Derenzo and Associates, Inc.
Environmental Consultants

RESULTS OF
AIR QUALITY MODELING ANALYSIS
FOR
SARASOTA ENERGY, L.L.C.
LANDFILL GAS FIRED ELECTRICITY GENERATION PROCESSES
AT THE
CENTRAL COUNTY SOLID WASTE DISPOSAL COMPLEX

Sarasota Energy, L.L.C.
Nokomis, Sarasota County, Florida

September 5, 2013

DAI Project No. 1301043

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

APPENDIX A PLOT MAP OF THE LANDFILL AND PROPOSED FACILITY

APPENDIX B CAT® ENGINE / GENERATOR TECHNICAL DATA

APPENDIX C CALPUFF MODELING FILES

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1.0 INTRODUCTION TO AIR QUALITY IMPACT ANALYSES

Sarasota Energy L.L.C. (Sarasota Energy) plans to construct electricity generation processes that will result in the beneficial use, after treatment, of landfill gas (LFG) that is collected from the Central County Solid Waste Disposal Complex (the landfill). The proposed electricity generation facility will be located on a leased site within the boundaries of the landfill in Nokomis, Sarasota County, Florida.

Currently, landfill gas that is generated by the landfill as a result of the degradation of the solid wastes placed in the facility is directed by a voluntarily installed active LFG collection system to an open flare for control. Sarasota Energy plans to install four (4) LFG-fueled Caterpillar® Model G3520C reciprocating internal combustion engines (RICE) at the landfill which will have the potential to produce 6.4 megawatts (MW) of electricity.

The air quality modeling results have been prepared for regulatory agency review for the performance of source impact analyses to support plans to install four (4) additional CAT® Model No. G3520C reciprocating IC engines at the proposed facility for the beneficial use of LFG that is expected to be generated by the landfill.

1.1 Class II Area Criteria Pollutant Modeling

The proposed Sarasota Energy LFG-fueled electricity generation facility will be a major source of carbon monoxide and will be subject federal Prevention of Significant Deterioration (PSD) regulations. Results of significant impact level analyses performed for the proposed facility indicate that maximum criteria pollutant emission rates have the potential to produce air quality impacts that exceed specified PSD significant impact level concentrations.

Multisource air quality impact analyses were performed to compare calculated impacts to PSD Increment values and applicable National Ambient Air Quality Standards (NAAQS). Results of the PSD increment and NAAQS modeling demonstrations were previously provided to the FDEP under a separate heading (document dated August 19, 2013).

1.2 Class I Area Significant Impact

PSD sources that have the potential to impact Class I areas are required to perform analyses to evaluate criteria pollutant impacts within the Class I area and demonstrate that the plume of the proposed air pollutant emission processes will not have an adverse impact on visibility within the Class I area.

The Sarasota Energy facility in Nokomis, Florida is located approximately 160 kilometers from an area designated as a Federal Class I Area (national parks, wilderness or refuge areas, and national memorials). The nearest Class I Area is the Chassahowitzka National Wildlife Refuge in Crystal River, a distance of approximately 157 km from the landfill.

Based on its location relative to federal Class I areas, Class I criteria pollutant analyses have been performed for the proposed LFG fueled facility. Results of these analyses are presented in Section 3.0.

2.0 SITE CHARACTERISTICS AND FACILITY INFORMATION

The following sections present detailed site characteristics and facility information that were considered in performing the air quality modeling analysis.

2.1 Site Characteristics and Topography

The proposed Sarasota Energy facility is located in an area that is surrounded by sparsely populated rural forest and grasslands (i.e., deciduous forest and pasture/hay landcover). The nearest residence is located approximately 2,800 meters south of the proposed Sarasota Energy facility.

The terrain of the land that surrounds the proposed Sarasota Energy facility is relatively flat. The base elevation for the proposed facility is approximately 20 ft. above sea level. The minimum release height for the proposed CAT® Model G3520C IC engine exhaust stacks (Engine Nos. 1 – 4) will be 30 ft. as measured from local grade, which results in a minimum exhaust stack release elevation of approximately 50 feet above sea level. Based on review of topography plots of the surrounding area, there is no terrain within 3 km of the source (landfill) that has elevations greater than 50 feet above sea level (i.e., simple terrain).

Appendix A provides a plot map of the landfill and proposed facility.

2.2 Facility Exhaust Parameters

The proposed Sarasota Energy facility will consist of four (4) CAT® G3520C IC engines (Engine Nos. 1 through 4). All engines are or will be fueled with treated LFG and designed to operate at base load (100% capacity) conditions.

The CAT® G3520C Gas Engine Technical Data Sheet provides a specification for exhaust gas flowrate based on an assumed LFG fuel quality and engine efficiency. Site-specific data collected by Derenzo and Associates at similar facilities operating the CAT® G3520C engine indicates that the engines exhaust up to 4,700 dscfm (dry gas flow corrected to standard temperature and pressure) at 8.0% oxygen. At actual operating conditions each of the proposed CAT® G3520C IC engines is expected to exhaust effluent gas at a rate of 13,700 acfm at 900°F through an 18-inch diameter stack. The four (4) exhaust stacks and parameters are identical, therefore, for the purposes of the Class I modeling analysis, all of the emissions were released through one representative exhaust stack.

Table 2.1 presents the exhaust stack parameters that were used in the air quality impact analyses for Engine Nos. 1 through 4 (the proposed facility).

Appendix B provides manufacturer's specification sheets for the CAT® Model Nos. G3520C IC engines.

2.3 Facility Criteria Air Pollutant Emission Rates

Criteria air pollutant emission rates for the proposed facility IC engines are presented in the air permit application document. The proposed IC engine emission rates are based on engine manufacturer guaranteed emissions rates, actual operations for similar engines, the application of best available control technology and USEPA AP-42 emission factors.

Table 2.2 presents criteria pollutant emission rates for the proposed CAT® G3520 LFG-fueled IC engines (Engine Nos. 1 through 4).

Table 2.1 Exhaust stack parameters for the proposed Sarasota Energy facility

Source ID	Location (UTM) East (m)	Location (UTM) North (m)	Base Elev. (m)	Stack Height (m)	Stack Height (ft)	Stack Diameter (m)	Stack Diameter (ft)	Temp. (°F)	Exit Velocity (m/s)
SarasotaEn	362850	3008954	6.10	9.14	30.0	0.46	1.50	900	129

Table 2.2 Criteria pollutant emission rates used in the air quality modeling analysis for the proposed Sarasota Energy CAT® G3520C LFG-fueled IC engines (Engine Nos. 1 through 4)

Pollutant	LFG-fueled IC engine emission factors		Modeled emission rate per IC engine[1] (lb/hr)	Modeled emission rate per IC engine[1] (g/s)	Emission rate for four (4) IC engines (g/s)	Emission rate for four (4) IC engines (ton/yr)
Nitrogen Oxides (NO_x)	0.60	g/bhp-hr	2.97	0.374	1.496	52.0
Sulfur Dioxide (SO_2)	48.0	lb/MMscf	2.05	0.258	1.032	36.0
Particulates ($PM_{10}/PM_{2.5}$)	0.24	g/bhp-hr	1.19	0.150	0.600	20.8

1. Based on continuous operation of a single engine at base load (100% capacity) conditions; engine output of 2,242 hp and maximum fuel consumption of 713 scfm (42,753 scfh) LFG.

