and (2) offshore locations where LNG unloading facilities and complementary onshore LNG storage and regasification facilities could be located.

8.2.1.2 Onshore LNG Terminals in Southern Florida

When evaluated against project objectives and facility siting criteria, AES determined that siting a new, onshore LNG facility in southern Florida was not feasible at this time. AES considered Miami, Fort Lauderdale and Port Everglades as potential ports. Only one – Port Everglades – possesses the requisite water depth to accommodate LNG vessels; the other potential locations would require extensive initial and maintenance dredging to maintain the required depth. The Port Everglades location, however, does not have sufficient available land area proximate to the point of vessel landing to site a storage and regasification facility. What this would require, then, is the construction of an overland cryogenic (frozen) pipeline to transport the LNG from the Port to the storage and regasification facility. The construction of such a pipeline is considered both economically and environmentally infeasible. Accordingly, an onshore LNG facility in southern Florida is not a viable alternative to siting the LNG terminal at Ocean Cay.

8.2.1.3 Offshore LNG Unloading Structure/Onshore LNG Storage and Regasification Facilities in Southern Florida

AES also considered the possibility of offshore locations where LNG unloading facilities could be constructed, and dredging to provide ship access and berthing would not be necessary. Under this scenario, subsea cryogenic LNG pipelines would transfer LNG to onshore storage and regasification facilities, and from there, the natural gas would be transported by pipeline. The principal criteria for this system alternative included sufficient offshore water depth to accommodate LNG unloading structures, and onshore facility interconnection options with adequate and appropriate land resources for LNG storage and regasification.

Onshore sites in the United States that were evaluated under the above criteria included Florida Power & Light Company's (FPL) St. Lucie Nuclear Power Plant in Hutchinson Island (eight miles southeast of Fort Pierce) and FPL's Turkey Point Nuclear Power Plant located on Biscayne Bay, 24 miles south of Miami, Florida.

In the case of the St. Lucie Plant, offshore locations where water depths are adequate to support LNG vessel landings are too far away to be economically feasible. That is, constructing cryogenic LNG pipelines from those depths to the site of the St. Lucie Plant would be prohibitively expensive as compared to the economics associated with the Project. In addition, the St. Lucie Plant site would require substantial upgrades on the FGT pipeline system to receive and distribute the gas which are not required at the Port Everglades site.

In the case of the Turkey Point Plant, offshore LNG unloading structures would need to be located outside the shallow waters of Biscayne Bay in order to accommodate the deep draft of LNG vessels. Potential LNG pipeline routes from such offshore locations to the Turkey Point area would need to traverse coral reefs and protected marine areas, including Biscayne National Park, the Biscayne Bay Aquatic Preserve, the John Pennekamp Coral Reef State Park, the Florida Keys National Marine Sanctuary and a designated "Outstanding Florida Water." AES determined that avoiding or minimizing impacts to all of these reefs and designated/sensitive areas did not appear to be feasible. Further, the Turkey Point Plant site, like the St. Lucie Plant site, would also require substantial upgrades on existing FGT pipeline system to receive and distribute natural gas. Accordingly, the alternative of using the Turkey Point Plant site was eliminated.

No other offshore loading/onshore storage and regasification sites in southern Florida that satisfied the Project objectives or key siting criteria were identified.

8.2.1.4 LNG Terminal Facilities in The Bahamas

Alternatively, AES examined potential options for siting a new LNG facility in The Bahamas. Key criteria for LNG terminal facility siting included:

- Deep water port capability: AES assumed that the draft of typical LNG vessels would require a minimum port water depth of 13 meters (43 feet) at the LNG facility.

- Land area and safety buffer availability: The regulatory requirements of The Bahamas and World Bank guidelines do not stipulate criteria for siting an LNG facility. Therefor, AES utilized U.S. Federal and Florida State regulations as guidance which stipulate that a LNG facility be located on a site of suitable size and configuration to minimize adjacent landowners' potential exposure to site accidents or releases. AES assumed that a site of 10.1 hectares (25 acres) would be necessary to meet these requirements.

- Ability to access existing natural gas transmission facilities in south Florida. AES assumed that an LNG facility would need to be sited to facilitate the supply, by subsurface pipelines, of natural gas to south Florida, and to access the existing FGT natural gas transmission facilities in that region (for FGT to re-deliver the gas to other points without incurring substantial upgrades on their system), in order to serve the south Florida market and avoid or minimize overland pipeline construction through densely populated communities in south Florida.

- Ability to supply natural gas to Ocean Cay and the Bimini Islands. AES assumed that an LNG facility would need to be sited to supply natural gas to the Bimini Islands by subsurface pipeline and to the electrical generating station at Ocean Cay.

Based on the above criteria, AES evaluated onshore locations in The Bahamas where LNG terminals could be sited.

8.2.1.5 Onshore LNG Terminals in The Bahamas with Natural Gas Piping

Based on the identified evaluation criteria, AES considered two onshore locations in The Bahamas where LNG terminals could be constructed for receiving, storing and regasifying LNG, and from which point natural gas could be transported by pipeline to southern Florida, as well as to the Bimini Islands. These two locations were Freeport, Grand Bahama, and Ocean Cay, Bahamas.

Although both islands provide the necessary physical characteristics, including deepwater berthing and unloading access and necessary land area for LNG terminal construction, AES found the Ocean Cay location to present a number of advantages. Ocean Cay is a 38 hectare (95 acre), man-made island with a history of industrial use. There are no permanent residents who would be affected by the proposed development. The island is close to deep water shipping channels and has an existing deep water berth, but also is remote from existing port facilities in The Bahamas, thereby greatly avoiding interference with existing port facilities or existing cruise line or commercial shipping traffic. Furthermore, the industrial nature, configuration and location of Ocean Cay present the opportunity to provide additional, Project-related benefits, such as gas-fired electrical generation and fresh water production, to the Bahamas and, possibly, Florida markets (gas-fired electrical generation).

Because of the beneficial aspects of the Ocean Cay site, AES determined that the Calypso Pipeline Project (Calypso), with its proposed LNG facility in Freeport and subsea pipeline making landfall at Port Everglades, is not a preferred alternative to the Project. Further, AES has selected a landfall location in south Florida for its AES Ocean Express pipeline – the Dania Beach Boulevard traffic circle – and a tie-in location for the existing FGT system that it believes avoid or minimize environmental and other stakeholder impacts more so than does the Calypso landfall location of Port Everglades. Accordingly, AES believes its project on Ocean Cay better meets its objective of satisfying the growing demand for natural gas in The Bahamas and south Florida, in a manner that avoids or minimizes potential adverse environmental and socioeconomic impacts.

In addition to the above factors and as summarized in Table 8-1, AES completed a more detailed analysis of the Freeport and Ocean Cay LNG terminal locations based on the following, supplemental evaluation criteria:

- Site development requirements: AES evaluated certain site development requirements, such as foundation suitability, flooding potential, land acquisition, size, and need for clearing, grading, and filling activities.

- Analysis of site development requirements: AES determined that while both Freeport and Ocean Cay are located within the 100-year floodplain, adequate flood protection either exists or can be developed. However, the available laydown area at Ocean Cay exceeds that at Freeport and Ocean Cay, by comparison, would offer greater site development flexibility.

- Site access: AES evaluated whether a suitable corridor exists that would permit access to the site for ship traffic to deliver fuel and barge and construction traffic to deliver construction materials, equipment and personnel. AES also considered whether the site raised the potential for interference with existing commercial or leisure ship transit corridors.

