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State of California

Energy Resources

Conservation and Development Commission

In the Matter of:
Application for Certification
for the PUENTE POWER PROJECT

Docket No. 15-AFC-01

EXPERT DECLARATION OF GARY RUBENSTEIN IN RESPONSE TO MARCH 10, 2017 COMMITTEE ORDERS

I, Gary Rubenstein, declare as follows:

1. I am employed by Sierra Research, which has been retained by the Applicant in these proceedings to conduct certain analyses associated with the proposed Puente Power Project (Project) and am duly authorized to make this declaration.

2. I earned a Bachelor of Science Degree in Engineering from the California Institute of Technology in 1973. I have over 44 years of experience regarding the evaluation of air quality and public health impacts, including impacts associated with greenhouse gas emissions, and related issues in the disciplines of alternatives, biological resources (nitrogen deposition), traffic and transportation (thermal plumes), visual resources (visible plumes), energy efficiency, and environmental justice. A copy of my current curriculum vitae was previously submitted in these proceedings. Based on my education, training and experience, I am qualified to provide expert testimony as to the matters addressed herein.

3. Except where stated on information and belief, the facts set forth herein and in the attachment hereto are true of my own personal knowledge, and the opinions set forth herein and in the attachment hereto are true and correct articulations of my opinions. If called as a witness, I could and would testify competently to the facts and opinions set forth herein and in the

attachment hereto.

4. On March 10, 2017, the Committee ordered submission of additional evidence on a limited number of specific issues identified in the "Committee Orders for Additional Evidence and Briefing Following Evidentiary Hearings" (TN #216505) (the "March 10 Orders").

5. The March 10 Orders direct the California Energy Commission staff and Applicant to prepare and submit specific additional evidence pertaining to four topic areas, including "Alternatives." With respect to the topic of Alternatives, the March 10 Orders direct the CEC staff and the Applicant to submit the following additional evidence:

- Analyze the use of one or more smaller (50 – 100 MW) turbines instead of the larger turbine proposed by the applicant at the two alternative sites analyzed in the Final Staff Assessment, the Del Norte/Fifth Street Off-site Alternative and the Ormond Beach Area Off-site Alternative, to determine whether it is feasible to reduce or eliminate the previously identified potential impacts on aviation.

6. The attached document entitled "Alternative Generating Technologies Thermal Plume Impact Analysis" was prepared by me and is submitted in response to the above-referenced request in the March 10 Orders.

7. I hereby sponsor this declaration and the attached document into evidence in these proceedings.

Executed on June 14, 2017, at Sacramento, California.

I declare under penalty of perjury of the laws of the State of California that the foregoing is true and correct.

Gary Rubenstein

ATTACHMENT

Alternative Generating Technologies
Thermal Plume Impact Analysis
Puente Power Project (15-AFC-01)

June 15, 2017

At the direction of the Committee, Applicant has analyzed the use of alternative generating technologies at the two alternative sites analyzed in the Final Staff Assessment (FSA). The Committee's request is restated below[1].

> *6. Analyze the use of one or more smaller (50 – 100 MW) turbines instead of the larger turbine proposed by the applicant at the two alternative sites analyzed in the Final Staff Assessment, the Del Norte/Fifth Street Off-site Alternative and the Ormond Beach Area Off-site Alternative, to determine whether it is feasible to reduce or eliminate the previously identified potential impacts on aviation.*

In the evaluation of alternative project locations in the FSA, Staff concluded that the Applicant's proposed GE H-class gas turbine generating technology could cause a significant impact relating to Traffic and Transportation due to the potential for thermal plumes to impact aircraft and pilot safety at both the Del Norte-Fifth Street and Ormond Beach Area Off-Site Alternative locations.[2] Thus, the focus of this supplemental analysis is to determine whether the use of multiple, smaller turbines, in lieu of the Applicant's proposed H-class turbine, could reduce or eliminate the potential impacts to aviation identified by Staff at those two alternative sites in the FSA. This analysis evaluates the potential for smaller gas turbines at these two sites to result in lesser impacts to aircraft than those identified by the Staff for the H-class turbine, using the Staff's criterion of 5.3 m/s average vertical velocity (10.6 m/s peak vertical velocity) and the "Spillane" approach.

In the FSA, the Staff determined that thermal plume peak vertical velocity for the proposed GE H-class gas turbine generating technology would exceed 10.6 m/s up to an altitude of approximately 2,375 feet AGL under the worst-case scenario of cool temperature/calm wind conditions.[3] The Applicant's analysis concludes that the elevations at which thermal plume peak vertical velocity of multiple smaller turbine configurations would exceed the Staff's criterion would be much lower—1100 to 1400 feet AGL—at either of the alternative sites. However, because of the proximity of the Camarillo Airport to the Del Norte/Fifth Street alternative site, the Staff concluded that arriving aircraft and arriving and departing helicopters often pass very close to, if not directly over, the site, so that the thermal plumes from multiple smaller

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[1] TN216505, p. 3.
[2] Exhibit 2000, TN214712, pp. 4.2-4, 4.2-110.
[3] Exhibit 2000, TN214712, p. 4.12-20.

turbine configurations would still be likely to have a significant impact to aircraft and pilot safety at the Del Norte/Fifth Street alternative site.

Similarly, representatives from the Department of the Navy, Naval Base Ventura County (NBVC) provided comments on the FSA[4] and in oral testimony[5] that air traffic from NBVC regularly flies a path over or very near the Ormond Beach Off-Site Alternative Site at relatively low altitudes, ranging from 500 and 3,000 feet above ground level. Therefore, although thermal plumes from multiple smaller turbine configurations would be expected to have a lower vertical velocity than the Applicant's proposed turbine, these thermal plumes would still be likely to have a significant impact to aircraft and pilot safety at the Ormond Beach Off-Site Alternative Site.

Therefore, Applicant concludes that use of multiple, smaller turbines at the two sites would not reduce or eliminate the previously identified potential impacts on aviation at either the Del Norte/Fifth Street or Ormond Beach Area Off-Site Alternative.

Alternative Generating Technologies

Two alternative generating technologies were evaluated: GE LM6000 gas turbines, rated at 50 MW (nominal); and GE LMS 100 gas turbines, rated at 100 MW (nominal). The alternatives were designed to match as closely as possible the project design nominal output of 262 MW (net nominal): five LM6000 gas turbines, for a total nominal output of 250 MW, or three LMS 100 gas turbines, for a total nominal output of 300 MW. The exhaust parameters used for each to the two technologies are summarized in Tables 1 and 2 below.

Table 1
Stack Parameters for Thermal Plume Velocity Calculations:
LM 6000 Gas Turbines[a]

Parameter	**Value**
Stack Height	24.38 m (80 ft)
Stack Diameter	3.66 m (12 ft)
Ambient Temperature	288.15 deg K
	59 deg F
Exhaust Temperature	629.3 deg K
Stack Velocity	30.17 m/s

a. Exhibit 2000, TN214712, Appendix TT-2, Table 3.

[4] Exhibit 1140, TN215583, p. 1.
[5] TN216593, pp. 176-177.

Table 2 Stack Parameters for Thermal Plume Velocity Calculations: LMS 100 Gas Turbines[a]			
Parameter	**Value**		
Stack Height	24.38 m (90 ft)		
Stack Diameter	4.11 m (13.5 ft)		
Operating Condition	Cold Temp.	Average Temp with Evap Cooling	Average Temp w/o Evap Cooling
Ambient Temperature	280.094 deg K	288.872 deg K	288.872 deg K
	44.5 deg F	60.3 deg F	60.3 deg F
Exhaust Temperature	679.65 deg K	688.21 deg K	688.21 deg K
Stack Velocity	35.95 m/s	36.32 m/s	36.29 m/s

a. ACECP, 07-AFC-06C, TN202287-3, Table 5.1E-2.

Stack Arrangements

Two alternative layouts were evaluated for each technology alternative at each site, as shown in Figures A-1 through A-8. For each technology, plume impacts were evaluated for one configuration in which all stacks were evenly spaced and for an alternative configuration in which adjacent stacks were paired.[6]

Methodology

The plume velocity analysis used the CEC staff's calculation approach, called the "Spillane approach" and presented in a 2003 paper by Best et al, to calculate worst-case plume vertical velocities.[7] This methodology was described in detail in Appendix TT-2 (Plume Velocity Analysis) to the FSA (Exhibit 2000).

Results of the Thermal Plume Analysis

The results of the thermal plume analysis at each alternative location are summarized in Tables 3 and 4 below. As discussed by Staff in Appendix TT-1 (Plume Threshold Determination) to the FSA (Exhibit 2000), an average vertical velocity of 5.3 m/s (10.6 m/s peak vertical velocity) is considered by Staff to be the threshold for potential impacts to aviation.

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[6] There are many ways the generating units could be arranged on the alternative sites; these two arrangements were selected by NRG engineers as representative.

[7] Best et al, "Aviation Safety and Buoyant Plumes." Presented at the 2003 Clean Air Conference, Newcastle, New South Wales, Australia. By Peter Best, Christine Killip, Lena Jackson, and Mark Kanowski of Katestone Environmental, Toowong, Queensland, Australia, and Kevin Spillane of Bendigo, Victoria, Australia.

Table 3 **Critical Elevations for Alternative Turbine Technologies at Del Norte / Fifth Street Alternative Location**				
Turbine Model and Configuration	LM 6000, Evenly Spaced	LM 6000, Paired Stacks	LMS 100, Evenly Spaced	LMS 100, Paired Stacks
Elevation above ground level at which average vertical velocity of the merged plume falls below threshold	~1300 ft	~1100 ft	~1400 ft	~1400 ft

Table 4 **Critical Elevations for Alternative Turbine Technologies at Ormond Beach Area Off-Site Alternative Location**				
Turbine Model and Configuration	LM 6000, Evenly Spaced	LM 6000, Paired Stacks	LMS 100, Evenly Spaced	LMS 100, Paired Stacks
Elevation above ground level at which average vertical velocity of the merged plume falls below threshold	~1300 ft	~1100 ft	~1400 ft	~1100 ft

Detailed modeling results are included in Attachment A.