3.0 CLASS I AREA MULTISOURCE MODELING ANALYSIS

3.1 Purpose

Based on guidance from the Federal Land Manager, a Class I area PSD increment and visibility analyses must be performed when a proposed facility is a potential major source that will be located within 300 km of a designated Class I area. The Sarasota Energy facility is located approximately 157 km from the nearest boundary of the Chassahowitzka National Wildlife Refuge. The Florida DEP recommends that Sarasota Energy analyze the potential impact the facility potentially has on the nearest Class I area as a demonstration for all Class I areas located beyond this minimum distance (i.e., between 157 and 300 km from Sarasota Energy).

3.2 Model Selection

Generally, analysis of Class I areas impacts are required to be determined using the CALPUFF dispersion model when the impact area is at a distance over 50 km from the emission source (Gaussian steady-state plume dispersion models such as AERMOD are only recommended up to 50 km). CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on air pollution transport, transformation and removal.

Guidance issued by USEPA indicates that the CALPUFF dispersion model can be used to assess haze impairment that may be attributable to the emissions from a single source at distances greater than 50 km from the source location. The distance between the Sarasota Energy facility location and the Chassahowitzka National Wildlife Refuge ranges from approximately 157 km at the closest point to 193 km at the furthest point. Based upon these distances, the Chassahowitzka National Wildlife Refuge area is greater than 50 km away from the Sarasota Energy location. Therefore, the CALPUFF model was used for the air pollutant dispersion and visibility impairment modeling.

The software suite CALPUFF Professional version 3.03.0, distributed by Oris Solutions, was used to determine potential criteria pollutant impacts and potential visibility degradation in the Chassahowitzka National Wildlife Refuge from the emissions produced by the proposed electricity generation facility. The CALPUFF executable program files (CALPUFF.exe and CALPOST.exe, EPA-approved version 2007 5.8) and other supporting files were acquired from the Atmosphere Studies Group (ASG) TRC CALPUFF homepage. Input data were entered into the model using the CALPUFF Professional software in the Existing Vistas Screening Project mode for Domain 2 (FL).

3.3 Model Data and Options

The source data (i.e., UTM coordinates and stack parameters), presented in Table 2.1, were entered into the CALPUFF interface.

Default values of zero (0) meters for the initial sigma y and initial sigma x were used and the momentum flux was set to the default value of one (1) meter.

For the visibility screening, a maximum relative humidity of 95% and Rayleigh Scattering value of 11.0 per megameter (Mm^{-1}) were used as recommended in the Interagency Workgroup on Air Quality Modeling (IWAQM) *Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts* (IWAQM Recommendation Document) and the *FLAG 2000, FLAG 2008* and *FLAG 2010* documents.

3.4 Receptor Network

The computer model requires the user to enter information relating to the Class I area under consideration. The CALPUFF Professional software includes a database of receptors for all United States Class I Areas. These receptor locations and specifications (including elevations) were initially acquired by Oris Solutions from the National Park Service website. For this Class I analyses, the Chassahowitzka National Wildlife Refuge was characterized by 113 discrete receptors within the boundaries of the Class I area.

Figure 3.1 presents the modeling domain of the Class I area significant impact evaluation.

Figure 3.2 presents the calculated domain of the Class I area significant impact evaluation.

3.5 Meteorological Data

The meteorological data used for the CALPUFF modeling were obtained from the Florida DEP. The data files were already processed in the CALMET pre-processer program that creates a file ready to be used in the CALPUFF model. The data files (.dat), along with the associated input files (.inp and .lst), for three years (2001-2003) were provided by the Florida DEP on an external hard drive and had to be renamed so that the file names were in chronological order (e.g. FL01apr.dat was changed to FL01-04.dat).

The 2003 meteorological data provided by the Florida DEP did not contain data for December 31 (only January 1 through December 30). Mr. Tom Rogers of the Florida DEP recommended (during a telephone conversation on January 8, 2010) using the 2003 meteorological year as provided by the Florida DEP. The completed 2003 model iteration did not include December 31, but was completed with over 99% of the 2003 meteorological data.

3.6 Class I Area Significant Impact

Table 3.1 presents the significant impact levels for Class I areas.

The CALPUFF model was executed to calculate impact concentrations of PM_{10} (24-hr and annual averaging periods), NO_2 (annual averaging period) and SO_2 (3-hr, 24-hr and annual averaging periods) at the specified Class I area receptors that result from operation of the proposed emission sources. The predicted impacts were compared to the significant impact levels in Table 3.1.

The proposed engines were modeled as one (1) combined emission source for the model iterations. Appropriate post-processors (POSTUTIL and CALPOST) were used to calculate pollutant impacts for the desired averaging periods for the three (3) years modeled.

3.7 Visibility

The presence of fine particulate matter (sulfates, nitrates and organic carbons) in the atmosphere has the potential to cause visibility impairment by the scattering or adsorbing of light. USEPA has concluded (*Guideline on Air Quality Models*, 40 CFR Part 51, Appendix W, §7.2.1) that the long-range transport of fine particulate matter can significantly impair visibility in areas that are located hundreds of kilometers from the source of these emissions. Therefore, based on the distance between the proposed electricity generation facility and the nearest Class I area (Chassahowitzka National Wildlife Refuge), the Florida DEP requires that analyses be performed to evaluate the potential impacts of the emission plume produced by Sarasota Energy at the closest Class I area.

Emission rates for PM_{10} and those constituents exhausted by the IC engine operation that have the potential to undergo chemical transformation to form nitrate and sulfate particulate compounds (NO_x and SO_2) were used in the visibility analyses as input for the CALPUFF calculations. The MESOPUFF II chemistry option was used, which considers the chemical species SO_2, SO_4, NO_x, HNO_3, NO_3 and primary particulate (PM) for assessing haze contributions within the Class I area.

The operating parameters of the CALPUFF model were configured to calculate light extinction values at the receptors located at the Chassahowitzka National Wildlife Refuge Class I area. All background concentration inputs (Ammonium Sulfate, Ammonium Nitrate, Coarse Particulates, Organic Carbon, Soil, Elemental Carbon) for the CALPUFF visibility demonstration were set to zero to calculate the maximum possible impacts the source could have on Class I area visibility (i.e., all calculated haze impairment was considered to be caused by Sarasota Energy without subtracting default background concentrations). A regional haze visibility degradation of 5% or less is considered acceptable visibility impairment (i.e., visibility degradation calculated with CALPUFF compared to the existing default background visibility impairment).