- Analysis of site access requirements: Though Freeport would require the addition of only minimal docking and mooring facilities relative to Ocean Cay, access to Ocean Cay would not be inhibited by the high commercial and leisure vessel traffic that characterizes Freeport, which significantly minimizes certain potential operational safety and security concerns.

- Dredging and reclamation activities: AES considered the scope of the dredging activity that would be required, both in terms of volume and area, the potential fill requirements, the type and natural resource value of biological resources that potentially may be impacted by dredging, and the potential for requiring disposal of contaminated dredge spoil.

- Analysis of dredging and reclamation activity requirements: Freeport would require deepening of the existing channel and possible fill for site activity and, relative to Ocean Cay, would be considerably more likely to require disposal of contaminated dredge spoil for the channel deepening activity. Ocean Cay would require dredging of the existing channel and turning basin, as well as a considerable amount of fill activity to expand the island to accommodate site activities.

- Ship Handling: Consideration was given to the accessibility of each site by LNG ships, with particular attention given to the largest ship that could be moored at a facility pier so as to maximize flexibility in fuel delivery options. When docked, an LNG ship must be positioned with its bow headed out to sea to permit the vessel to quickly leave the terminal in the event of an emergency. Further, other shipping traffic near the facility must be able to pass the port without being hindered by the LNG offloading activities or facilities

- Analysis of ship handling requirements: Freeport has ample docking facilities available, but offers limited area for turning activities and ship traffic may be precluded from accessing the pier during LNG offloading activities. Access by other shipping traffic would not be a concern at Ocean Cay since it will be a dedicated port. Ocean Cay would require deepening of the existing turning basin and construction of additional docking facilities. Further details of the requirements for ship handling are provided in the Shipping Survey, Appendix T.

- Required Pipeline Length: AES evaluated the length of the natural gas pipelines necessary to supply gas to the Florida market for both the Ocean Cay and Freeport, Grand Bahama, alternatives.

- Analysis of required pipeline length requirements: The Ocean Cay alternative results in a shorter pipeline length, and therefore less potential environmental and economic impacts.

- Potential Environmental Impacts: AES has given extensive consideration to the potential environmental impacts that may be associated with the siting of an LNG facility at Freeport and Ocean Cay. Among the sub-factors that AES considered are:

  - *Air quality impacts*. While Freeport is located approximately one-half mile from the nearest sensitive receptor and existing source of air pollutant emissions, Ocean Cay is located approximately eight miles from both and, thus, poses less potential for impacts to local ambient air quality.

  - *Noise*. Freeport is located approximately one-half mile from the nearest noise sensitive receptors and existing noise sources; whereas, Ocean Cay is located approximately eight miles from both, meaning that Ocean Cay poses less potential for noise-related impacts.

  - *Surface water quality impacts and availability*. Both Freeport and Ocean Cay have ample availability of process water sources and fair, ambient water quality. Unlike Freeport, Ocean Cay, however, does not raise the possibility of potential conflicting water uses.

  - *Threatened and endangered species*. Neither Freeport nor Ocean Cay would appear to be established habitat for rare, threatened or endangered species and are not likely locations for occurrences of such species.

  - *Aesthetics*. The existing landscape quality at Ocean Cay would be characterized as having low aesthetic appeal and a low number of potential observers; whereas, the landscape quality at Freeport has a good or moderate aesthetic appeal and a high number of potential viewers. Freeport supports a significant tourist business and Ocean Cay, as a private, industrial island is not identified as a tourist destination. The visibility of the project in the vicinity of both locations is considered to be high. The potential for aesthetic impacts thus would be considered greater at Freeport than Ocean Cay.

  - *Land use / socioeconomics*. Ocean Cay currently is an industrialized site for which only industrial land uses are anticipated in the future. Freeport typically is considered to have primarily recreational or tourist land use and it is expected that such uses would predominate future land use in that area.

- *Cultural resources*. No potential for cultural resources, including upland or marine sites, has been identified at Ocean Cay. Freeport has limited potential for the occurrence of upland sites and moderate potential for marine sites.

Table 8-1
Summary of LNG Site Evaluation Criteria – The Bahamas

Evaluation Criteria	Ocean Cay Site	Freeport, Grand Bahama Site
Air Quality		
Distance to existing sources	Approximately 8 miles	Approximately 0.5 mile
Distance to sensitive receptors	Approximately 8 miles	Approximately 0.5 mile
Aesthetics		
Degree of visibility (from 1 mile distance)	Highly visible	Highly visible
Number of potential viewers	Low	High
Tourism Industry	None	Significant
Existing landscape quality	Poor/Industrial	Good/moderate development
Land Use/Socioeconomics		
Compatibility with Existing land use	Industrial	Recreational/tourist
Compatibility with future land use	Industrial	Recreational/tourist
Surrounding land uses	Industrial/mining	Industrial/tourism
Dredging and Filling		
Dredging requirements	Dredging of approach channel and turning basin required	Deepening of existing channel required
Filling Requirements	Large amounts of fill utilized for island expansion	Possible fill for site activity
Surface Water		
Availability of Process Water	High	High
Water Quality	Fair	Fair
Conflicting Uses	None	Potential users
Threatened and Endangered Species		
Probability of Species Occurrence	Minimal	Minimal
Species Use Patterns	Rare/unlikely	Rare
Site Access		
Ship traffic	Low volume of ship traffic, except for dredges and supply barges related to existing mining operations	High volumes of cruise line and importing traffic

Table 8-1 (continued)
Summary of LNG Site Evaluation Criteria – The Bahamas

Evaluation Criteria	Ocean Cay Site	Freeport, Grand Bahama Site
Barge/construction traffic	Additional docking/mooring facilities required	Minimal additional docking/mooring facilities
Ship Handling		
Size and depth of turning basin	Can deepen existing turning basin	Insufficient turning area for design ships
Docking Facilities	Additional docking facilities to be constructed	Available but will require upgrades and expansions to accommodate LNG operations
Navigation Access for other shipping during fueling	Will not preclude other ship traffic from using dock	May preclude other ship traffic from using dock
Required Pipeline Length		
Total length of pipeline to serve Florida	136.2 km (84.6 mi)	154 km (95.7 mi)
Cultural Resources		
Potential for Upland Sites	None found	Limited potential
Potential for Marine Sites	None found	Moderate
Site Development Requirements		
Flood Potential	High	High
Useable Area	Within 100-year flood plain, island will be designed to prevent flooding	Within 100-year flood plain, flood protection exists
Available Laydown Area	Adequate laydown space and good flexibility	Poor laydown space and limited flexibility due to commercial traffic
Noise		
Distance to Noise Sensitive receptors	Approximately 8 miles	Less than 0.5 miles
Distance to Existing Noise Sources	Approximately 8 miles	Less than 0.5 miles

8.2.1.6 Conclusion and Preferred LNG Terminal Location

Of the various LNG terminal locations evaluated, only the Project as proposed, with its linkage to the advantageous Ocean Cay site, meets the technical, environmental and economic criteria for project viability. Because the Ocean Cay site satisfied the selection criteria, AES did not consider locations in The Bahamas where offshore LNG receiving terminals and onshore LNG storage and regasification facilities could be sited, particularly due to the expense that AES would incur to install and operate an undersea cryogenic LNG pipeline. Therefore, as summarized in Table 8-1, the alternatives analysis indicates that among the alternatives considered, Ocean Cay is the optimal location for construction and operation of the LNG terminal and ancillary facilities.