Attachment A

Description of Modeling Assumptions for Thermal Plumes from Multiple Stacks

Applicant used the Spillane approach to determine the vertical velocity and top-hat radius of a single exhaust plume for each of the two gas turbine technologies considered, based on the exhaust parameters shown in the preceding Tables 1 and 2. Because merging multiple plumes increases vertical velocity, the geometry of each individual site layout was then considered to determine whether the separate plumes would merge. The merged plume velocity was then calculated based on equation 5 in Appendix TT-2 of the FSA (Exhibit 2000), as follows:

$$V_m = V_{sp} * N^{0.25}$$

Where: V_m = multiple stack combined plume average vertical velocity (m/s)

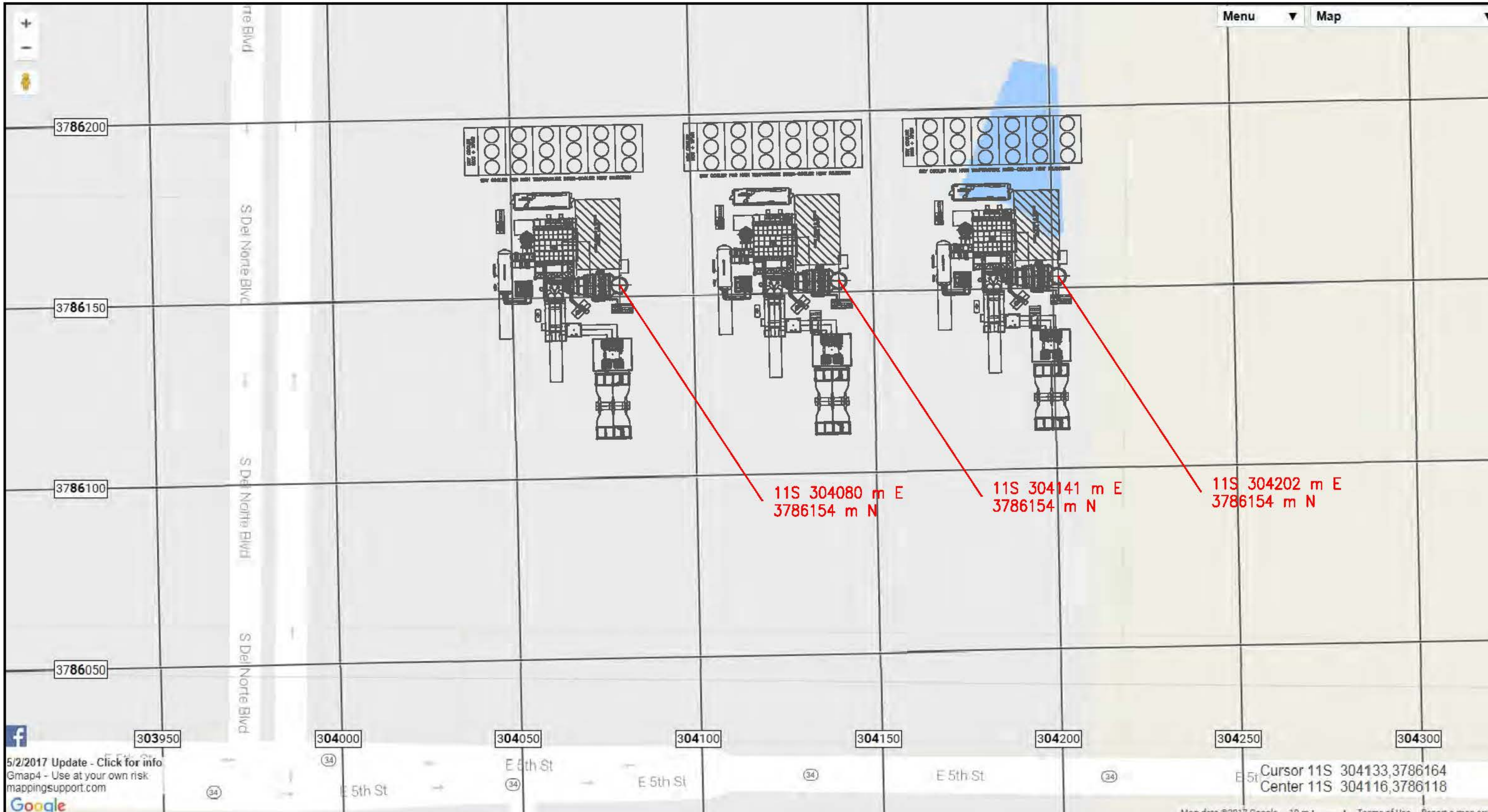
V_{sp} = single plume average vertical velocity (m/s)

N = number of stacks

For the evenly spaced stack configurations at the two sites (Figures A-1, A-3, A-5 and A-7), the multiple stack plume velocity configuration is relatively straightforward because the distances between the stacks are roughly equivalent. However, for the paired stack configurations the stack spacing varies significantly. For example, for the LM6000 paired stack arrangement at the Ormond Beach Off-Site Area Alternative location, the stack separation varies from 7 meters (between paired stacks) to 60 meters. For these paired stack arrangements, the stack separation used in the merged plume velocity calculation was established by looking at the separation distance at which all the plumes would merge (that is, where the single plume top-hat radius exceeds the distance between the stacks) before the average plume velocity reaches the critical value of 5.3 m/s. This distance is shown as the “Critical Distance” in Table A-1 below. Only plumes that are less than the critical distance apart will merge. For example, for the three LMS 100 turbines at Del Norte and Fifth (shown in Figure A-2), the critical distance for all three stacks is approximately 62.4 meters. Since the distance between the separate stack and the paired stacks is 50.24 meters, all three plumes will merge before the combined average plume velocity falls below the 5.3 m/s threshold. However, for the LM 6000 turbines at Del Norte and Fifth (shown in figure A-4), the critical distance is approximately 53.4 meters. Since the western-most stack is more than 100 meters from the eastern-most stack, only four of the five plumes will merge.

Table A-1 Critical Distances for Merging Thermal Plumes in Paired Stack Layouts							
Alternative Site	Turbine Type	Figure #	Critical Distance between Stacks (m)	Stack Separation Distance Used (m)	Plume Elevation at Merge (ft above ground level)	Number of Stacks Merging	Plume Velocity at Merge (m/s)
Del Norte/Fifth	LMS 100	A-2	62.4	50.24	1150	3	5.7
Del Norte/Fifth	LM 6000	A-4	53.4	32.0	760	4	6.0
Ormond	LMS 100	A-6	62.4	7.0	265	2	10.0
Ormond	LM 6000	A-8	53.4	38.5	895	4	5.7

Detailed calculations are provided on the following pages.



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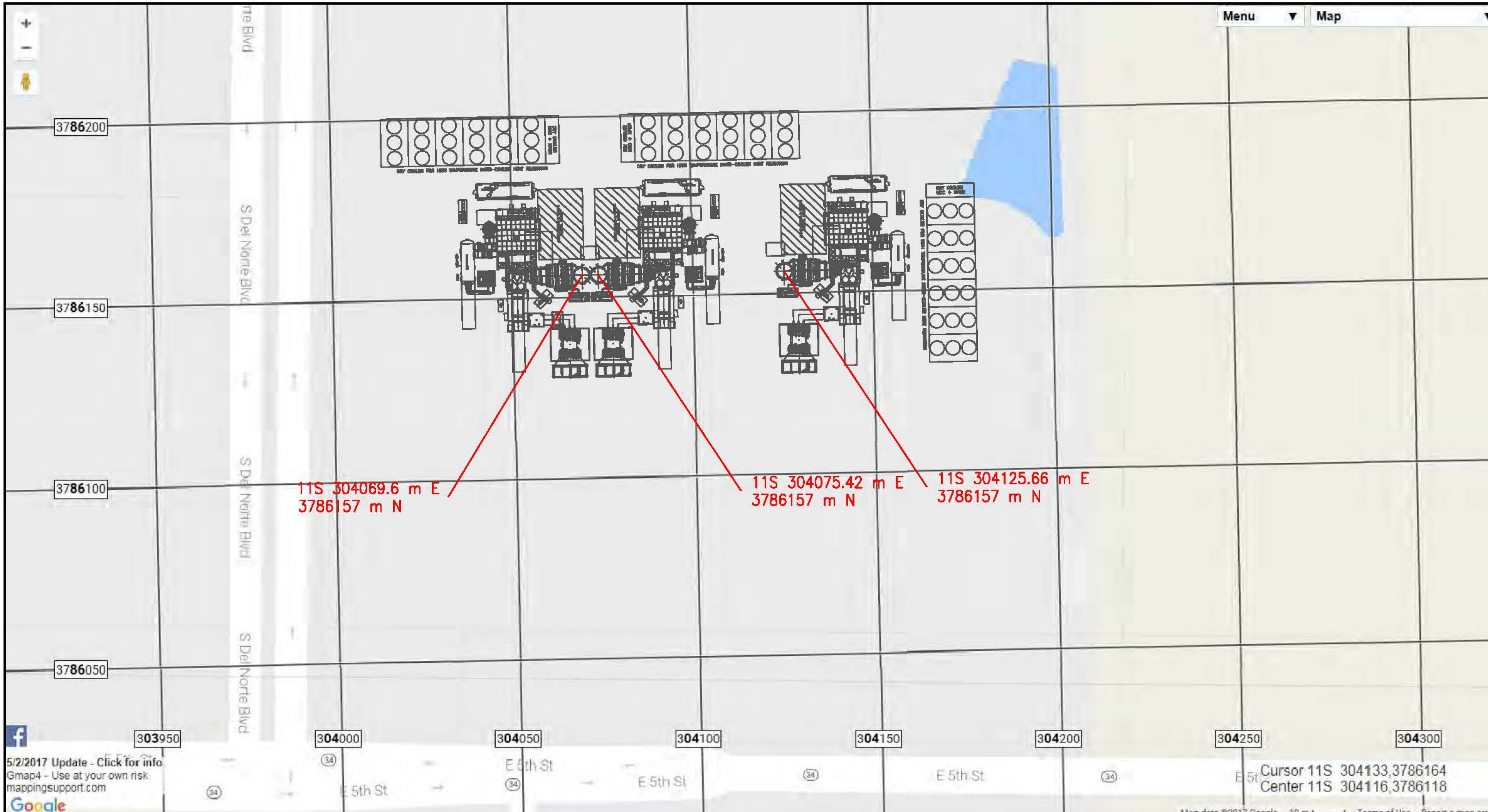
PUENTE POWER PROJECT
ALTERNATIVE SITE ANALYSIS
DEL NORTE & FIFTH – 3x LMS100
FIGURE A-1

AFE/WORK ORDER

ASBUILT DWG. NO. SK-M-FIG61

CONSTRUCTION DWG. NO.