Table 3.2 presents visibility analyses criterion for Class I areas.

3.8 Model Results

Appendix C provides a compact disc of the input files used and output files generated in the Class I Area analyses.

Meteorological data provided by the Florida DEP used in the CALPUFF modeling are not included on the Appendix C compact disc due to the size of the meteorological data files.

3.8.1 Criteria Pollutant Results

Table 3.3 presents maximum air pollutant impacts predicted by the CALPUFF model in the Class I area for emissions from the proposed electricity generation facility

The maximum predicted NO_2 (annual average), PM_{10} (24-hr and annual averages) and SO_2 (3-hr, 24-hr and annual averages) impacts are less than the corresponding Class I significant impact levels.

3.8.2 Visibility Results

Table 3.4 presents the results of the CALPUFF Class I area visibility impairment analysis.

The visibility impairment modeling results for the three-year meteorological data set indicate that:

- The greatest one-day (24-hr) light extinction value over the three-year period is 0.16%.
- The exhaust plume did not cause greater than 5 % light extinction for any day within the three-year period.

The predicted visibility impairment parameters are below the criteria for visibility impacts at a Class I location. Therefore, no further analyses are required.

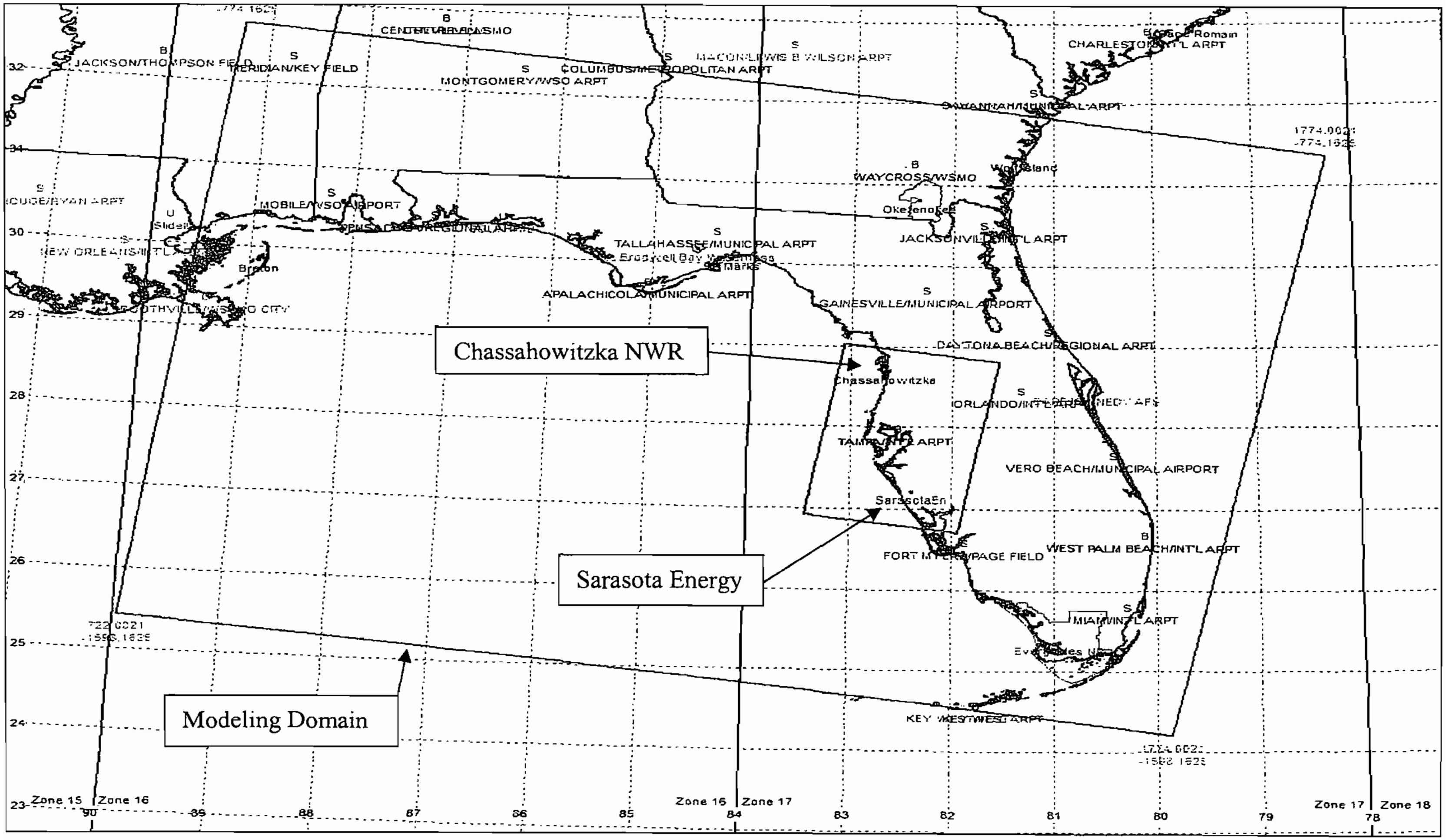


Figure 3.1. Class I area modeling domain

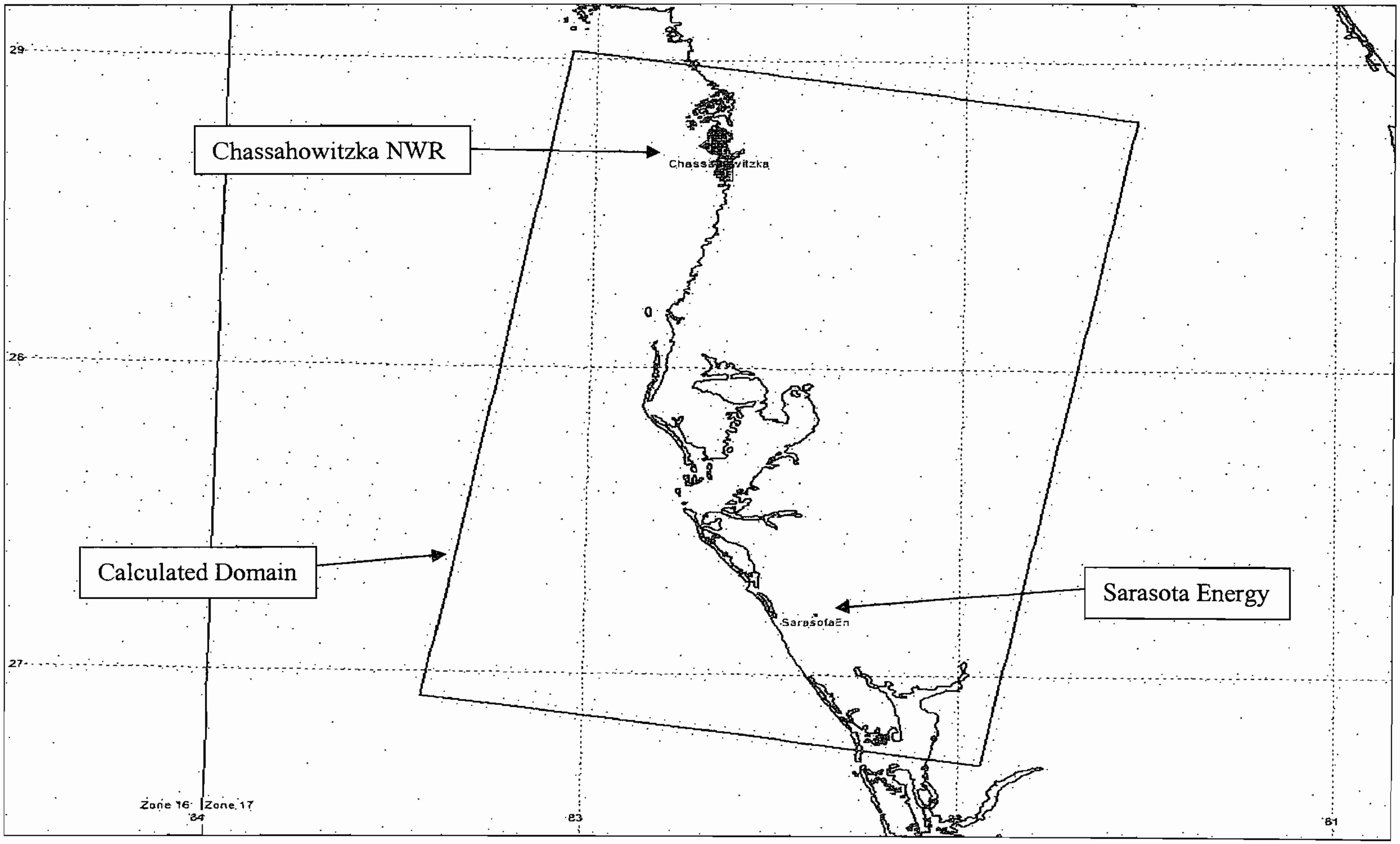


Figure 3.2. Class I area calculated domain

Table 3.1 PSD Significant Impact Levels (μg/m³) for Class I Areas

Pollutant	Annual	24-hr	3-hr
Inhalable Particulates (PM_{10})	0.2	0.3	---
Nitrogen Dioxide (NO_2)	0.1	---	---
Sulfur Dioxide (SO_2)	0.1	0.2	1

Table 3.2 Visibility Impairment Criterion for Class I Areas

Pollutant	Annual	24-hr	3-hr
Visibility – Light Extinction (b_{ext})	---	5%	---

Table 3.3 Air Pollutant Impact Results for the proposed Sarasota Energy facility compared to Class I Area PSD Significant Impact Levels

Pollutant	Averaging Time	Predicted Impact[1] (μg/m³)	PSD Class I Area Significant Impact Levels (μg/m³)	Radius of Significant Impact (km)
NO_2	Annual	0.00006	0.1	NA
PM_{10}	Annual	0.0001	0.2	NA
PM_{10}	24-hr	0.002	0.3	NA
SO_2	Annual	0.0001	0.1	NA
SO_2	24-hr	0.003	0.2	NA
SO_2	3-hr	0.01	1.0	NA

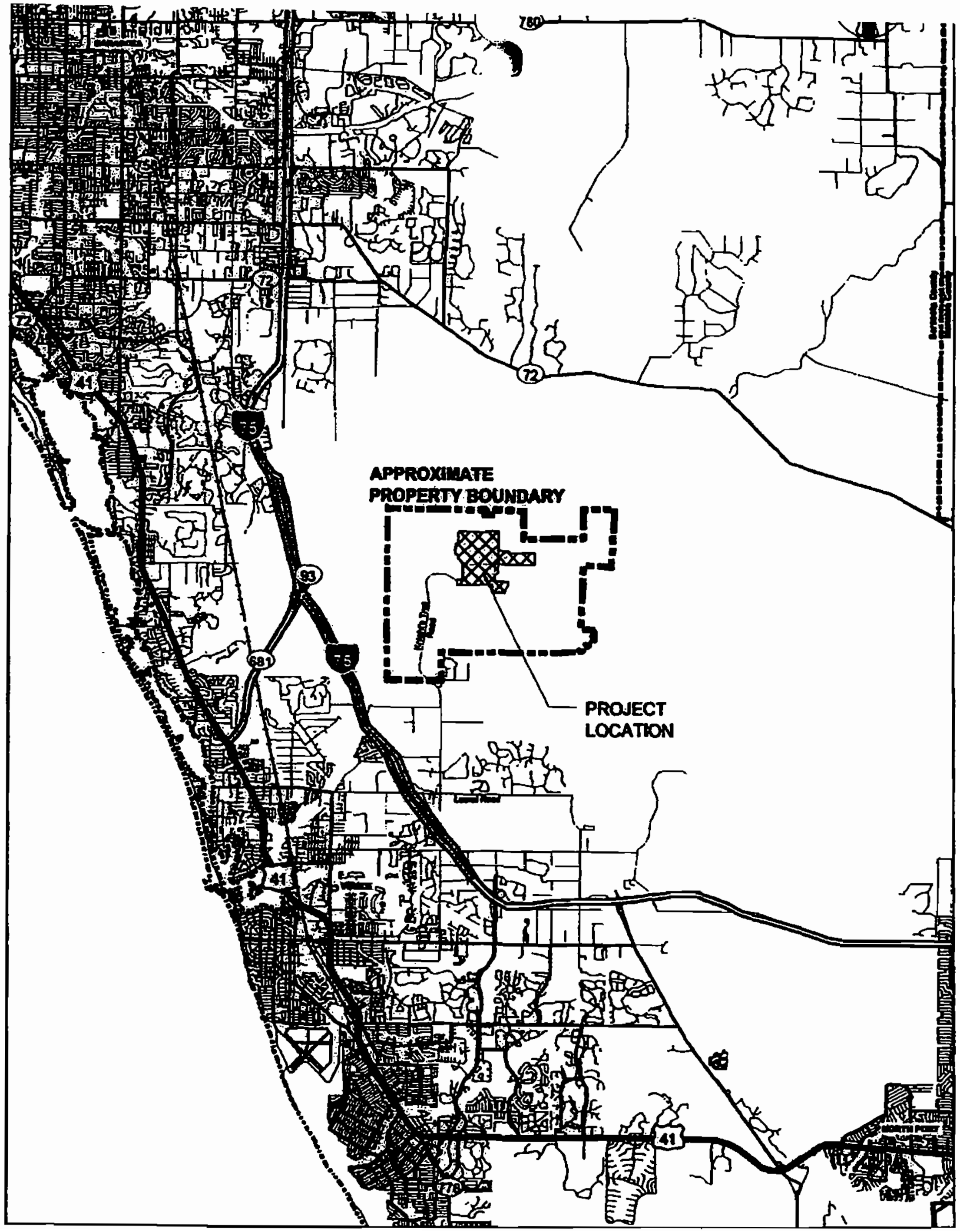
1. Maximum impact over the 3-year meteorological data set.