8.2.2 Sub-System Alternatives

Having determined Ocean Cay to be the optimal location for siting the proposed LNG terminal and ancillary facilities, AES evaluated certain sub-system alternatives for the seawater desalination, electrical generating and LNG regasification facilities at Ocean Cay. As discussed below, AES concluded, on the basis of its evaluation of the available alternatives, that the Seawater Reverse Osmosis system (desalination facility), a simple-cycle natural gas combustion turbine configuration (electrical generating facility) and a seawater-based LNG regasification facility would best accommodate the Project's objectives. Provided below is a summary of the analysis of these sub-system alternatives; a more detailed analysis of each of the alternatives is included in Appendix V to the EIA.

8.2.2.1 Desalination System Alternatives

AES has evaluated two alternative systems for providing a potable water supply of 1892 m^3/day, equivalent to 500,000 gallons per day (gpd), to the Project facilities and the Bimini Islands: (1) a Sea Water Reverse Osmosis (SWRO) system; and (2) a Mechanical Vapor Compression (MVC) system. Based on the analysis set forth below, AES concluded that the SWRO system would best accommodate the Project's objectives.

A. Seawater Reverse Osmosis Desalination System

The SWRO system involves a two-stage, reverse osmosis (RO) configuration that produces fresh water from seawater. The system has two identical RO trains; each rated at 946.1 m^3/day, equivalent to 250,000 gpd. The SWRO process takes a saline solution (seawater) and transfers it under pressure through a series of water-permeable membranes that separate the dissolved solids (salts) from the water to produce potable quality water. The SWRO technology has been used reliably in this type of application for several years and requires minimal operator attention and maintenance compared to the alternative MVC technology. The major energy input required for the process is for pressurization of the initial feed water. No heating or phase change (i.e. liquid to vapor to liquid) of the feed water is required. Therefore, the energy input requirements for this type of system are minimal and environmental impacts associated with SWRO technology, including production of the requisite energy input, are relatively insignificant.

B. Mechanical Vapor Compression Desalination System

MVC desalination systems remove dissolved solids from seawater by boiling the seawater and capturing and condensing the resulting steam to produce fresh water. Salts and other impurities would be discharged from the system back to the ocean. This process has been available commercially for almost 50 years. However, this type of system generally is not considered to be economical due to the high cost of corrosion-resistant equipment and materials and the need for increased operator attention due to scaling concerns at higher operating temperatures. In addition, because MVC systems require a steam heat supply, the proposed electrical generating station would have to use a combined cycle configuration, which would be more expensive than a simple cycle configuration (see Section 8.2.2.2 below) and would result in significantly more environmental impacts. Further, an MVC system requires additional maintenance and operator attention for safe reliable operations and is highly susceptible to scaling of heat transfer surfaces due to the elevated temperatures of the heated seawater supply.

C. Preferred Seawater Desalination System

Based on its evaluation of the SWRO and MVC systems, AES has determined that SWRO is the preferred desalination system because:

- capital and operating costs associated with SWRO are significantly lower than those associated with MVC;
- operator attention required for SWRO is significantly lower than those associated with MVC;
- energy input requirements for SWRO are significantly lower than those required for MVC; in particular, SWRO does not require steam heat input that would necessitate a combined cycle configuration of the proposed electrical generating facility (see Section 8.2.2.2 below);and
- while the wastewater discharged from both the RO and MVC systems would not be expected to result in significant environmental impacts, the steam input required for an MVC system would

necessitate the use of a combined cycle combustion turbine configuration (with duct firing) for the electrical generating station. The air pollutant emissions, particularly NO_x and particulate matter emissions, associated with a combined cycle facility typically are greater than those from a simple cycle facility, depending upon the type of emissions control technology that is utilized.

A more detailed analysis of the SWRO and MVC systems is provided in Appendix S, Part 1, of this EIA.

8.2.2.2 Electrical Generating Facility Alternatives

Once constructed, operation of the Ocean Cay LNG Project and the existing mining operations is anticipated to require approximately 30 Megawatts (MW) of electrical power annually. To meet the projected demand, AES evaluated two alternative technologies for the on-site generation of electrical power at Ocean Cay -- namely, (1) simple cycle gas turbine generation (GTG), and (2) combined cycle GTG and steam turbine generation (STG). Based on its evaluation of those two alternatives, AES concluded that the simple cycle GTG system would provide the more economical alternative capable of satisfying the projected demand, while achieving the same comparable level of system reliability and environmental protection as would the combined cycle GTG/STG system. Provided below is a comparison of the alternative systems, including the design, reliability, capital and operating costs, and projected air pollutant emissions associated with each system. A more detailed analysis of the two system alternatives is included in Appendix V, Part 2, of the EIA.

A. System Description

The proposed simple cycle configuration consists of three, 50 percent capacity simple cycle GTGs, each with a nominal rating of 15 MW. The ALSTOM GT35 gas turbine model was selected for the purpose of comparing the simple cycle and combined cycle systems. The simple cycle configuration would be able to meet the projected annual demand for the Ocean Cay LNG Project while operating two GTGs at any given time and maintaining the third GTG as a back-up unit.

The combined cycle configuration consists of two, combined cycle blocks, each of which includes two GTGs with a net output of approximately 22 MW (11 MW each) and one STG with a net output of approximately eight MW. Each block thus would generate approximately 30 MW of power while the second block remains in stand-by mode. For the combined cycle configuration, Solar Titan was selected as the gas turbine model for comparison purposes.

Table 8-2 summarizes the estimated performance of the simple cycle and combined cycle systems, while operating on natural gas, at 100 percent load and at GT inlet and ambient air temperatures of 23.9°C (75°F) and 35°C (95°F), respectively.

Table 8-2
Performance Data Summary

Performance	Simple Cycle Configuration	Combined Cycle Configuration
Total GT Gross Output (MW)	30.8	22.2
GT Auxiliary Loads (MW)	0.8	0.2
Total GT Net Output (MW)	30.0	22.0
ST Gross Output (MW)	0	8.9
ST Auxiliary Loads MW	0	0.8
ST Net Output MW	0	8.1
Total Plant Net Power Output MW	30.0	30.1
LHV Heat Rate BTU/kWh (kcal/kWh)	11,529 (2,900)	8,187 (2,060)
Fuel Consumption pph (kg/h)	16,200 (7,350)	11,400 (5,170)

B. System Reliability Comparison

To evaluate system reliability, AES considered, as a critical factor, the ability of each generating system to provide sufficient back-up generation capacity. For the simple cycle configuration, AES evaluated the reliability of systems consisting of three, 15-MW GTGs, each of which would operate at 50 percent capacity, and two 30-MW GTGs, each of which would operate at 100 percent capacity. For the combined cycle system, two 30-MW blocks were considered. The reliability of either simple cycle configuration would be significantly higher than that for the combined cycle plant. Although both utilize GTGs, the combined cycle plant will require HRSGs, steam turbines, condensers, and several auxiliary systems, such as chemical feed, boiler blowdown, boiler feedwater, and condensate systems. Because of the equipment needs and greater operating complexity of the combined cycle plant, the reliability of that configuration is expected to be less than for the simple cycle configuration.

C. Capital Cost Comparison

Capital costs considered for the simple cycle configuration include costs for gas turbine generators and auxiliary equipment, balance of plant equipment, construction materials and construction labor costs.