SHEET 1 OF 1 | REV. NO. B



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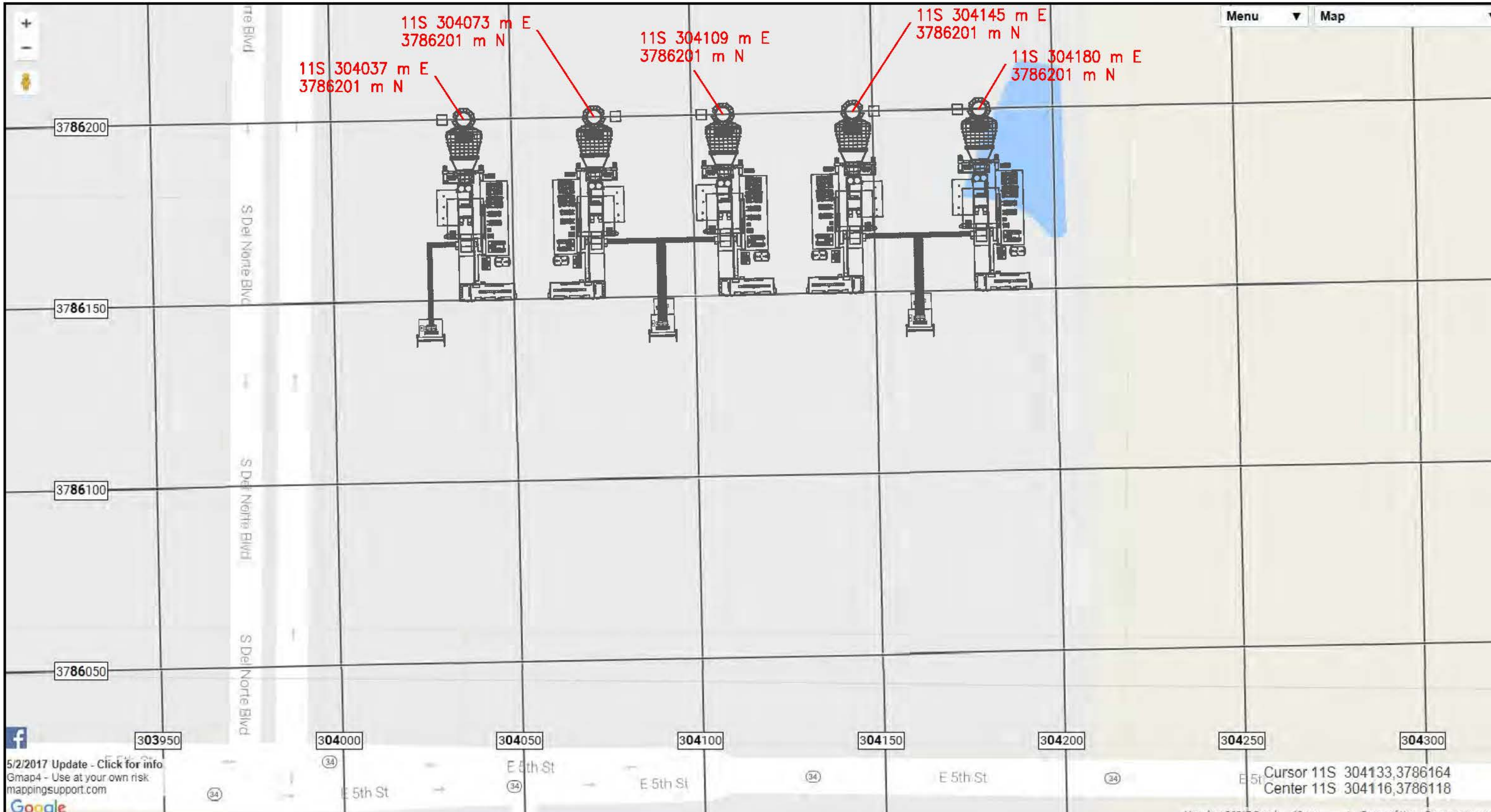
PUENTE POWER PROJECT
ALTERNATIVE SITE ANALYSIS
DEL NORTE & FIFTH
3x LMS100 BACK-TO-BACK
FIGURE A -2

AFE/WORK ORDER	
ASBUILT DWG. NO.	SK-M-FIG62
CONSTRUCTION DWG. NO.	
SHEET 1 OF 1	REV. NO. B



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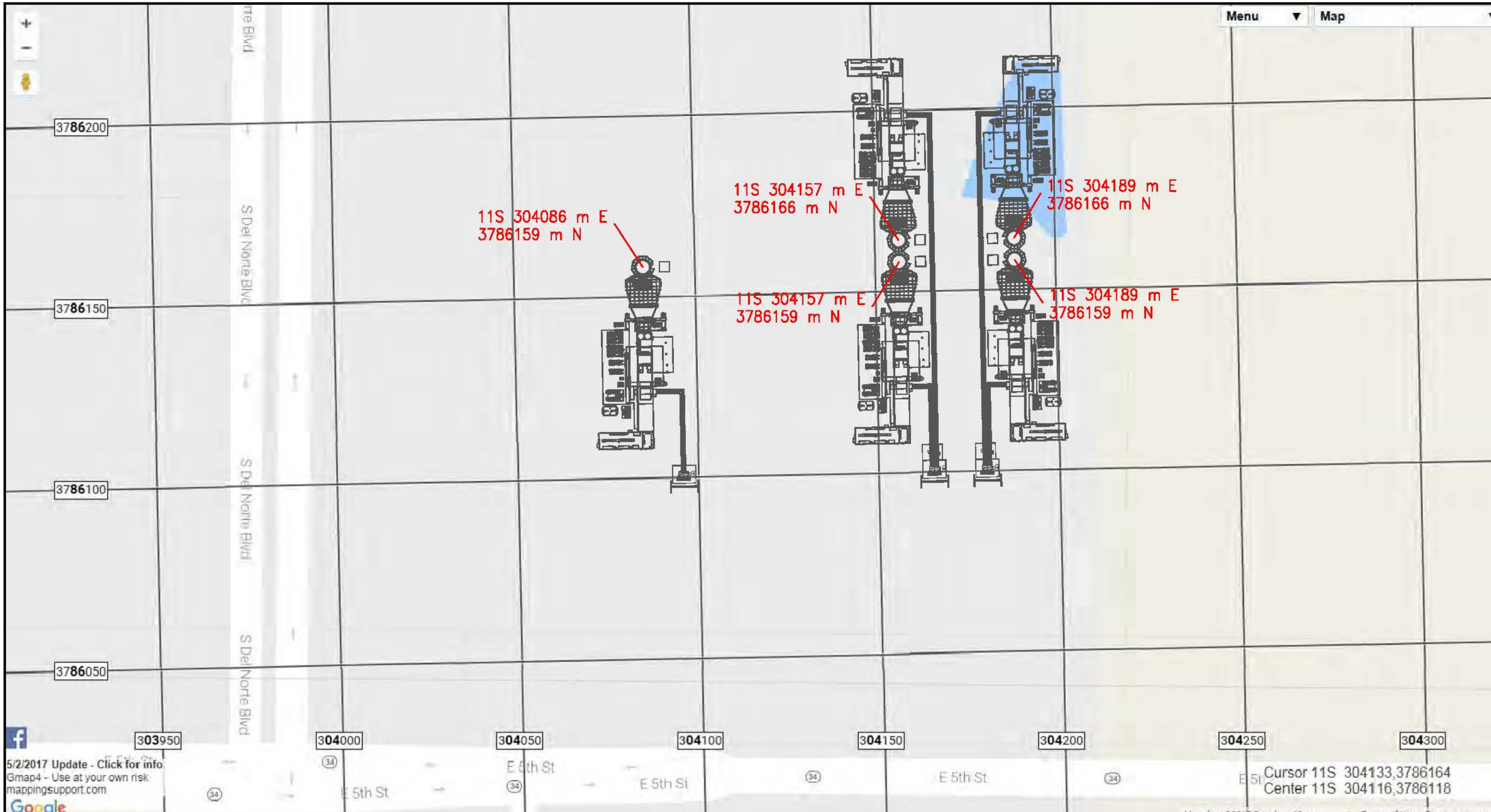
PUENTE POWER PROJECT
ALTERNATIVE SITE ANALYSIS
DEL NORTE & FIFTH – 5x LM6000
FIGURE A-3