Table 3.4 Results of CALPUFF visibility impairment analysis for the Chassahowitzka National Wildlife Refuge Class I Area

Meteorological Year	Greatest Light Extinction Change (b_{ext}) (%)	Days with > 10% Light Extinction	Days with > 5% Light Extinction
2001	0.09	0	0
2002	0.16	0	0
2003	0.13	0	0
Average	0.13	0	0

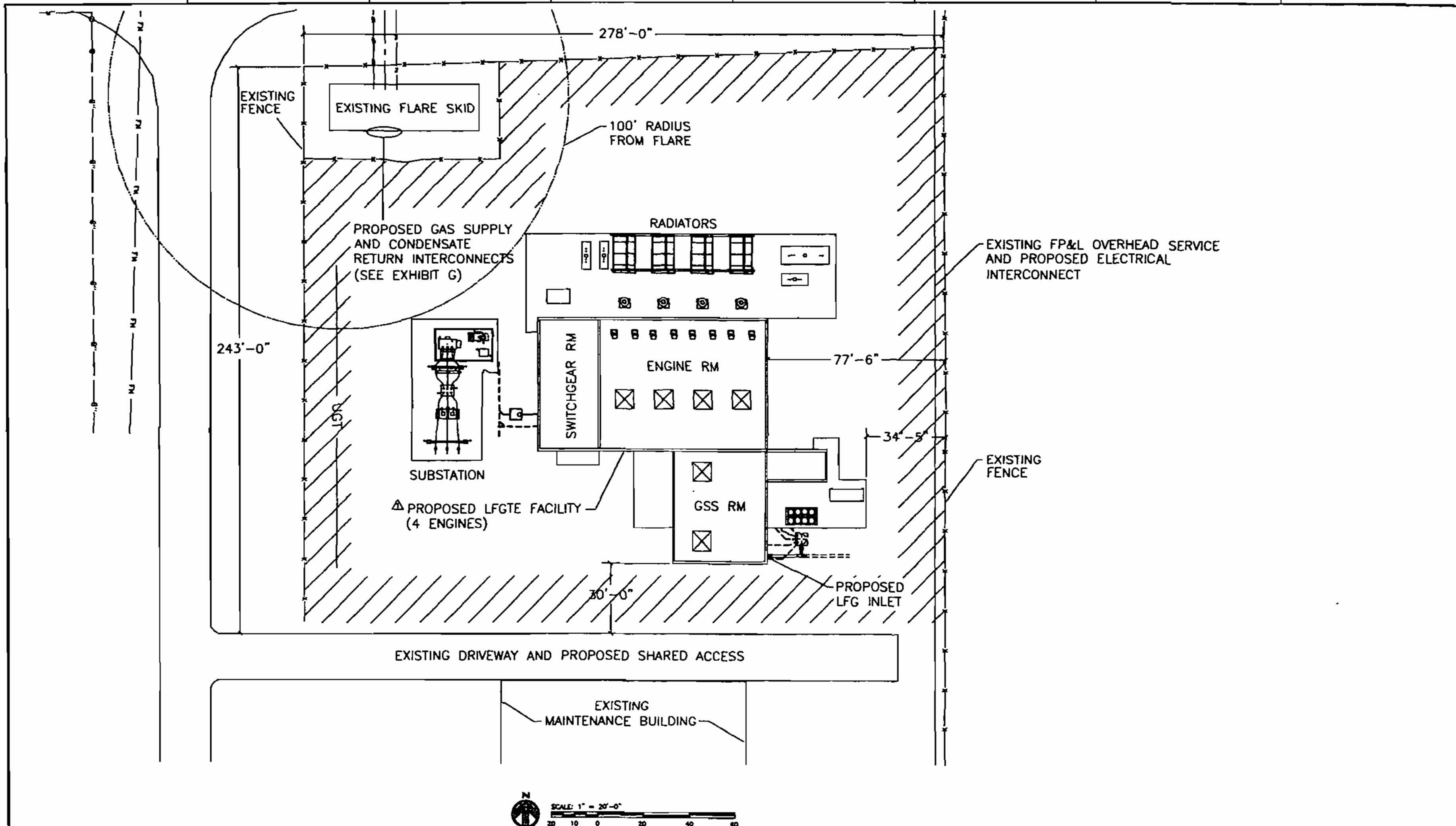
APPENDIX A

PLOT MAPS OF THE LANDFILL
AND PROPOSED FACILITY



APPROXIMATE
PROPERTY BOUNDARY
PROJECT
LOCATION
Laurel Road


3 57 000
3 58 000
3 59 000
3 60 000
3 61 000
3 62 000
3 63 000
3 64 000
3 65 000
3 66 000
3 67 000
3 68 000
3 69 000
30 13 000
30 12 000
30 11 000
30 10 000
30 09 000
30 08 000
30 07 000
30 06 000
North American Datum of 1983
1:50000 scale