Capital cost of the combined cycle configuration includes the gas turbine generators, heat recovery steam generators, steam turbine generators, condensers, balance of plant equipment, construction materials and construction labor costs. The estimated capital costs for the two configurations are summarized below in Table 8-3. As indicated, the total projected capital cost for the combined cycle system is $69.5 million, as compared to $37.5 million for the simple cycle configuration.

Table 8-3

Capital Cost Summary

Items	Simple Cycle Configuration		Combined Cycle Configuration	
	Quantity	Cost (MM$)	Quantity	Cost (MM$)
Gas Turbine Package	3	22.0	4	19.7
Inlet Air Chilling System	3	1.0	4	1.0
Heat Recover Boiler	0	0	4	7.3
Steam Turbine Package	0	0	2	8.4
Water Cooled Condenser	0	0	2	0.4
Other Equipment	-	2.5	-	5.3
Civil	-	1.2	-	2.1
Mechanical	-	2.0	-	6.3
Electrical Assembly	-	0.2	-	0.7
Other Structures	-	0.4	-	0.8
Engineering & Start-up	-	1.0	-	4.5
EPC margin & Soft Costs	-	4.0	-	7.4
Owner's Soft Costs	-	3.0	-	5.6
Total Estimated Cost	-	37.3	-	69.5

D. Operating Cost Comparison

The operating costs for the power generation plant mainly consists of the fuel and operation and maintenance (O&M) costs. The fuel price is estimated as US $ 2.5/MMBtu based on the supply of natural gas from the on-site LNG facilities. The estimated annual operating costs and the total present-worth costs of the two configurations for the power plant are presented below in Table 8-4.

Table 8-4

Annual Operating Costs and Present-Worth Costs

Cost Item	**Simple Cycle Total Cost** (MM US$)	**Combined Cycle Total Cost** (MM US$)
Fuel (Natural gas)	7.1	4.8
Operation & Maintenance	1.7	3.2
Taxes and Insurance	0.7	1.4
Admin & Overhead Charges	0.8	1.5
Total Annual Operating Cost	10.3	10.9
Present Worth of Operating Cost	103	109
Capital Cost	37.3	69.5
Total Cost in Current $	140.3	178.5

The present-worth cost is obtained by multiplying the total annual operating cost by the present-worth factor. The present-worth factor in this case is assumed to be approximately 10, based on an interest rate of nine percent per year and a total plant life of about 30 years.

E. Air Emissions Comparison

The air emissions data for the two configurations is summarized in Table 8-5. For comparison purposes, the data is based on running two Alstom GT35 gas turbine generators with dry low-NO_x combustors, on natural gas at full load operation at 23.9°C (75°F) GT inlet air temperature. The combined cycle plant emissions data is based on running two Solar Titan (dry low-NO_x combustor) gas turbines on natural gas at full load operation at 23.9°C (75°F) inlet air temperature. For both cases, the inlet air is cooled by inlet air chillers to 20°F below the ambient temperature.

Table 8-5

Air Emissions Data

Parameter	Unit	**Simple Cycle**	**Combined Cycle**
NOx	ppmvd @15%O2	25	25
NOx (Total)	Metric Tons/year	134	113
CO	ppmvd @15%O2	25	50
CO (Total)	Metric Tons/year	82	139
UHC (as CH4)	ppmvd @15%O2	7	25
UHC (as CH4) (Total)	Metric Tons/year	13	40

F. Conclusion

A comparison of the two, alternative electrical generating systems indicates that the simple cycle configuration would provide the more economical alternative, while achieving a level of system reliability and environmental protection comparable to the combined cycle system. The principal factors that support this determination include:

- Based on the performance data, both configurations are capable of serving the projected, annual demand for the Ocean Cay LNG Project of 30 MW power.
- Both systems would satisfy the stand-by requirements for reliability.
- The capital cost requirement for the combined cycle configuration would exceed that for the simple cycle configuration by approximately $32.2 million.
- Of the two systems, the combined cycle configuration has a lower heat rate, which reduces the fuel consumption. The projected annual operating fuel cost for the simple cycle system would be approximately $2.3 million higher. However, the total annual operating cost for the

combined cycle system will be approximately $0.6 million higher than that for the simple cycle system ($10.9 million for combined cycle and $10.3 million for simple cycle). This difference is attributable to the complexity of the combined cycle design involving the Heat Recovery Steam Generator (HRSG), the STG, and the auxiliaries.

- The total present worth cost of the combined cycle configuration is approximately $38 million higher than for the simple cycle configuration.

- A comparison of the projected air pollutant emissions indicates that the combined cycle system will result in lower NO_x emissions due to the lower stack mass flow. However, for the selected gas turbine model, the combined cycle system will result in higher emissions of CO and UHC. Given the relatively small size of the gas turbines selected for both systems, the total estimated NO_x emissions for the simple cycle and combined cycle systems are roughly equivalent at 134 Metric Tons (MT)/year and 113 MT/year, respectively.

8.2.2.3 LNG Regasification Alternatives

Once LNG has been received and stored at Ocean Cay, thermal energy will be required to regasify the LNG to natural gas as the LNG passes through the heat exchangers. To satisfy this thermal energy requirement, AES evaluated five alternative technologies, including:

1. Seawater (base design): Seawater system for LNG regasification provides seawater as the heating medium to a series of shell and tube heat exchangers;

2. Fin-fan heaters: Fin-fan heater uses ambient air to provide heat to a glycol loop which in turn provides heat for LNG regasification;

3. Heat recovery from GT exhaust gases: The glycol loop is heated by the GT exhaust gas which in turn provides heat for LNG regasification;

4. Use of hot water boilers: Fuel gas is combusted in the boiler to heat the glycol loop which in turn provides heat for LNG regasification; and

5. Direct-fired LNG evaporation: The direct fired system involves burning of natural gas in close proximity to the LNG facilities.

No further consideration was given to the direct-fired LNG evaporation alternative because of the substantial hazards that may be associated with its use. With the exception of the direct-fired LNG evaporation alternative, AES completed a detailed comparison of the technical feasibility, capital and operating costs and potential environmental impacts associated with each of the four remaining alternative technologies. On the basis of its analysis, AES determined the seawater-based system to be the optimal LNG regasification technology because of its technical feasibility, comparatively lower cost and ability to minimize potential adverse environmental impacts.

A. Technical Feasibility

To evaluate the technical feasibility of each of the four alternative technologies, AES considered energy efficiency, functionality, operability, spatial requirements and reliability of the technology.

Alternate 1

Seawater as the LNG regasification heat source is by far the most common and proven design practice in the industry. The seawater system utilizes an inherently more efficient process involving liquid-to-liquid heat transfer and liquid pumping as compared to a gaseous medium. The process is relatively simple and utilizes only a few components, all of which have a proven design and have been in use in various industries for several years. Therefore, the seawater system is considered to be extremely reliable and would satisfy the reliability criteria for a utility grade plant.

Alternate 2

The fin fan system has been used in similar applications that do not have other sources of heat available for regasification. Based on its review, AES was not able to locate an application of a size comparable to that required for the Ocean Cay LNG Project using fin-fan heaters to regasify LNG. In addition the fin-fan heater system requires a very large site area to accommodate the large heat transfer surfaces necessary for effective heat transfer, which would require an expansion of Ocean Cay beyond the size currently anticipated. While AES has the ability to increase the size of Ocean Cay to accommodate the fin- fan heat exchanger system, the incremental increase in the planned expansion would result in additional costs and potential environmental impacts.