AFE/WORK ORDER	
ASBUILT DWG. NO. SK-M-FIG63	
CONSTRUCTION DWG. NO.	
SHEET 1 OF 1	REV. NO. B



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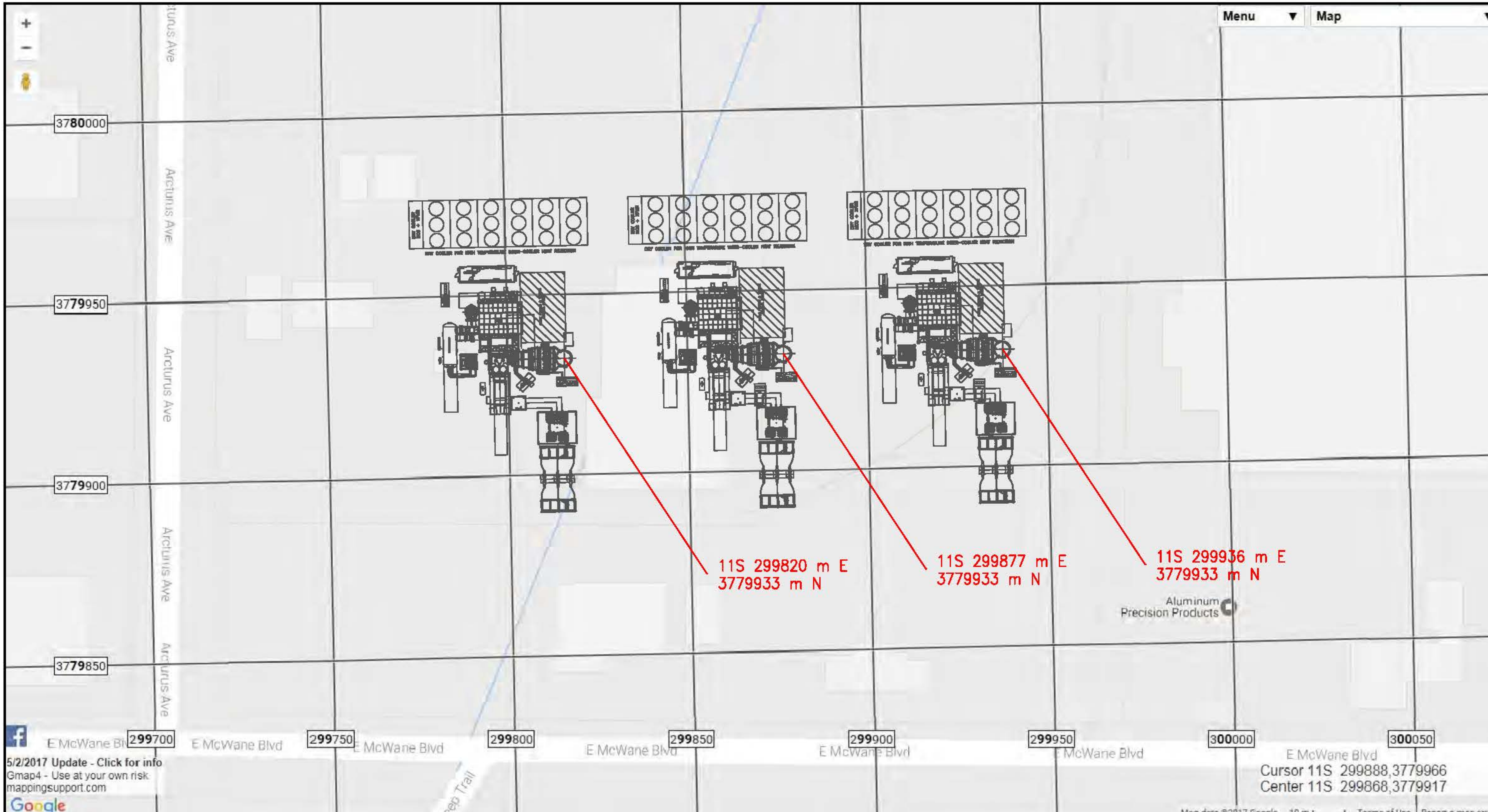
PUENTE POWER PROJECT
ALTERNATIVE SITE ANALYSIS
DEL NORTE & FIFTH
5x LM6000 PAIRED STACKS
FIGURE A-4

AFE/WORK ORDER

ASBUILT DWG. NO.
SK-M-FIG64

CONSTRUCTION DWG. NO.

SHEET 1 OF 1 | REV. NO. C



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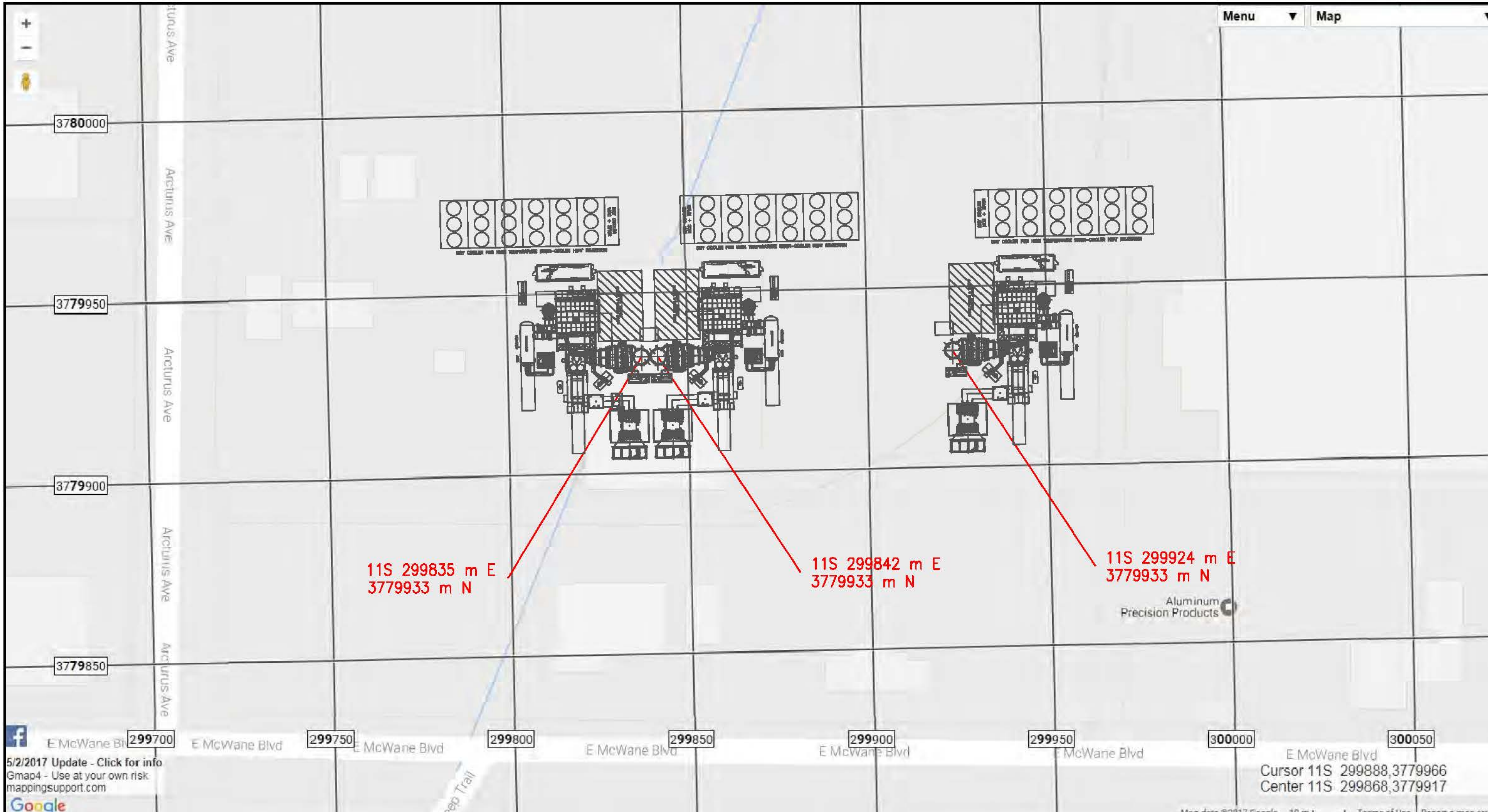
PUENTE POWER PROJECT
ALTERNATIVE SITE ANALYSIS
ORMOND OFF THE BEACH – 3x LMS100
FIGURE A-5