REVISION	DATE	DESCRIPTION
1	4/25/13	ROTATED PROPOSED LFGTE FACILITY 90 DEG CW

HDR

ISSUE	DATE	DESCRIPTION
A	7 APR 11	EXHIBIT D ISSUE

PROJECT MANAGER	
DESIGNED BY	
DRAWN BY	
CHECKED BY	
PROJECT NUMBER	125411

Central County Solid Waste Disposal Complex

PRELIMINARY

SARASOTA COUNTY FLORIDA

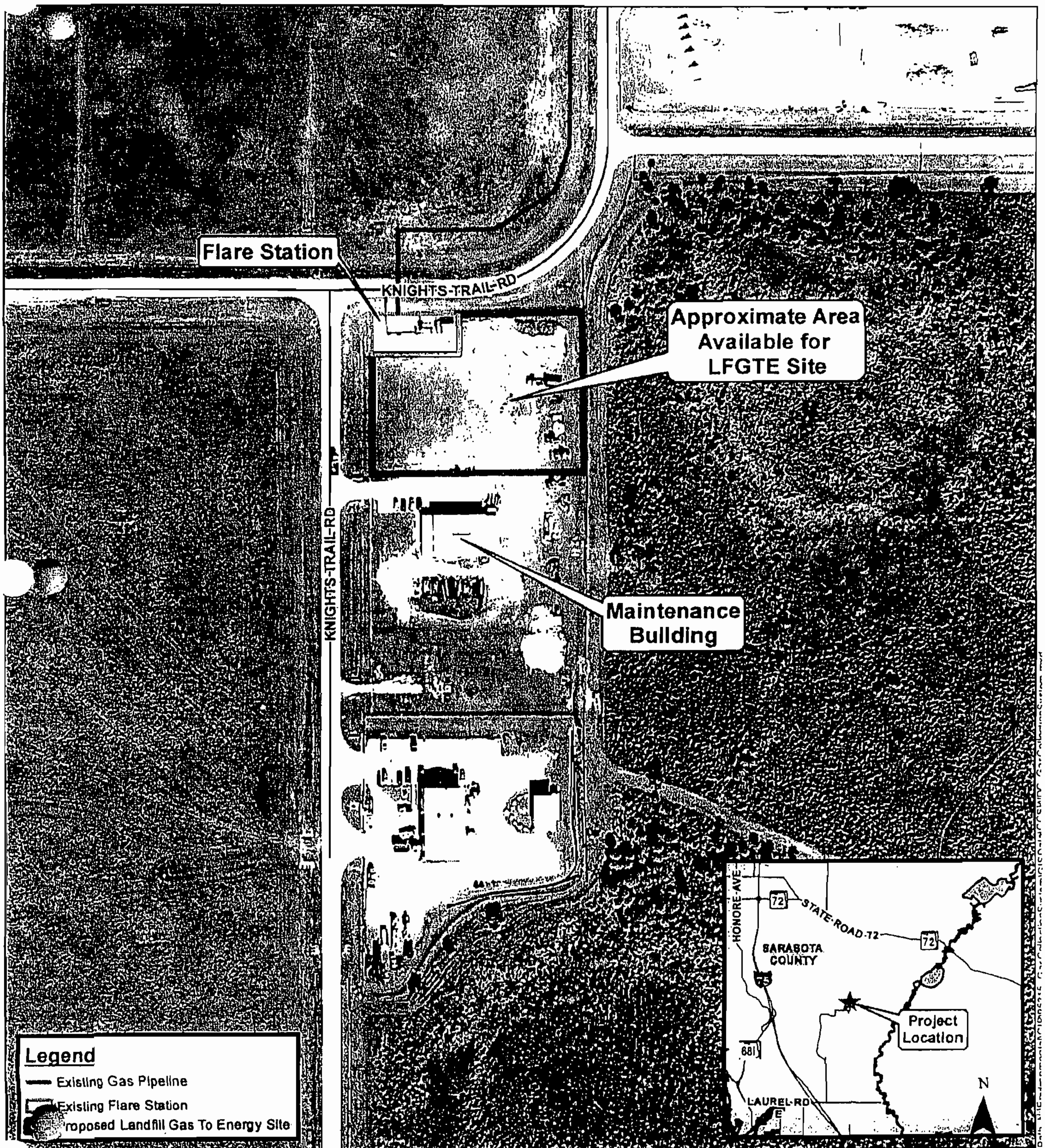
EXHIBIT D
PROPOSED FACILITY SITE AND INTERCONNECTIONS

FILENAME	125411-CGA-M1001
SCALE	1" = 20'-0"

SHEET M1001

Central County Solid Waste Disposal Complex
Landfill Gas to Energy Facility

CIP# 95215



Map published using ArcGIS 10.0 by jgrimes on Wednesday, October 12, 2011

Sarasota County

Aerial Imagery Provided by PhotoScience: Sarasota County, FL December 2010 to January 2011

N W E

0 100 200

This map is produced from Sarasota County GIS, and is representative information only. The County does not warrantee, guarantee, or

APPENDIX B

CAT® ENGINE / GENERATOR TECHNICAL DATA

G3520C

GAS ENGINE TECHNICAL DATA

CATERPILLAR®

ENGINE SPEED (rpm):	1200	FUEL:	Low Energy
COMPRESSION RATIO:	11.3	FUEL SYSTEM:	CAT LOW PRESSURE
AFTERCOOLER - STAGE 2 INLET (°F):	130		WITH AIR FUEL RATIO CONTROL
AFTERCOOLER - STAGE 1 INLET (°F):	217	FUEL PRESSURE RANGE(psig):	1.5-5.0
JACKET WATER OUTLET (°F):	230	FUEL METHANE NUMBER:	140
ASPIRATION:	TA	FUEL LHV (Btu/scf):	500
COOLING SYSTEM:	JW+1AC, OC+2AC	ALTITUDE CAPABILITY AT 77°F INLET AIR TEMP. (ft):	1378
IGNITION SYSTEM:	ADEM3	APPLICATION:	Genset
EXHAUST MANIFOLD:	DRY	POWER FACTOR:	0.8
COMBUSTION:	Low Emission	VOLTAGE(V):	480-4160
NOx EMISSION LEVEL (g/bhp-hr NOx):	0.5		

RATING		NOTES	LOAD	100%	75%	50%
GENSET POWER	(WITHOUT FAN)	(1)(2)	ekW	1600	1200	800
GENSET POWER	(WITHOUT FAN)	(1)(2)	KVA	2000	1500	1000
ENGINE POWER	(WITHOUT FAN)	(2)	bhp	2242	1683	1128
GENERATOR EFFICIENCY		(1)	%	95.7	95.6	95.1
GENSET EFFECIENCY	(ISO 3046/1)	(3)	%	38.3	37.0	34.5
GENSET EFFECIENCY	(NOMINAL)	(3)	%	37.4	36.1	33.7
ENGINE EFFICIENCY	(NOMINAL)	(3)	%	39.1	37.8	35.4
THERMAL EFFICIENCY	(NOMINAL)	(4)	%	39.8	39.1	40.5
TOTAL EFFICIENCY	(NOMINAL)	(5)	%	77.2	75.2	74.2

ENGINE DATA						
GENSET FUEL CONSUMPTION	(ISO 3046/1)	(6)	Btu/ekW-hr	8907	9221	9895
GENSET FUEL CONSUMPTION	(NOMINAL)	(6)	Btu/ekW-hr	9124	9446	10137
ENGINE FUEL CONSUMPTION	NOMINAL	(6)	Btu/bhp-hr	6511	6734	7189
AIR FLOW (77°F, 14.7 psia)	(WET)	(7)	scfm	4441	3372	2284
AIR FLOW	(WET)	(7)	lb/hr	19691	14952	10130
COMPRESSOR OUT PRESSURE			in Hg(abs)	107.2	80.7	54.8
COMPRESSOR OUT TEMPERATURE			°F	378	304	218
AFTERCOOLER AIR OUT TEMPERATURE			°F	142	138	136
INLET MAN. PRESSURE		(8)	in Hg(abs)	93.5	71.0	49.1
INLET MAN. TEMPERATURE	(MEASURED IN PLENUM)	(9)	°F	142	138	136
TIMING		(10)	°BTDC	28	28	28
EXHAUST TEMPERATURE - ENGINE OUTLET		(11)	°F	903	949	986
EXHAUST GAS FLOW (@engine outlet temp, 14.5 psia)	(WET)	(12)	ft3/min	12723	10008	7001
EXHAUST GAS MASS FLOW	(WET)	(12)	lb/hr	21863	16638	11336
MAX INLET RESTRICTION		(13)	in H2O	10.04	10.04	10.04
MAX EXHAUST RESTRICTION		(13)	in H2O	20.07	20.07	20.07