The efficiency of fin-fan heaters is significantly lower than the efficiency of the seawater heat exhanger because of the air to liquid heat transfer and, thus, greater heat transfer surface required for the fin-fan heater system. The fin-fin heater system requires approximately 100 modules to meet the total heat load requirement. This results in about 200 axial fans. In view of the significant number of the rotating equipment to be used, the maintenance operations will have to be intensive to ensure the required degree of reliability for the plant. Consequently, the requirements for spare parts and maintenance staff will be very high. In addition, the fin-fan units are more subject to damage during severe hurricane conditions.

Alternate 3

The use of heat recovery systems for GTG exhaust gases to produce hot glycol is not a new technology but is a new application of this technology. Although, this option is technically feasible, the operating and maintenance issues are expected to be higher than that associated with typical installations involving similar technology in similar applications. The complexity of the GTG operation increases significantly because of the interface with LNG regasification system, particularly during startup and GTG switchover operations.

The use of a heat recovery system on the back-end of GTG overall will result in a more efficient facility but, because of a higher GTG exhaust pressure drop, will result in an approximate 0.5 MW GT output decrease.

The system operating flexibility will be limited to one GT and HRSG operation as a train. The system will also require bypass dampers to permit GT operation for power generation with no LNG regasification load. Therefore, the design of the seawater system will have to be based on 100 percent of the base case flow, to achieve the necessary reliability level required of this facility.

Alternate 4

Use of conventional package boilers to generate hot water is a feasible approach for the project. The boilers will be standard industrial package units designed for this specific application. The fuel for the boilers will be natural gas generated on-site.

Using boilers to generate hot glycol will require a significant amount of fuel. As compared to all other alternatives evaluated. This is the only case where additional fuel will be required, thereby making this option the least energy efficient. It is anticipated that the required level of reliability can be achieved by use of standard equipment and redundancy.

B. Cost Analysis Results

Table 8-6 summarizes the cost factors for comparison of the four alternatives evaluated. The table includes present-worth operating cost and the cost of each alternative in current dollars (U.S.).

Table 8-6

Cost Comparison for Alternatives

Cost Item	Total Cost (MM US$)			
	Base	Fin-Fan	GT	Boiler
Total Annual Operating Cost	0.86	6.0	3.16	14.3
Present Worth of Operating Cost	8.6	60	31	143
Capital Cost	12	64.4	23.5	10.4
Total Cost in Current $	**21.46**	**130.4**	**58.26**	**167.7**

The lowest cost option was the base case using seawater as the heat source. The boiler option and fin-fan cooler option costs are substantially higher cost than the base case and the GT heat recovery case. The GT heat recovery case is about $37 million more than the base case. The cost for providing redundancy comparable to the base case will be prohibitive (use of additional GT and heat recovery system for stand-by).

C. Environmental Factors

Table 8-7 compares the air emissions and seawater discharge for each of the four alternatives.

Table 8-7

Emissions Comparison for Alternatives

Alternatives	Air Emissions		Seawater Discharge at 7°C (45 °F)
	NO_x	CO	
	Metric Tons/yr	Metric Tons/yr	Kg/hr
Base	6	4	7.82E+06
Fin-Fans	47	28	N/A
GT Heat Recovery	21	13	5.87+06 *
Boilers	211	128	N/A

*The seawater flow is the expected normal operating value. The flow can vary based on the GT operating loads. During shut down of heat recovery system the flow will be same as the Base Case and will result in similar environmental impacts.

The base case (seawater) air emissions are the lowest of all the alternatives. The boiler option air emissions are significantly higher than all the other alternatives. The fin-fan and the boiler cases do not require seawater for the LNG regasification and consequently do not require discharge of cooled seawater.

The thermal discharges from the base case are well within the accepted guidelines as demonstrated in the Thermal and Cold Discharge Study (Section 3 and Appendix H) for the project. According to this study, the maximum temperature decrease in the discharge area will be less than 1.8°C (3.3°F) below the ambient seawater temperature. The 1.8°C (3.3°F) temperature decrease plume extends to less than 5 m (16.4 ft) along the discharge pipe axis. In addition, the discharge pipe is located in the turning basin area that will be dredged and disturbed during construction.

D. Conclusion

Heat recovery from GT exhaust gas system is not a proven technology for LNG regasification. The operation and maintenance of the heat recovery system is significantly more complex than the seawater heat exchangers. Therefore, based upon the above observations, the proposed Project design (seawater as heat source for the LNG regasification) is the preferred LNG regasification technology for the project, minimizing cost and potential adverse impacts to the environment.

8.3 Offshore Route Alternatives

Based on its determination that Ocean Cay provides the optimal location for siting the LNG terminal and ancillary facilities, AES proceeded to evaluate various offshore route alternatives for (1) the 610-mm (24-inch) Ocean Cay Pipeline (natural gas) extending from Ocean Cay to the EEZ boundary between The Bahamas and the United States, and interconnecting at the EEZ boundary with a 610-mm natural gas pipeline that will extend to delivery points in south Florida (Ocean Express Pipeline), and (2) a 51-mm (2-inch) natural gas pipeline and 203-mm (8-inch) potable water supply pipeline from Ocean Cay to the Bimini Islands (Cay Express Pipeline).

The routes selected for the Ocean Cay (natural gas) and Cay Express (natural gas and water) Pipelines reflect AES' efforts to balance the interests that may be affected by construction of those pipelines. The following criteria were considered in selecting the routes:

- The nature and extent of potential adverse environmental impacts (including the avoidance, minimization or mitigation of those impacts);
- The number and location of residential structures in close proximity to the construction right-of-way;
- The extent of wetland and waterbody crossings;
- The extent of land that requires clearing;
- The presence of and potential impacts to threatened and endangered species, essential fish habitat, and sensitive coastal and offshore ecosystems, such as coral reef systems;

- The number and extent of state and local parks that are crossed, and extent of crossings through recreational or other special use areas;
- The extent of cultural resources affected;
- The impacts on local businesses such as commercial fishing and shipping;
- The impacts on affected landowners and communities (including the avoidance, minimization or mitigation of those impacts);
- The constructibility of the pipeline on the selected route;
- The ability to reasonably, reliably, and safely conduct ongoing operations and maintenance on the pipeline; and
- The capital cost of constructing the pipeline on the selected route.

To identify potential routes for the Ocean Cay and Cay Express Pipelines that would satisfy the above criteria, AES used initial screening information consisting of desktop studies and limited field investigations. That information primarily was used to ensure the presence of appropriate seabed characteristics necessary to support pipeline installation and to avoid or minimize impacts to sensitive environmental areas and marine communities.

Using the initial screening information, AES identified areas west of Ocean Cay, and along the eastern and western edges of the Bahama Bank and Bimini Islands chain (see Figure 4.23), for more detailed evaluation. A marine reconnaissance survey program, consisting of geophysical, geotechnical, hydrographic, biological and archaeological assessments, was then completed, the objectives of which were to:

- identify water depths and bottom topography;
- determine seabed and subsurface geological conditions;
- identify natural and manmade obstructions on and below the bottom;
- collect physical samples of subsurface and near surface sediments (upper three meters);
- collect visual information on substrate composition through underwater video; and

- provide support for biological and archaeological studies.