DWG. NO. SK-M-FIG65
SHEET 1 OF 1
REV. NO. B



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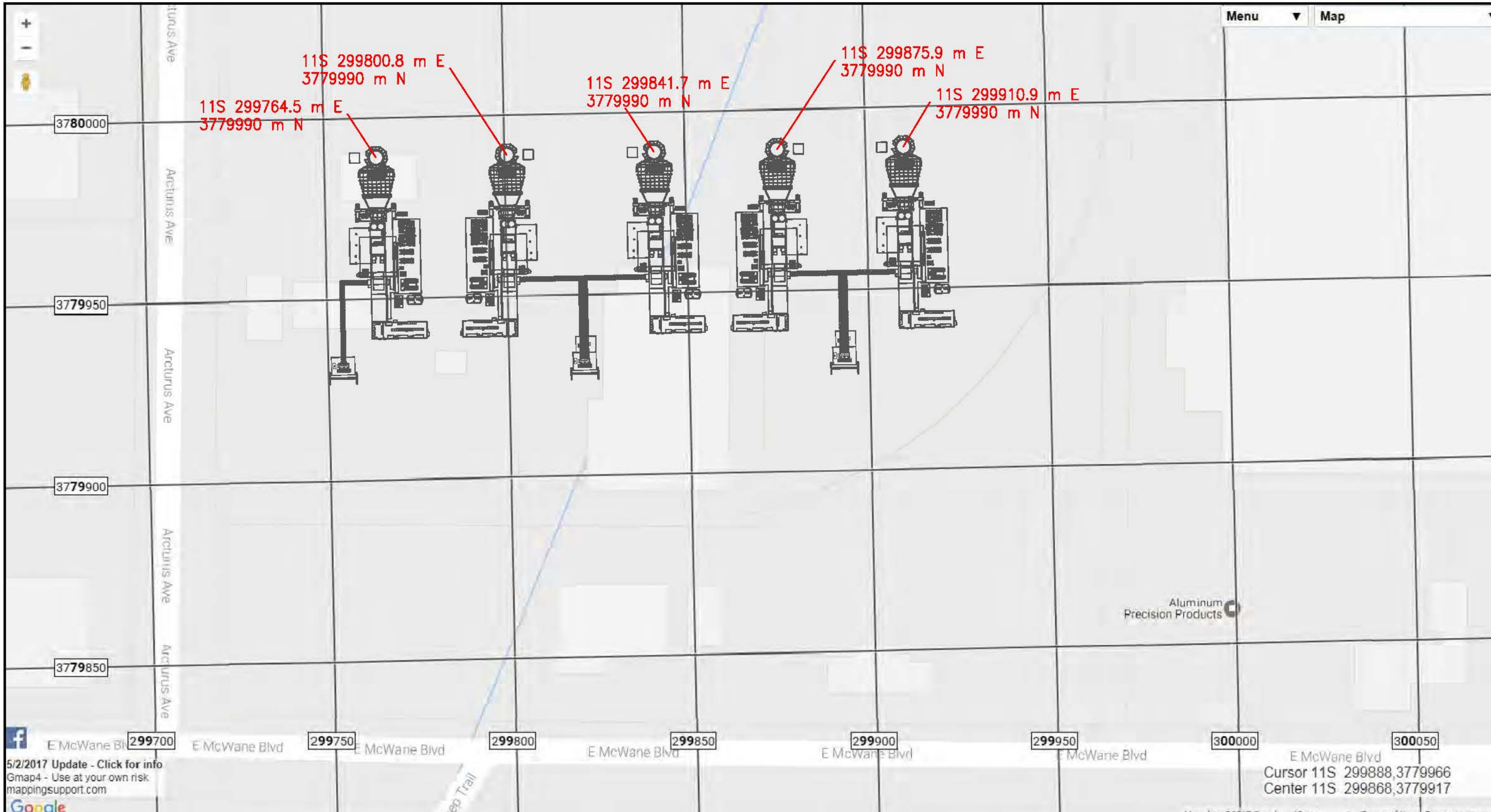
PUENTE POWER PROJECT
ALTERNATIVE SITE ANALYSIS
ORMOND OFF THE BEACH
3x LMS100 BACK-TO-BACK
FIGURE A -6

AFE/WORK ORDER

ASBUILT DWG. NO. SK-M-FIG66

CONSTRUCTION DWG. NO.

SHEET 1 OF 1 REV. NO. B



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PUENTE POWER PROJECT
ALTERNATIVE SITE ANALYSIS
ORMOND OFF THE BEACH – 5x LM6000
FIGURE A-7

AFE/WORK ORDER
ASBUILT DWG. NO. SK-M-FIG67
CONSTRUCTION DWG. NO.
SHEET 1 OF 1
REV. NO. B

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PUENTE POWER PROJECT
ALTERNATIVE SITE ANALYSIS
ORMOND OFF THE BEACH
5x LM6000 PAIRED STACKS
FIGURE A-8

AFE/WORK ORDER

ASBUILT DWG. NO. SK-M-FIG68

CONSTRUCTION DWG. NO.

SHEET 1 OF 1

REV. NO. B

Attachment A-1

P3, Alternative Site, Del Norte and 5th
Predicted Calm Wind Plume Velocities
3 LMS100 (3 stacks evenly spaced)

Table A-1-1 . Input Parameters of Single LMS 100 Turbine for the Plume Velocity Calculation

Equipment		LMS 100 Gas Turbine		
Operating Mode		Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
Inputs	Ambient Temperature (F)	44.5	60.3	60.3
	Ambient Temperature (k)	280.094	288.872	288.872
	Stack Height (m)	27.43	27.43	27.43
	Stack diameter (m)	4.11	4.11	4.11
	Stack Velocity (m/s)	35.95	36.32	36.29
	Exhaust Temperature (K)	679.65	688.21	688.21
	Gravity g=	9.81	m/s^2	
	Critical Velocity	5.3	m/s	
Calculations	Zv Virtual source Height (m)[2]	9.20	9.05	9.05
	F^0 initial stack buoyancy (m^4/s^3)[3]	875.55	873.09	872.37
	$(V*a)_0$[4]	47.43	48.36	48.32

Note:
1. The above calculation are based on the methodology detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental
2. Zv=6.25D[1-(θe/θs)^0.5], here θ~=T
3. F=g*Vs*ds^2*[(Ts-Ta)/(4*Ts)]
4. (Va)0=Vexit*D/2*(θe/θs)^0.5

Table A-1-2 . Plume Velocity Calculation for a Single LMS100 Turbine

Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine		
			Plume Velocity, m/s		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	13.35	13.47	13.46
300	64.0	210	8.36	8.38	8.38
400	94.5	310	6.92	6.93	6.92
500	125.0	410	6.16	6.16	6.16
600	155.5	510	5.66	5.66	5.66
700	185.9	610	5.30	5.29	5.29
800	216.4	710	5.01	5.01	5.01
900	246.9	810	4.78	4.78	4.78
1,000	277.4	910	4.59	4.59	4.58
1,100	307.9	1,010	4.42	4.42	4.42
1,200	338.3	1,110	4.28	4.28	4.28
1,300	368.8	1,210	4.16	4.15	4.15
1,400	399.3	1,310	4.04	4.04	4.04
1,500	429.8	1,410	3.94	3.94	3.94
1,600	460.3	1,510	3.85	3.85	3.85
1,700	490.7	1,610	3.77	3.76	3.76
1,800	521.2	1,710	3.69	3.69	3.69
1,850	536.5	1,760	3.65	3.65	3.65
1,900	551.7	1,810	3.62	3.62	3.61
2,000	582.2	1,910	3.55	3.55	3.55
2,100	612.7	2,010	3.49	3.49	3.49
2,200	643.1	2,110	3.44	3.43	3.43
2,300	673.6	2,210	3.38	3.38	3.38
2,400	704.1	2,310	3.33	3.33	3.33
2,450	719.3	2,360	3.31	3.30	3.30
2,500	734.6	2,410	3.28	3.28	3.28
2,550	749.8	2,460	3.26	3.26	3.26
2,600	765.1	2,510	3.24	3.24	3.23
2,650	780.3	2,560	3.22	3.21	3.21
2,700	795.5	2,610	3.20	3.19	3.19

Attachment A-1

P3, Alternative Site, Del Norte and 5th
Predicted Calm Wind Plume Velocities
3 LMS100 (3 stacks evenly spaced)

Table A-1-3 . Plume Top-hat Radius Calculation for a Single LMS100 Turbine[5]

Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine		
			Gas Turbine Plume Top-hat Radius (m)		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	3.89	3.92	3.92
300	64.0	210	8.77	8.79	8.79
400	94.5	310	13.65	13.67	13.67
500	125.0	410	18.52	18.55	18.55
600	155.5	510	23.40	23.42	23.42
700	185.9	610	28.28	28.30	28.30
800	216.4	710	33.15	33.18	33.18
900	246.9	810	38.03	38.06	38.06
1,000	277.4	910	42.91	42.93	42.93
1,100	307.9	1,010	47.78	47.81	47.81
1,200	338.3	1,110	52.66	52.69	52.69
1,300	368.8	1,210	57.54	57.56	57.56
1,400	399.3	1,310	62.41	62.44	62.44
1,500	429.8	1,410	67.29	67.32	67.32
1,600	460.3	1,510	72.17	72.19	72.19
1,700	490.7	1,610	77.05	77.07	77.07
1,800	521.2	1,710	81.92	81.95	81.95
1,850	536.5	1,760	84.36	84.38	84.38
1,900	551.7	1,810	86.80	86.82	86.82
2,000	582.2	1,910	91.68	91.70	91.70
2,100	612.7	2,010	96.55	96.58	96.58
2,200	643.1	2,110	101.43	101.45	101.45
2,300	673.6	2,210	106.31	106.33	106.33
2,400	704.1	2,310	111.18	111.21	111.21
2,450	719.3	2,360	113.62	113.65	113.65
2,500	734.6	2,410	116.06	116.08	116.08
2,550	749.8	2,460	118.50	118.52	118.52
2,600	765.1	2,510	120.94	120.96	120.96
2,700	795.5	2,610	125.81	125.84	125.84
2,800	826.0	2,710	130.69	130.71	130.71