EMISSIONS DATA - ENGINE OUT					
NOx (as NO2)	(14)(15)	g/bhp-hr	0.50	0.50	0.50
CO	(14)(16)	g/bhp-hr	4.22	4.35	4.49
THC (mol. wt. of 15.84)	(14)(16)	g/bhp-hr	5.63	6.37	7.49
NMHC (mol. wt. of 15.84)	(14)(16)	g/bhp-hr	0.85	0.96	1.12
NMNEHC (VOCs) (mol. wt. of 15.84)	(14)(16)(17)	g/bhp-hr	0.56	0.64	0.75
HCHO (Formaldehyde)	(14)(16)	g/bhp-hr	0.42	0.43	0.43
CO2	(14)(16)	g/bhp-hr	747	773	794
EXHAUST OXYGEN	(14)(18)	% DRY	8.8	8.5	8.4
LAMBDA	(14)(18)		1.68	1.64	1.55

ENERGY BALANCE DATA					
LHV INPUT	(19)	Btu/min	243311	188925	135157
HEAT REJECTION TO JACKET WATER (JW)	(20)(27)	Btu/min	29209	23554	22109
HEAT REJECTION TO ATMOSPHERE	(21)	Btu/min	7210	6013	4823
HEAT REJECTION TO LUBE OIL (OC)	(22)(28)	Btu/min	7791	6995	6197
HEAT REJECTION TO EXHAUST (LHV TO 77°F)	(23)	Btu/min	80267	67378	48301
HEAT REJECTION TO EXHAUST (LHV TO 350°F)	(23)	Btu/min	54199	44836	32646
HEAT REJECTION TO A/C - STAGE 1 (1AC)	(24)(27)	Btu/min	13343	5446	7
HEAT REJECTION TO A/C - STAGE 2 (2AC)	(25)(28)	Btu/min	8434	6176	3904
PUMP POWER	(26)	Btu/min	1977	1977	1977

CONDITIONS AND DEFINITIONS

Engine rating obtained and presented in accordance with ISO 3046/1. (Standard reference conditions of 77°F, 29.60 in Hg barometric pressure, 500 ft. altitude.) No overload permitted at rating shown. Consult altitude curves for applications above maximum rated altitude and/or temperature.

Emission levels are at engine exhaust flange prior to any after treatment. Values are based on engine operating at steady state conditions, adjusted to the specified NOx level at 100% load. Tolerances specified are dependent upon fuel quality. Fuel methane number cannot vary more than ± 3.

For notes information consult page three.

FUEL USAGE GUIDE

CAT METHANE NUMBER	110	120	130	140	150
SET POINT TIMING	-	24	26	28	30
DERATION FACTOR	0	1	1	1	1

ALTITUDE DERATION FACTORS AT RATED SPEED

INLET AIR TEMP °F	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	0.96	0.93	0.89	0.86	0.83	0.79	0.76	0.73	0.70	0.68	0.65	0.62	0.60
120	0.98	0.94	0.91	0.87	0.84	0.81	0.78	0.75	0.72	0.69	0.66	0.64	0.61
110	1	0.96	0.92	0.89	0.85	0.82	0.79	0.76	0.73	0.70	0.67	0.65	0.62
100	1	0.98	0.94	0.90	0.87	0.84	0.80	0.77	0.74	0.71	0.69	0.66	0.63
90	1	0.99	0.96	0.92	0.89	0.85	0.82	0.79	0.76	0.73	0.70	0.67	0.64
80	1	1	0.97	0.94	0.90	0.87	0.83	0.80	0.77	0.74	0.71	0.68	0.65
70	1	1	0.99	0.96	0.92	0.88	0.85	0.82	0.79	0.75	0.72	0.69	0.67
60	1	1	1	0.97	0.94	0.90	0.87	0.83	0.80	0.77	0.74	0.71	0.68
50	1	1	1	0.99	0.96	0.92	0.88	0.85	0.82	0.78	0.75	0.72	0.69

ALTITUDE (FEET ABOVE SEA LEVEL)

AFTERCOOLER HEAT REJECTION FACTORS (ACHRF)

INLET AIR TEMP °F	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	1.33	1.37	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39
120	1.26	1.31	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
110	1.19	1.24	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
100	1.13	1.17	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19
90	1.06	1.11	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
80	1	1.04	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
70	1	1	1	1	1	1	1	1	1	1	1	1	1
60	1	1	1	1	1	1	1	1	1	1	1	1	1
50	1	1	1	1	1	1	1	1	1	1	1	1	1

ALTITUDE (FEET ABOVE SEA LEVEL)

FUEL USAGE GUIDE:
This table shows the derate factor required for a given fuel. Note that deration occurs as the methane number decreases. Methane number is a scale to measure detonation characteristics of various fuels. The methane number of a fuel is determined by using the Caterpillar Methane Number Calculation program.

ALTITUDE DERATION FACTORS:
This table shows the deration required for various air inlet temperatures and altitudes. Use this information along with the fuel usage guide chart to help determine actual engine power for your site.

ACTUAL ENGINE RATING:
To determine the actual rating of the engine at site conditions, one must consider separately, limitations due to fuel characteristics and air system limitations. The Fuel Usage Guide deration establishes fuel limitations. The Altitude/Temperature deration factors and RPC (reference the Caterpillar Methane Program) establish air system limitations. RPC comes into play when the Altitude/Temperature deration is less than 1.0 (100%). Under this condition, add the two factors together. When the site conditions do not require an Altitude/Temperature derate (factor is 1.0), it is assumed the turbocharger has sufficient capability to overcome the low fuel relative power, and RPC is ignored. To determine the actual power available, take the lowest rating between 1) and 2).
1) Fuel Usage Guide Deration
2) 1-((1-Altitude/Temperature Deration) + (1-RPC))

AFTERCOOLER HEAT REJECTION FACTORS(ACHRF):
Aftercooler heat rejection is given for standard conditions of 77°F and 500 ft. altitude. To maintain a constant air inlet manifold temperature, as the inlet air temperature goes up, so must the heat rejection. As altitude increases, the turbocharger must work harder to overcome the lower atmospheric pressure. This increases the amount of heat that must be removed from the inlet air by the aftercooler. Use the aftercooler heat rejection factor (ACHRF) to adjust for inlet air temp and altitude conditions. See Notes 27 and 28 below for application of this factor in calculating the heat exchanger sizing criteria. Failure to properly account for these factors could result in detonation and cause the engine to shutdown or fail.