Data obtained from the seabed and benthic habitat characterization, and the subsurface geology, were used to assess site conditions for pipeline routing and design, select appropriate pipeline installation methods, design the electrical generating facility and marine terminals at Ocean Cay, redesign the depth and area of the existing harbor and turning basin at Ocean Cay, and complete marine environmental impact assessments. Further, to complete the characterization of marine site conditions in the areas identified from the initial screening for further evaluation, AES completed the following tasks:

- Hydrographic surveys to determine water depths and map the existing bottom topography;
- Shoreline mapping to accurately delineate the land-sea boundary in areas critical to all aspects of the project;
- Tidal study to acquire nearly continuous water level information for correction of depth sounding data to the project datum;
- Sub-bottom profiling to identify near-surface sub-bottom stratigraphy (upper 2-5 m (6.6 – 16.4 ft)) along routes and deeper stratigraphy (depth to bedrock) within Area A1;
- Side scan sonar surveys to identify morphologic variations and natural and man made obstructions on the seabed;
- Magnetic intensity measurements to identify obstructions containing ferrous material on or below the seabed;
- Vibratory coring to acquire physical information (samples) of the near-surface sediments to 3 m (9.8 ft) below the seabed;
- Jet probing to the project depth to acquire indirect physical information on subsurface lithology to ground truth seismic reflection data;
- Sediment grab sampling to obtain physical samples of surficial materials where bedrock was too close to the seafloor to allow coring;

- Underwater video to obtain visual information on the seafloor for qualitative assessment of benthic habitats; and

- Scientific and vessel support for detailed biological assessment which included SCUBA diving and inspection, underwater video, and bottom sampling.

Provided below is a discussion of the results of this comprehensive marine survey investigation, with respect to AES' evaluation of the offshore route alternatives for the Ocean Cay Pipeline (natural gas) and the Cay Express Pipeline (natural gas and water) (see Figure 8.1 and Section 2.3.1.4 of the EIA).

8.3.1 Major Offshore Route Alternatives – Ocean Cay Pipeline (610 mm (24 in) - Natural Gas Pipeline)

In designing a subsea pipeline to transport natural gas originating at an LNG facility on Ocean Cay, AES considered, in addition to the evaluation criteria listed in Section 8.3 above, how best to route the Ocean Cay Pipeline in a manner that would accommodate the need (1) to interconnect at the U.S.-Bahamas EEZ boundary with the Ocean Express Pipeline and (2) for the Ocean Express Pipeline to be sited so as to make landfall at the Dania Beach Boulevard traffic circle in Broward County, Florida, and interconnect with the existing FGT system.

To select a possible route from Ocean Cay, AES used initial screening information to identify the following potential routes for further evaluation:

- Alternative 1 – Proposed Ocean Cay Pipeline

- Alternative 2 – Southern Route 1

AES then evaluated Alternatives 1 and 2, which are shown on Figure 8.3, based on the results of the comprehensive marine investigation survey described in Section 8.3 above. AES also completed deep water reconnaissance surveys to evaluate the offshore route alternatives from Ocean Cay to the EEZ boundary. The deepwater reconnaissance survey, which was designed to map the continental shelf and slope west of Ocean Cay, involved the collection of hydrographic, side scan sonar, magnetometer and seismic reflection data (see Figure 8.1 and Appendix D).

The results of AES' analysis of the offshore route alternatives from Ocean Cay to the EEZ boundary are summarized below.

8.3.1.1 Offshore Alternative 1 – Proposed Ocean Cay Pipeline

From Ocean Cay, the proposed Ocean Cay Pipeline heads northwest and parallels the East Route landfall approach for the Cay Express Pipeline (see Section 8.3.2.1 below) before curving west to traverse the Straits of Florida (see Figure 8.2). As compared to Alternative 2, Alternative 1 was selected as the proposed route for the Ocean Cay Pipeline based on its technological and environmental advantages, including:

- Avoids existing hard bottom coral communities to the west of Ocean Cay;
- Characterized by barren sand bottom interspersed with areas of patchy seagrass and algal cover (<50% cover), and a low abundance of marine communities along the route; and
- Located away from port operations, such as cruise ships, and cargo berthing locations.

8.3.1.2 Offshore Alternative 2 – Southern Route 1

Alternative 2 follows the existing approach channel as it heads west to southwest from Ocean Cay toward the EEZ boundary. At a point approximately [insert number] miles offshore from Ocean Cay in the deep water, Alternative 2 bends north to northwest toward the coast of Florida, to a point on the EEZ boundary where Alternative 2 interconnects with the Ocean Express Pipeline. Alternative 2 was determined not to be viable due to the following factors:

- Presence of extensive live reef and hard bottom areas;
- Presence of potentially unstable slopes at the continental shelf break; and
- Additional technical difficulties posed by irregular seabed.

8.3.2 Major Offshore Route Alternatives – Cay Express Pipeline (60 mm (2 in) Natural Gas and 219 mm (8 in) Water Pipelines)

To design subsea pipelines to transport natural gas and fresh water originating at an LNG facility on Ocean Cay, AES considered how best to route the Cay Express Pipeline in a manner that would be technically feasible, and also would avoid or minimize potential adverse impacts to natural resources and the environment.

To select a possible route from Ocean Cay to North Bimini, AES used initial screening information supplemented with data obtained from the comprehensive marine investigation survey described in Section 8.3 of the EIA (see Appendix E and K). Based on that analysis, AES identified two possible alternatives for further consideration:

- Alternative 1 – West Route Alternative
- Alternative 2 – East Route Alternative

The locations of the alternative routes for the Cay Express Pipeline are shown on Figure 8.1. The results of AES' more detailed analysis of the offshore route alternatives from Ocean Cay to the EEZ boundary, based on the criteria listed in Section 8.3 and the data obtained from the comprehensive marine investigation survey, are summarized below and set forth in Table 8-2.

8.3.2.1 West Route Alternative –Cay Express Pipeline (Natural Gas and Water)

The West Route Alternative travels north to northwest from Ocean Cay to a location west of Victory Cay, Cat Cay, Gun Cay and Turtle Rocks, at which point the alternative heads due north to the west coast of the Bimini Islands where the alternative terminates at the North Bimini landing point.

The West Route Alternative was rejected due to significant technical and environmental concerns, among which are:

- significant presence of hard bottom communities inhabited by soft corals and patch reef along the length of the route alternative;
- highly-variable slopes in seabed that parallel the route;
- average water depth of seven to 10 meters (23-32.8 feet);
- considerable commercial and recreational use by local fisherman, SCUBA diving enthusiasts and deep sea fisherman; and
- presence of the Saponia Shipwreck in close proximity to the route alternative (cultural resource).

8.3.2.2 East Route Alternative – Cay Express Pipeline (Natural Gas and Water)

Despite its close proximity to the West Route Alternative, the East Route Alternative differs dramatically in its geophysical and biological characterization. The East Route Alternative leaves Ocean Cay at the western side of the island near the departure point for the Ocean Cay Pipeline and bends to the east of the chain of islands between Ocean Cay and the Biminis. The route bends to the west just below the southern tip of South Bimini and then travels along the western coast of Bimini to the landing point on North Bimini.

Because of its more advantageous technical and environmental characteristics, which are listed below and in Table 8-2, the East Route Alternative was selected as the proposed route for the Cay Express Pipeline.

- low slope variability, making the route alternative more conducive to pipeline construction;
- average water depths of three to five meters (9.8 to 16.4 feet);
- limited presence of coral reefs, patch reefs and individual coral heads in sandy sediments inhabited by sea grasses; and
- limited local fishing activity (conch and lobster).