Table A-1-4 . Merged Plume Velocity for Three Single LMS100 Turbines

Inputs		Distance between stacks (m):	61.00	No. of stacks	3
Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine		
			Gas Turbine Plume Top-hat Radius (m)		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	Not Merge	Not Merge	Not Merge
300	64.0	210	Not Merge	Not Merge	Not Merge
400	94.5	310	Not Merge	Not Merge	Not Merge
500	125.0	410	Not Merge	Not Merge	Not Merge
600	155.5	510	Not Merge	Not Merge	Not Merge
700	185.9	610	Not Merge	Not Merge	Not Merge
800	216.4	710	Not Merge	Not Merge	Not Merge
900	246.9	810	Not Merge	Not Merge	Not Merge
1,000	277.4	910	Not Merge	Not Merge	Not Merge
1,100	307.9	1,010	Not Merge	Not Merge	Not Merge
1,200	338.3	1,110	Not Merge	Not Merge	Not Merge
1,300	368.8	1,210	Not Merge	Not Merge	Not Merge
1,400	399.3	1,310	5.32	5.32	5.31
1,500	429.8	1,410	5.19	5.18	5.18
1,600	460.3	1,510	5.07	5.06	5.06
1,700	490.7	1,610	4.96	4.95	4.95
1,800	521.2	1,710	4.86	4.85	4.85
1,850	536.5	1,760	4.81	4.80	4.80
1,900	551.7	1,810	4.76	4.76	4.76
2,000	582.2	1,910	4.68	4.67	4.67
2,100	612.7	2,010	4.60	4.59	4.59
2,200	643.1	2,110	4.52	4.52	4.52
2,300	673.6	2,210	4.45	4.45	4.44
2,400	704.1	2,310	4.38	4.38	4.38
2,450	719.3	2,360	4.35	4.35	4.35
2,500	734.6	2,410	4.32	4.32	4.32
2,550	749.8	2,460	4.29	4.29	4.29
2,600	765.1	2,510	4.26	4.26	4.26
2,700	795.5	2,610	4.23	4.23	4.23
2,800	826.0	2,710	4.21	4.20	4.20

Note:
5. N^0.25 approximation for merged stacks was based on methodology for merged plume, detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental

Attachment A-2

P3, Alternative Site, Del Norte and 5th
Predicted Calm Wind Plume Velocities
3 LMS100 (one set of paired stacks; third stack at a distance)

Table A-2-1 . Input Parameters of Single LMS 100 Turbine for the Plume Velocity Calculation

Equipment		LMS 100 Gas Turbine		
Operating Mode		Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
Inputs	Ambient Temperature (F)	44.5	60.3	60.3
	Ambient Temperature (k)	280.094	288.872	288.872
	Stack Height (m)	27.43	27.43	27.43
	Stack diameter (m)	4.11	4.11	4.11
	Stack Velocity (m/s)	35.95	36.32	36.29
	Exhaust Temperature (K)	679.65	688.21	688.21
	Gravity g=	9.81	m/s^2	
	Critical Velocity	5.3	m/s	
Calculations	Zv Virtual source Height (m)[2]	9.20	9.05	9.05
	F^0 initial stack buoyancy (m^4/s^3)[3]	875.55	873.09	872.37
	$(V*a)_0$[4]	47.43	48.36	48.32

Note:
1. The above calculation are based on the methodology detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental
2. Zv=6.25D[1-(θe/θs)^0.5], here θ~=T
3. F=g*Vs*ds^2*[(Ts-Ta)/(4*Ts)]
4. (Va)0=Vexit*D/2*(θe/θs)^0.5

Table A-2-2 . Plume Velocity Calculation for a Single LMS100 Turbine

Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine		
			Plume Velocity, m/s		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	13.35	13.47	13.46
300	64.0	210	8.36	8.38	8.38
400	94.5	310	6.92	6.93	6.92
500	125.0	410	6.16	6.16	6.16
600	155.5	510	5.66	5.66	5.66
700	185.9	610	5.30	5.29	5.29
800	216.4	710	5.01	5.01	5.01
900	246.9	810	4.78	4.78	4.78
1,000	277.4	910	4.59	4.59	4.58
1,100	307.9	1,010	4.42	4.42	4.42
1,200	338.3	1,110	4.28	4.28	4.28
1,300	368.8	1,210	4.16	4.15	4.15
1,400	399.3	1,310	4.04	4.04	4.04
1,500	429.8	1,410	3.94	3.94	3.94
1,600	460.3	1,510	3.85	3.85	3.85
1,700	490.7	1,610	3.77	3.76	3.76
1,800	521.2	1,710	3.69	3.69	3.69
1,850	536.5	1,760	3.65	3.65	3.65
1,900	551.7	1,810	3.62	3.62	3.61
2,000	582.2	1,910	3.55	3.55	3.55
2,100	612.7	2,010	3.49	3.49	3.49
2,200	643.1	2,110	3.44	3.43	3.43
2,300	673.6	2,210	3.38	3.38	3.38
2,400	704.1	2,310	3.33	3.33	3.33
2,450	719.3	2,360	3.31	3.30	3.30
2,500	734.6	2,410	3.28	3.28	3.28
2,550	749.8	2,460	3.26	3.26	3.26
2,600	765.1	2,510	3.24	3.24	3.23
2,650	780.3	2,560	3.22	3.21	3.21
2,700	795.5	2,610	3.20	3.19	3.19

P3, Alternative Site, Del Norte and 5th
Predicted Calm Wind Plume Velocities
3 LMS100 (one set of paired stacks; third stack at a distance)

Table A-2-3 . Plume Top-hat Radius Calculation for a Single LMS100 Turbine[5]					
	Equipment		LMS 100 Gas Turbine		
Height Above Ground Level (ft)			Gas Turbine Plume Top-hat Radius (m)		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	3.89	3.92	3.92
300	64.0	210	8.77	8.79	8.79
400	94.5	310	13.65	13.67	13.67
500	125.0	410	18.52	18.55	18.55
600	155.5	510	23.40	23.42	23.42
700	185.9	610	28.28	28.30	28.30
800	216.4	710	33.15	33.18	33.18
900	246.9	810	38.03	38.06	38.06
1,000	277.4	910	42.91	42.93	42.93
1,100	307.9	1,010	47.78	47.81	47.81
1,200	338.3	1,110	52.66	52.69	52.69
1,300	368.8	1,210	57.54	57.56	57.56
1,400	399.3	1,310	62.41	62.44	62.44
1,500	429.8	1,410	67.29	67.32	67.32
1,600	460.3	1,510	72.17	72.19	72.19
1,700	490.7	1,610	77.05	77.07	77.07
1,800	521.2	1,710	81.92	81.95	81.95
1,850	536.5	1,760	84.36	84.38	84.38
1,900	551.7	1,810	86.80	86.82	86.82
2,000	582.2	1,910	91.68	91.70	91.70
2,100	612.7	2,010	96.55	96.58	96.58
2,200	643.1	2,110	101.43	101.45	101.45
2,300	673.6	2,210	106.31	106.33	106.33
2,400	704.1	2,310	111.18	111.21	111.21
2,450	719.3	2,360	113.62	113.65	113.65
2,500	734.6	2,410	116.06	116.08	116.08
2,550	749.8	2,460	118.50	118.52	118.52
2,600	765.1	2,510	120.94	120.96	120.96
2,700	795.5	2,610	125.81	125.84	125.84
2,800	826.0	2,710	130.69	130.71	130.71

Table A-2-4 . Merged Plume Velocity for Three Single LMS100 Turbines					
Inputs		Distance between stacks (m):	50.24	No. of stacks	3
	Equipment		LMS 100 Gas Turbine		
Height Above Ground Level (ft)			Gas Turbine Plume Top-hat Radius (m)		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	Not Merge	Not Merge	Not Merge
300	64.0	210	Not Merge	Not Merge	Not Merge
400	94.5	310	Not Merge	Not Merge	Not Merge
500	125.0	410	Not Merge	Not Merge	Not Merge
600	155.5	510	Not Merge	Not Merge	Not Merge
700	185.9	610	Not Merge	Not Merge	Not Merge
800	216.4	710	Not Merge	Not Merge	Not Merge
900	246.9	810	Not Merge	Not Merge	Not Merge
1,000	277.4	910	Not Merge	Not Merge	Not Merge
1,100	307.9	1,010	Not Merge	Not Merge	Not Merge
1,200	338.3	1,110	5.63	5.63	5.63
1,300	368.8	1,210	5.47	5.46	5.46
1,400	399.3	1,310	5.32	5.32	5.31
1,500	429.8	1,410	5.19	5.18	5.18
1,600	460.3	1,510	5.07	5.06	5.06
1,700	490.7	1,610	4.96	4.95	4.95
1,800	521.2	1,710	4.86	4.85	4.85
1,850	536.5	1,760	4.81	4.80	4.80
1,900	551.7	1,810	4.76	4.76	4.76
2,000	582.2	1,910	4.68	4.67	4.67
2,100	612.7	2,010	4.60	4.59	4.59
2,200	643.1	2,110	4.52	4.52	4.52
2,300	673.6	2,210	4.45	4.45	4.44
2,400	704.1	2,310	4.38	4.38	4.38
2,450	719.3	2,360	4.35	4.35	4.35
2,500	734.6	2,410	4.32	4.32	4.32
2,550	749.8	2,460	4.29	4.29	4.29
2,600	765.1	2,510	4.26	4.26	4.26
2,700	795.5	2,610	4.23	4.23	4.23
2,800	826.0	2,710	4.21	4.20	4.20

Note:
5. N^0.25 approximation for merged stacks was based on methodology for merged plume, detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental

Attachment A-3

P3, Alternative Site, Del Norte and 5th
Predicted Calm Wind Plume Velocities
5 LM6000 (5 stacks evenly spaced)

Table A-3-1 . Input Parameters of Single LM 6000 Turbine for the Plume Velocity Calculation

Equipment		LM 6000 Gas Turbine
Inputs	Ambient Temperature (F)	59
	Ambient Temperature (k)	288.150
	Stack Height (m)	24.38
	Stack diameter (m)	3.66
	Stack Velocity (m/s)	30.17
	Exhaust Temperature (K)	629.30
	Gravity g=	9.81
	Critical Velocity	5.3
Calculations	Zv Virtual source Height (m)[2]	7.40
	F^0 initial stack buoyancy (m^4/s^3)[3]	537.32
	$(V^*a)_0$[4]	37.36