NOTES:
1. Generator efficiencies, power factor, and voltage are based on standard generator. [Genset Power (ekW) is calculated as: Engine Power (bkW) x Generator Efficiency], [Genset Power (kVA) is calculated as: Engine Power (bkW) x Generator Efficiency / Power Factor]
2. Rating is with two engine driven water pumps. Tolerance is (+)3, (-)0% of full load.
3. ISO 3046/1 Genset efficiency tolerance is (+)0, (-)5% of full load % efficiency value. Nominal genset and engine efficiency tolerance is ± 2.5% of full load % efficiency value.
4. Thermal Efficiency is calculated as: (Heat rejection to jacket water + Heat Rejection to A/C Stage 1 + Heat rejection to exhaust to 350°F) / LHV Input
5. Total efficiency is calculated as: Genset Efficiency + Thermal Efficiency. Tolerance is ±10% of full load data.
6. ISO 3046/1 Genset fuel consumption tolerance is (+)5, (-)0% of full load data. Nominal genset and engine fuel consumption tolerance is ± 2.5% of full load data.
7. Air flow value is on a 'wet' basis. Flow is a nominal value with a tolerance of ± 5 %.
8. Inlet manifold pressure is a nominal value with a tolerance of ± 5 %.
9. Inlet manifold temperature is a nominal value with a tolerance of ± 9°F.
10. Timing indicated is for use with the minimum fuel methane number specified. Consult the appropriate fuel usage guide for timing at other methane numbers.
11. Exhaust temperature is a nominal value with a tolerance of (+)63°F, (-)54°F.
12. Exhaust flow value is on a 'wet' basis. Flow is a nominal value with a tolerance of ± 6 %.
13. Inlet and Exhaust Restrictions are maximum allowed values at the corresponding loads. Increasing restrictions beyond what is specified will result in a significant engine derate.
14. Emissions data is at engine exhaust flange prior to any after treatment.
15. NOx tolerances are ± 18% of specified value.
16. CO, CO2, THC, NMHC, NMNEHC, and HCHO values are "Not to Exceed" levels. THC, NMHC, and NMNEHC do not include aldehydes.
17. VOCs - Volatile organic compounds as defined in US EPA 40 CFR 60, subpart JJJJ
18. Exhaust Oxygen tolerance is ± 0.5; Lambda tolerance is ± 0.05. Lambda and Exhaust Oxygen level are the result of adjusting the engine to operate at the specified NOx level.
19. LHV rate tolerance is ± 2.5%.
20. Heat rejection to jacket water value displayed includes heat to jacket water alone. Value is based on treated water. Tolerance is ± 10% of full load data.
21. Heat rejection to atmosphere based on treated water. Tolerance is ± 50% of full load data.
22. Lube oil heat rate based on treated water. Tolerance is ± 20% of full load data.
23. Exhaust heat rate based on treated water. Tolerance is ± 10% of full load data.
24. Heat rejection to A/C - Stage 1 based on treated water. Tolerance is ±5% of full load data.
25. Heat rejection to A/C - Stage 2 based on treated water. Tolerance is ±5% of full load data.
26. Pump power includes engine driven jacket water and aftercooler water pumps. Engine brake power includes effects of pump power.
27. Total Jacket Water Circuit heat rejection is calculated as: (JW x 1.1) + (1AC x 1.05) + [0.9 x (1AC + 2AC) x (ACHRF - 1) x 1.05]. Heat exchanger sizing criterion is maximum circuit heat rejection at site conditions, with applied tolerances. A cooling system safety factor may be multiplied by the total circuit heat rejection to provide additional margin.
28. Total Second Stage Aftercooler Circuit heat rejection is calculated as: (OC x 1.2) + (2AC x 1.05) + [(1AC + 2AC) x 0.1 x (ACHRF - 1) x 1.05]. Heat exchanger sizing criterion is maximum circuit heat rejection at site conditions, with applied tolerances. A cooling system safety factor may be multiplied by the total circuit heat rejection to provide additional margin.

FREE FIELD MECHANICAL & EXHAUST NOISE

MECHANICAL: Sound Power (1/3 Octave Frequencies)

Gen Power Without Fan	Percent Load	Engine Power	Overall	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz
ekW	%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
1600	100	2242	116.6	77.2	87.0	87.7	90.3	96.5	98.1	98.9	101.2	93.8	102.6
1200	75	1683	115.5	76.3	84.2	84.9	88.9	93.3	97.2	94.3	99.0	92.5	100.8
800	50	1128	113.7	73.8	81.0	80.4	87.2	90.5	93.2	92.4	98.1	90.5	99.6

MECHANICAL: Sound Power (1/3 Octave Frequencies)

Gen Power Without Fan	Percent Load	Engine Power	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
ekW	%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
1600	100	2242	107.9	105.6	108.6	105.5	103.2	102.6	101.3	101.0	101.1	106.1	109.8
1200	75	1683	107.9	103.4	105.7	104.3	101.2	101.1	100.1	100.1	100.7	110.6	99.2
800	50	1128	108.2	101.3	104.2	105.6	99.7	100.1	98.8	98.9	102.7	98.0	95.2

EXHAUST: Sound Power (1/3 Octave Frequencies)

Gen Power Without Fan	Percent Load	Engine Power	Overall	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz
ekW	%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
1600	100	2242	117.6	107.2	98.1	98.0	88.1	106.8	97.7	106.0	100.2	94.2	102.5
1200	75	1683	117.1	106.8	96.7	96.0	92.9	110.8	99.0	105.5	97.8	95.8	102.1
800	50	1128	114.8	106.3	95.0	93.9	89.4	108.0	96.1	101.8	94.2	94.8	98.8

EXHAUST: Sound Power (1/3 Octave Frequencies)

Gen Power Without Fan	Percent Load	Engine Power	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
ekW	%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
1600	100	2242	100.4	102.1	101.7	101.9	104.9	106.9	107.2	107.4	105.8	104.7	107.9
1200	75	1683	97.9	100.9	101.6	98.9	103.0	105.2	105.9	106.6	105.3	101.0	105.8
800	50	1128	94.7	97.6	98.5	95.1	101.0	103.9	103.9	103.9.	101.3	101.5	100.8

SOUND PARAMETER DEFINITION:

Sound Power Level Data - DM8702-01

Sound power is defined as the total sound energy emanating from a source irrespective of direction or distance. Sound power level data is presented under two index headings:
Sound power level -- Mechanical
Sound power level -- Exhaust

Mechanical: Sound power level data is calculated in accordance with ISO 6798. The data is recorded with the exhaust sound source isolated.

Exhaust: Sound power level data is calculated in accordance with ISO 6798 Annex A.

Measurements made in accordance with ISO 6798 for engine and exhaust sound level only. No cooling system noise is included unless specifically indicated. Sound level data is indicative of noise levels recorded on one engine sample in a survey grade 3 environment.

How an engine is packaged, installed and the site acoustical environment will affect the site specific sound levels. For site specific sound level guarantees, sound data collection needs to be done on-site or under similar conditions.

APPENDIX C

CALPUFF MODELING FILES
(COMPACT DISC®)