Table 8-8
Comparison of West and East Route Alternatives (Cay Express Pipeline)

	WEST ROUTE ALTERNATIVE	EAST ROUTE ALTERNATIVE
Bottom Topography	18% Hard Bottom Highly variable slopes	18% Hard Bottom Little variable slopes
Biology		
■ **Coral Abundance**	High	Low
■ **Seagrass Abundance**	Moderate	High
Water Depth	7 to 10 m	3 to 5 m
Recreational Uses	Highly Utilized (commercial & recreational fishing, diving)	Slightly utilized for recreational fishing
Cultural Resources	Presence of the Saponia Shipwreck	No Significant Resources
Length of Pipeline	Approximately 38 km	Approximately 38 km

8.4 Ocean Cay Dredging Technology Alternatives

Once Ocean Cay was selected as the optimal location for construction and operation of the LNG terminal and ancillary facilities, AES evaluated several alternatives for completing the dredging activities required to expand the island and enhance the island's existing storm protection capabilities. As a result of its evaluation, and as detailed in Table 8-3 to Section 8 of the EIA, AES determined that hydraulic dredging – specifically, the cutterhead suction dredge (CSD) method – would be the preferred dredging technology due to its low sedimentation rate, high production rate and ability to handle the materials expected to be present in the channel. Each of the Ocean Cay dredging alternatives is discussed below.

8.4.1 Mechanical Dredging Technologies

Mechanical dredges are comparable to land-based excavating machines and include grapple, dragline, dipper, bucket and backhoe dredges. The dredged material removed by mechanical methods is typically high in solids content. Material removed mechanically from the dredged site is placed in scows or on barges and transported to the disposal area. The mechanical dredge can leave an irregular bottom and, significantly, typically generates higher levels of turbidity throughout the water column at the dredging site, notwithstanding the availability of various bucket designs that can reduce the generation of suspended solids.

Mechanical dredges are rugged, highly reliable and capable of removing a broad range of materials, such as unconsolidated silts, consolidated clays, sand, gravel, trash, and debris. The production rate of a mechanical dredge is significantly lower compared to a hydraulic dredge or a cutter head dredge, due to scow loading operations. Such operations are subject to spills and splashing, which result in resuspension of sediments in the water. However, for specific applications, recent innovations in dredge bucket design have made it possible to minimize turbidity caused by the use of mechanical dredging operations. Each of the available mechanical dredge technologies is evaluated below.

8.4.1.1 Grapple Mechanical Dredge Technology

Grapple dredge consists of a derrick mounted on a barge and equipped with a "clamshell" bucket. Grapple dredges are best suited for dredging of very soft deposits. Grapple dredges have a very low production rate and are not suitable for excavation of hard material. Considering the large volume of material to be dredged at Ocean Cay and the hard nature of the material, the use of a grapple dredge at Ocean Cay is not feasible.

8.4.1.2 Dragline Mechanical Dredge Technology

The dragline is an excavating tool consisting of a steel bucket, which is suspended from a movable crane. After biting into the soil, it is dragged toward the crane by a cable. Draglines are best suited for dredging of very soft deposits, and have a very low production rate, and are not suitable for excavation of hard material. Considering the large volume of material to be dredged at Ocean Cay and the hard nature of the material, the use of a dragline at Ocean Cay is not feasible.

8.4.1.3 Dipper Mechanical Dredge Technology

The dipper dredge is similar to the land-based mechanical excavating shovel. Due to its leverage it works best in hard compacted material or rock. The dipper dredge has a rather low production rate and is not efficient for dredging and reclamation activities as this method relies on scows for disposal/transport of the excavated material. Considering the large volume of material to be dredged at Ocean Cay and the hard nature of the material, the use of a dipper dredge at Ocean Cay is not feasible.

8.4.1.4 Bucket Mechanical Dredge Technology

The bucket dredge consists of a pontoon with a well and six anchors. The buckets are connected on an uninterrupted chain which moves over the ladder on rollers. The ladder goes down from a high support to the dredge level. The submerged part can be lowered and hoisted with a fixed gantry and winch. During the dredging, the soil is excavated by the buckets and transported to the top of the ladder. When the bucket tumbles, the dredged materials fall into a drop chute, which leads the material to a transport barge alongside the dredge.

The bucket dredge is suitable for accurate dredging of clay and other sticky materials. It can also be used for dredging of gravel and other coarse materials. It can be used for pipeline trenches, inland canals, and harbor basins (as long as there is no navigation). The number and capacity of transport barges is related to the production and distance to the disposal site(s). The bucket dredge is noisy, due to the use of the bucket chain. In addition, the bucket dredge is best suited for sheltered locations, such as protected harbors. Use of a bucket dredge at Ocean Cay is not feasible due to the hard nature of the material to be dredged, the large volume of dredged material, and the exposed location of the site.

8.4.1.5 Backhoe Mechanical Dredge Technology

A backhoe dredge is a stationary dredge, as described in Section 2.4.1.2. It consists of a hydraulic excavator mounted on a spud barge or a self-elevating platform. The type and size of the bucket is, apart from the type of excavator, dependent on the dredging depth and the type of material to be dredged. For the dredging of contaminated materials, the dredge can be fitted with a visor bucket, in order to reduce turbidity. The dredged materials are generally stored and transported to the dumping site using bottom dump barges. Although a backhoe dredge is a stationary dredge, it normally does not have anchor wires and it requires considerably less space while dredging compared with a bucket dredge. From this point of view it is preferable for the project.

8.4.1.6 Conclusions -- Mechanical Dredging Technology

Due to the nature of material to be dredged (i.e., rock), the large quantity of material to be dredged, and the required reclamation volume, the use of a mechanical dredge to widen and deepen the approach channel and turning basin at Ocean Cay is not feasible. The efficiency, versatility and cost of using a mechanical dredge at the main dredging plant at Ocean Cay would not be satisfactory, and a continuous self-contained digging and disposal operation would not be feasible. If a mechanical dredge were to be used, the duration of the dredging activities at Ocean Cay would be significantly increased thus resulting in an extension of the period during which potential environmental impacts could occur. In addition, the use of a mechanical dredge would significantly increase marine traffic, since a fleet of scows would be required to transport the dredged material to reclamation site. This in turn would result in a higher consumption of fossil fuel. However, considering the volume and anticipated nature of material to be dredged, the low production rate requirements, and factoring in mobilization and demobilization costs, and plant availability, a backhoe dredge will likely be used for the dredging of the foundation trench for the caisson as well as the trench for the intake and outfall pipe and structures.

8.4.2 Hydraulic Dredging Technology

Hydraulic dredges are self-contained units, which handle both phases of dredging operations, i.e., excavating and disposal/reclamation. Hydraulic dredges operate using a solids handling centrifugal pump. Hydraulically operating dredges can be classified into two basic categories: hopper (trailing suction) and cutterhead suction dredge.