Note:
1. The above calculation are based on the methodology detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental
2. Zv=6.25D[1-(θe/θs)^0.5], here θ~=T
3. F=g*Vs*ds^2*[(Ts-Ta)/(4*Ts)]
4. (Va)0=Vexit*D/2*(θe/θs)^0.5

Table A-3-2 . Plume Velocity Calculation for a Single LM 6000 Turbine

Height Above Ground Level (ft)	Equipment		LM 6000 Gas Turbine
	Height above stacktop (m)	Height above stacktop (ft)	Plume Velocity, m/s
100	6.1	20	N/A
200	36.6	120	9.65
300	67.1	220	6.74
400	97.5	320	5.72
500	128.0	420	5.14
600	158.5	520	4.74
700	189.0	620	4.45
800	219.5	720	4.22
900	249.9	820	4.03
1,000	280.4	920	3.87
1,100	310.9	1,020	3.74
1,200	341.4	1,120	3.62
1,300	371.9	1,220	3.51
1,400	402.3	1,320	3.42
1,500	432.8	1,420	3.34
1,600	463.3	1,520	3.26
1,700	493.8	1,620	3.19
1,800	524.3	1,720	3.13
1,850	539.5	1,770	3.09
1,900	554.7	1,820	3.07
2,000	585.2	1,920	3.01
2,100	615.7	2,020	2.96
2,200	646.2	2,120	2.91
2,300	676.7	2,220	2.87
2,400	707.1	2,320	2.82
2,450	722.4	2,370	2.80
2,500	737.6	2,420	2.78
2,550	752.9	2,470	2.76
2,600	768.1	2,520	2.75
2,650	783.3	2,570	2.73
2,700	798.6	2,620	2.71

P3, Alternative Site, Del Norte and 5th
Predicted Calm Wind Plume Velocities
5 LM6000 (5 stacks evenly spaced)

Table A-3-3 . Plume Top-hat Radius Calculation for a Single LM 6000 Turbine[5]

Height Above Ground Level (ft)	Equipment		LM 6000 Gas Turbine
	Height above stacktop (m)	Height above stacktop (ft)	Gas Turbine Plume Top-hat Radius (m)
100	6.1	20	N/A
200	36.6	120	4.67
300	67.1	220	9.55
400	97.5	320	14.42
500	128.0	420	19.30
600	158.5	520	24.18
700	189.0	620	29.05
800	219.5	720	33.93
900	249.9	820	38.81
1,000	280.4	920	43.68
1,100	310.9	1,020	48.56
1,200	341.4	1,120	53.44
1,300	371.9	1,220	58.31
1,400	402.3	1,320	63.19
1,500	432.8	1,420	68.07
1,600	463.3	1,520	72.94
1,700	493.8	1,620	77.82
1,800	524.3	1,720	82.70
1,850	539.5	1,770	85.14
1,900	554.7	1,820	87.58
2,000	585.2	1,920	92.45
2,100	615.7	2,020	97.33
2,200	646.2	2,120	102.21
2,300	676.7	2,220	107.08
2,400	707.1	2,320	111.96
2,450	722.4	2,370	114.40
2,500	737.6	2,420	116.84
2,550	752.9	2,470	119.27
2,600	768.1	2,520	121.71
2,700	798.6	2,620	126.59
2,800	829.1	2,720	131.47

Table A-3-4 . Merged Plume Velocity for Five Single LM 6000 Turbines

Inputs		Distance between stacks (m):	36.00
		No. of Stacks	5
Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine
			Gas Turbine Plume Top-hat Radius (m)
	Height above stacktop (m)	Height above stacktop (ft)	0
100	6.1	20	N/A
200	36.6	120	Not Merge
300	67.1	220	Not Merge
400	97.5	320	Not Merge
500	128.0	420	Not Merge
600	158.5	520	Not Merge
700	189.0	620	Not Merge
800	219.5	720	Not Merge
900	249.9	820	6.03
1,000	280.4	920	5.79
1,100	310.9	1,020	5.59
1,200	341.4	1,120	5.41
1,300	371.9	1,220	5.25
1,400	402.3	1,320	5.11
1,500	432.8	1,420	4.99
1,600	463.3	1,520	4.87
1,700	493.8	1,620	4.77
1,800	524.3	1,720	4.67
1,850	539.5	1,770	4.63
1,900	554.7	1,820	4.58
2,000	585.2	1,920	4.50
2,100	615.7	2,020	4.43
2,200	646.2	2,120	4.35
2,300	676.7	2,220	4.29
2,400	707.1	2,320	4.22
2,450	722.4	2,370	4.19
2,500	737.6	2,420	4.16
2,550	752.9	2,470	4.13
2,600	768.1	2,520	4.11
2,700	798.6	2,620	4.08
2,800	829.1	2,720	4.05

Note:
5. N^0.25 approximation for merged stacks was based on methodology for merged plume, detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Env

Attachment A-4

P3, Alternative Site, Del Norte and 5th
Predicted Calm Wind Plume Velocities
5 LM6000 (two sets of paired stacks, fifth stack at a distance)

Table A-4-1 . Input Parameters of Single LM 6000 Turbine for the Plume Velocity Calculation

Equipment		LM 6000 Gas Turbine
Inputs	Ambient Temperature (F)	59
	Ambient Temperature (k)	288.150
	Stack Height (m)	24.38
	Stack diameter (m)	3.66
	Stack Velocity (m/s)	30.17
	Exhaust Temperature (K)	629.30
	Gravity g=	9.81
	Critical Velocity	5.3
Calculations	Zv Virtual source Height (m)[2]	7.40
	F^0 initial stack buoyancy (m^4/s^3)[3]	537.32
	$(V*a)_0$[4]	37.36

Note:
1. The above calculation are based on the methodology detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental
2. Zv=6.25D[1-(θe/θs)^0.5], here θ~=T
3. F=g*Vs*ds^2*[(Ts-Ta)/(4*Ts)]
4. (Va)0=Vexit*D/2*(θe/θs)^0.5

Table A-4-2 . Plume Velocity Calculation for a Single LM 6000 Turbine

Height Above Ground Level (ft)	Equipment		LM 6000 Gas Turbine
	Height above stacktop (m)	Height above stacktop (ft)	Plume Velocity, m/s
100	6.1	20	N/A
200	36.6	120	9.65
300	67.1	220	6.74
400	97.5	320	5.72
500	128.0	420	5.14
600	158.5	520	4.74
700	189.0	620	4.45
800	219.5	720	4.22
900	249.9	820	4.03
1,000	280.4	920	3.87
1,100	310.9	1,020	3.74
1,200	341.4	1,120	3.62
1,300	371.9	1,220	3.51
1,400	402.3	1,320	3.42
1,500	432.8	1,420	3.34
1,600	463.3	1,520	3.26
1,700	493.8	1,620	3.19
1,800	524.3	1,720	3.13
1,850	539.5	1,770	3.09
1,900	554.7	1,820	3.07
2,000	585.2	1,920	3.01
2,100	615.7	2,020	2.96
2,200	646.2	2,120	2.91
2,300	676.7	2,220	2.87
2,400	707.1	2,320	2.82
2,450	722.4	2,370	2.80
2,500	737.6	2,420	2.78
2,550	752.9	2,470	2.76
2,600	768.1	2,520	2.75
2,650	783.3	2,570	2.73
2,700	798.6	2,620	2.71

Attachment A-4

P3, Alternative Site, Del Norte and 5th
Predicted Calm Wind Plume Velocities
5 LM6000 (two sets of paired stacks, fifth stack at a distance)

Table A-4-3 . Plume Top-hat Radius Calculation for a Single LM 6000 Turbine[5]			
Height Above Ground Level (ft)	Equipment		LM 6000 Gas Turbine
	Height above stacktop (m)	Height above stacktop (ft)	Gas Turbine Plume Top-hat Radius (m)
100	6.1	20	N/A
200	36.6	120	4.67
300	67.1	220	9.55
400	97.5	320	14.42
500	128.0	420	19.30
600	158.5	520	24.18
700	189.0	620	29.05
800	219.5	720	33.93
900	249.9	820	38.81
1,000	280.4	920	43.68
1,100	310.9	1,020	48.56
1,200	341.4	1,120	53.44
1,300	371.9	1,220	58.31
1,400	402.3	1,320	63.19
1,500	432.8	1,420	68.07
1,600	463.3	1,520	72.94
1,700	493.8	1,620	77.82
1,800	524.3	1,720	82.70
1,850	539.5	1,770	85.14
1,900	554.7	1,820	87.58
2,000	585.2	1,920	92.45
2,100	615.7	2,020	97.33
2,200	646.2	2,120	102.21
2,300	676.7	2,220	107.08
2,400	707.1	2,320	111.96
2,450	722.4	2,370	114.40
2,500	737.6	2,420	116.84
2,550	752.9	2,470	119.27
2,600	768.1	2,520	121.71
2,700	798.6	2,620	126.59
2,800	829.1	2,720	131.47

Table A-4-4 . Merged Plume Velocity for Five Single LM 6000 Turbines			
Inputs		Distance between stacks (m):	32.00
		No. of Stacks	4
Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine
			Gas Turbine Plume Top-hat Radius (m)
	Height above stacktop (m)	Height above stacktop (ft)	0
100	6.1	20	N/A
200	36.6	120	Not Merge
300	67.1	220	Not Merge
400	97.5	320	Not Merge
500	128.0	420	Not Merge
600	158.5	520	Not Merge
700	189.0	620	Not Merge
800	219.5	720	5.97
900	249.9	820	5.70
1,000	280.4	920	5.48
1,100	310.9	1,020	5.28
1,200	341.4	1,120	5.12
1,300	371.9	1,220	4.97
1,400	402.3	1,320	4.84
1,500	432.8	1,420	4.72
1,600	463.3	1,520	4.61
1,700	493.8	1,620	4.51
1,800	524.3	1,720	4.42
1,850	539.5	1,770	4.38
1,900	554.7	1,820	4.34
2,000	585.2	1,920	4.26
2,100	615.7	2,020	4.19
2,200	646.2	2,120	4.12
2,300	676.7	2,220	4.05
2,400	707.1	2,320	3.99
2,450	722.4	2,370	3.97
2,500	737.6	2,420	3.94
2,550	752.9	2,470	3.91
2,600	768.1	2,520	3.88
2,700	798.6	2,620	3.86
2,800	829.1	2,720	3.83