8.4.2.1 Hopper Hydraulic Dredge Technology

Hopper dredges are self-propelled ships that include an integral suction pipe or several suction pipes, which are dragged along the seabed. The bottom materials are drawn through a suction head on the drag arms, are passed through the suction pipe and centrifugal pump, and are deposited, as a slurry, in a large onboard hopper. After loading, the hopper dredge can sail to an offshore or other designated dumpsite, open bottom doors, and discharge the dredged materials. Some hopper dredges have the capacity to off-load the dredged materials by rainbow method, which consist of pumping and spraying the dredged material at the reclamation site. Hopper dredges are able to operate in sea conditions that would restrict the safe operation of other types of dredges. In addition, hopper dredges present a minimum interference to other vessel operations when working in busy channels and are able to efficiently transport dredged materials over short haul distances. However, disposal of the dredged materials requires that the dredging process be temporarily suspended as the dredge travels to the disposal site.

Hopper dredges are particularly effective when dredging in deep channel projects with long straight reaches and are not effective in restricted areas, such as berths and docking facilities. Hopper dredges have high production characteristics when dredging loose sediments and unconsolidated sands, but are severely restricted by stiff clays and hard bottom materials. Use of the hopper dredge with hardbottom materials may require extensive blasting. Due to the hard nature of the material to be dredged at Ocean Cay, the use of a hopper dredge is not feasible.

8.4.2.2 Cutterhead Suction Hydraulic Dredge Technology

The Cutterhead Suction Dredge (CSD) is described in Section 2.4.1.2 and shown on Figure 2.23. The CSD is a stationary dredge anchored at its stern by two heavy spud poles. The "cutter" of the CSD is a rotating cutting device surrounding the intake end of the suction pipe. The cutter is usually in the form of an open basket, which may include blades or cutting teeth. As the cutter rotates around a longitudinally mounted shaft it disintegrates and loosens the seabed material and places it in the high velocity stream at the suction intake. For removal of rock-like formations without blasting, larger and more powerful CSDs are required. A heavy suction arm (ladder) is connected to the hull with hinges and can be accurately lowered or hoisted with a heavy gantry and a winch. One or two centrifugal dredge pumps are installed in the pump room and some dredges also have a submerged pump on the ladder, as close as possible to the entrance of the suction pipe. The cutter head is connected near the entrance of the suction pipe and is driven mechanically by an engine and a shaft along the ladder, or directly by a submerged motor. The dredged material can be transported to the reclamation/disposal site using a pipeline.

Considering the volume of material to be dredged and depending on the finalized construction schedule requirements, one or two CSD(s) will be employed at Ocean Cay. The CSDs will have at least an 863.6-mm (34-in)-diameter cutterhead. Due to nature of seabed, each CSD will likely have a minimum total power of 20,000 HP with a cutter power of 4,000 HP. Since no specific information about the offshore soil conditions is available, it is very difficult to provide output projections. However, based on previous dredging projects in the Bahamas, a preliminary averaged production rate in the order of 12,000 m^3/day (17,700 yd^3/day) can be used for scheduling purposes. It is important to note that the actual production rate can only be estimated once additional information about the composition and the strength of the seabed material is available.

Based on preliminary soils information, it is likely that the dredging can be accomplished with minimal or no blasting.

8.4.3 Preferred Dredge Technology

Given the anticipated soil conditions and the estimated dredging volumes, the project strongly favors the use of a large Cutter Suction Dredge (CSD) for the major dredging tasks proposed at Ocean Cay as described in Section 2.4.1.2. For dredging the trench for the caisson structure and the trench for the cooling water intake and outfall, a mechanical dredge can be used. At Ocean Cay two types of mechanical dredges can be used, namely bucket dredges and backhoe dredges; however, the bucket dredge is the preferred method for the proposed project. The criteria utilized to evaluate each dredging technique are summarized below in Table 8-3.

Table 8-9
Analysis of Mechanical and Hydraulic Dredging Alternatives

Mechanical Dredges	**Sedimentation Rate**	**Materials Capable of Being Dredged**	**Production Rate**	**Comments**	**Feasible for proposed Project**
Grapple Dredge	High	Very Soft Deposits	Low	Not suitable for hard materials	No
Dragline Dredge	High	Very Soft Deposits	Low	Not suitable for hard materials	No
Dipper Dredge	High	Hard compacted rock	Low	Inefficient use of scows for disposal of materials	No
Bucket Dredge	High	Clays, gravel and coarse materials	Low	High noise, high fuel consumption due to barges for disposal of dredged material	Yes, for caisson and intake pipe trenches
Backhoe Dredge	Moderate	Clays, gravel and coarse materials	Low	Compact size, can be equipped with turbidity controls	Yes, for caisson and intake pipe trenches
Hydraulic Dredges					
Hopper Dredge	Low	Loose sediments and unconsolidated sand	High	Disposal of dredged material may require dredging operations to be suspended	No
Cutterhead Suction Dredge	Low	All alluvial materials, compacted deposits and rock-like formations	High	Not designed for heavy sea conditions, floating pipeline can deposit dredge spoils in disposal area	Yes

9.0 PUBLIC CONSULTATION

9.1 Develop Public Consultation Plan

In consultation with BEST, AES will develop an appropriate approach for soliciting and adequately addressing relevant public concerns about the project. This approach will include identifying and documenting the public consultation process to be used; methods for disseminating pertinent information about the project and obtaining public input (The Biminis, North and South Cat Cay, and the islands in the vicinity of Ocean Cay); timeframes and appropriate junctures for public consultation; respective roles, responsibilities and expectations for BEST, AES, and other interested parties; and other appropriate characteristics of a useful public consultation process. Once an overall approach has been agreed upon, AES will develop a Public Consultation Plan for BEST's review and approval. We understand that BEST desires to play a lead role in the public consultation process itself and we intend to develop a plan that meets BEST's approval and requirements.

9.2 Implement Public Consultation Plan

Although a detailed plan will be developed mutually between BEST and AES, BEST will take a lead role in the public consultation process. This will likely include, among other things, the conduct of town meetings and open forums and consultations with community leaders, politicians, government officials, interest groups and other interested parties. AES will participate in all meetings with BEST and offer relevant technical assistance, present relevant background information on the project, and respond to questions and concerns. AES will be responsible for documenting the results of all public consultation activities and initiatives, addressing and responding to identified issues and concerns, and incorporating pertinent information into the EIA process, associated draft reports, and final EIA documentation.

10.0 ENVIRONMENTAL MANAGEMENT PLAN

AES has prepared an Environmental Management Plan, attached as Appendix T, which will be implemented during the construction, decommissioning and operations phases of the project. The Environmental Management Plan contains guidelines for the minimum requirements of the development of detailed programs, procedures, and monitoring plans to protect human health and the environment including the following:

- Attachment 1: Construction Spill Prevention, Control and Countermeasures (SPCC) Plan;
- Attachment 2: Integrated Spill Control, Response, Pollution Prevention and Stormwater Management Plan;
- Attachment 3: Contractor Health and Safety Plan;
- Attachment 4: Sediment, Erosion and Stormwater Control Plan;
- Attachment 5: Marine Biological (Cetacean and Sea Turtle) Monitoring Plan;
- Attachment 6: Contaminated Sediment and Soil Management Plan;
- Attachment 7: Waste Minimization Plan;
- Attachment 8: Seagrass Mitigation Plan;
- Attachment 9: Marine Safety Plan;
- Attachment 10: Worker Safety Plan;
- Attachment 11: Emergency Plan;
- Attachment 12: Security Plan;
- Attachment 13: Intake and Discharge Monitoring Plan; and
- Attachment 14: Marine Turbidity Monitoring Program.

This EMP and its associated attachments serve as a guideline for the minimum requirements of the detailed procedure to be developed and will be updated and revised as needed throughout the construction and operation phases of the Project.