Note:
5. N^0.25 approximation for merged stacks was based on methodology for merged plume, detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental

Attachment A-5

P3, Alternative Site, Ormond Off the Beach
Predicted Calm Wind Plume Velocities
3 LMS100 (3 stacks evenly spaced)

Table A-5-1 . Input Parameters of Single LMS 100 Turbine for the Plume Velocity Calculation

Equipment		LMS 100 Gas Turbine		
Operating Mode		Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
Inputs	Ambient Temperature (F)	44.5	60.3	60.3
	Ambient Temperature (k)	280.094	288.872	288.872
	Stack Height (m)	27.43	27.43	27.43
	Stack diameter (m)	4.11	4.11	4.11
	Stack Velocity (m/s)	35.95	36.32	36.29
	Exhaust Temperature (K)	679.65	688.21	688.21
	Gravity g=	9.81	m/s^2	
	Critical Velocity	5.3	m/s	
Calculations	Zv Virtual source Height (m)[2]	9.20	9.05	9.05
	F^0 initial stack buoyancy (m^4/s^3)[3]	875.55	873.09	872.37
	$(V^*a)_0$[4]	47.43	48.36	48.32

Note:
1. The above calculation are based on the methodology detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental
2. Zv=6.25D[1-(θe/θs)^0.5], here θ~=T
3. F=g*Vs*ds^2*[(Ts-Ta)/(4*Ts)]
4. (Va)0=Vexit*D/2*(θe/θs)^0.5

Table A-5-2 . Plume Velocity Calculation for a Single LMS100 Turbine

Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine		
			Plume Velocity, m/s		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	13.35	13.47	13.46
300	64.0	210	8.36	8.38	8.38
400	94.5	310	6.92	6.93	6.92
500	125.0	410	6.16	6.16	6.16
600	155.5	510	5.66	5.66	5.66
700	185.9	610	5.30	5.29	5.29
800	216.4	710	5.01	5.01	5.01
900	246.9	810	4.78	4.78	4.78
1,000	277.4	910	4.59	4.59	4.58
1,100	307.9	1,010	4.42	4.42	4.42
1,200	338.3	1,110	4.28	4.28	4.28
1,300	368.8	1,210	4.16	4.15	4.15
1,400	399.3	1,310	4.04	4.04	4.04
1,500	429.8	1,410	3.94	3.94	3.94
1,600	460.3	1,510	3.85	3.85	3.85
1,700	490.7	1,610	3.77	3.76	3.76
1,800	521.2	1,710	3.69	3.69	3.69
1,850	536.5	1,760	3.65	3.65	3.65
1,900	551.7	1,810	3.62	3.62	3.61
2,000	582.2	1,910	3.55	3.55	3.55
2,100	612.7	2,010	3.49	3.49	3.49
2,200	643.1	2,110	3.44	3.43	3.43
2,300	673.6	2,210	3.38	3.38	3.38
2,400	704.1	2,310	3.33	3.33	3.33
2,450	719.3	2,360	3.31	3.30	3.30
2,500	734.6	2,410	3.28	3.28	3.28
2,550	749.8	2,460	3.26	3.26	3.26
2,600	765.1	2,510	3.24	3.24	3.23
2,650	780.3	2,560	3.22	3.21	3.21
2,700	795.5	2,610	3.20	3.19	3.19

Attachment A-5

P3, Alternative Site, Ormond Off the Beach
Predicted Calm Wind Plume Velocities
3 LMS100 (3 stacks evenly spaced)

Table A-5-3 . Plume Top-hat Radius Calculation for a Single LMS100 Turbine[5]					
	Equipment		LMS 100 Gas Turbine		
Height Above			Gas Turbine Plume Top-hat Radius (m)		
Ground Level (ft)	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	3.89	3.92	3.92
300	64.0	210	8.77	8.79	8.79
400	94.5	310	13.65	13.67	13.67
500	125.0	410	18.52	18.55	18.55
600	155.5	510	23.40	23.42	23.42
700	185.9	610	28.28	28.30	28.30
800	216.4	710	33.15	33.18	33.18
900	246.9	810	38.03	38.06	38.06
1,000	277.4	910	42.91	42.93	42.93
1,100	307.9	1,010	47.78	47.81	47.81
1,200	338.3	1,110	52.66	52.69	52.69
1,300	368.8	1,210	57.54	57.56	57.56
1,400	399.3	1,310	62.41	62.44	62.44
1,500	429.8	1,410	67.29	67.32	67.32
1,600	460.3	1,510	72.17	72.19	72.19
1,700	490.7	1,610	77.05	77.07	77.07
1,800	521.2	1,710	81.92	81.95	81.95
1,850	536.5	1,760	84.36	84.38	84.38
1,900	551.7	1,810	86.80	86.82	86.82
2,000	582.2	1,910	91.68	91.70	91.70
2,100	612.7	2,010	96.55	96.58	96.58
2,200	643.1	2,110	101.43	101.45	101.45
2,300	673.6	2,210	106.31	106.33	106.33
2,400	704.1	2,310	111.18	111.21	111.21
2,450	719.3	2,360	113.62	113.65	113.65
2,500	734.6	2,410	116.06	116.08	116.08
2,550	749.8	2,460	118.50	118.52	118.52
2,600	765.1	2,510	120.94	120.96	120.96
2,700	795.5	2,610	125.81	125.84	125.84
2,800	826.0	2,710	130.69	130.71	130.71

Table A-5-4 . Merged Plume Velocity for Three Single LMS100 Turbines					
Inputs		Distance between stacks (m):	59.00	No. of stacks	3
	Equipment		LMS 100 Gas Turbine		
Height Above			Gas Turbine Plume Top-hat Radius (m)		
Ground Level (ft)	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	Not Merge	Not Merge	Not Merge
300	64.0	210	Not Merge	Not Merge	Not Merge
400	94.5	310	Not Merge	Not Merge	Not Merge
500	125.0	410	Not Merge	Not Merge	Not Merge
600	155.5	510	Not Merge	Not Merge	Not Merge
700	185.9	610	Not Merge	Not Merge	Not Merge
800	216.4	710	Not Merge	Not Merge	Not Merge
900	246.9	810	Not Merge	Not Merge	Not Merge
1,000	277.4	910	Not Merge	Not Merge	Not Merge
1,100	307.9	1,010	Not Merge	Not Merge	Not Merge
1,200	338.3	1,110	Not Merge	Not Merge	Not Merge
1,300	368.8	1,210	Not Merge	Not Merge	Not Merge
1,400	399.3	1,310	5.32	5.32	5.31
1,500	429.8	1,410	5.19	5.18	5.18
1,600	460.3	1,510	5.07	5.06	5.06
1,700	490.7	1,610	4.96	4.95	4.95
1,800	521.2	1,710	4.86	4.85	4.85
1,850	536.5	1,760	4.81	4.80	4.80
1,900	551.7	1,810	4.76	4.76	4.76
2,000	582.2	1,910	4.68	4.67	4.67
2,100	612.7	2,010	4.60	4.59	4.59
2,200	643.1	2,110	4.52	4.52	4.52
2,300	673.6	2,210	4.45	4.45	4.44
2,400	704.1	2,310	4.38	4.38	4.38
2,450	719.3	2,360	4.35	4.35	4.35
2,500	734.6	2,410	4.32	4.32	4.32
2,550	749.8	2,460	4.29	4.29	4.29
2,600	765.1	2,510	4.26	4.26	4.26
2,700	795.5	2,610	4.23	4.23	4.23
2,800	826.0	2,710	4.21	4.20	4.20

Note:
5. N^0.25 approximation for merged stacks was based on methodology for merged plume, detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental

P3, Alternative Site, Ormond Off the Beach
Predicted Calm Wind Plume Velocities
3 LMS100 (one set of paired stacks, third stack at a distance)

Table A-6-1 . Input Parameters of Single LMS 100 Turbine for the Plume Velocity Calculation

Equipment		LMS 100 Gas Turbine		
Operating Mode		Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
Inputs	Ambient Temperature (F)	44.5	60.3	60.3
	Ambient Temperature (k)	280.094	288.872	288.872
	Stack Height (m)	27.43	27.43	27.43
	Stack diameter (m)	4.11	4.11	4.11
	Stack Velocity (m/s)	35.95	36.32	36.29
	Exhaust Temperature (K)	679.65	688.21	688.21
	Gravity g=	9.81	m/s^2	
	Critical Velocity	5.3	m/s	
Calculations	Zv Virtual source Height (m)[2]	9.20	9.05	9.05
	F^0 initial stack buoyancy (m^4/s^3)[3]	875.55	873.09	872.37
	$(V*a)_0$[4]	47.43	48.36	48.32

Note:
1. The above calculation are based on the methodology detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental
2. Zv=6.25D[1-(θe/θs)^0.5], here θ~=T
3. F=g*Vs*ds^2*[(Ts-Ta)/(4*Ts)]
4. (Va)0=Vexit*D/2*(θe/θs)^0.5

Table A-6-2 . Plume Velocity Calculation for a Single LMS100 Turbine

Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine		
			Plume Velocity, m/s		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	13.35	13.47	13.46
300	64.0	210	8.36	8.38	8.38
400	94.5	310	6.92	6.93	6.92
500	125.0	410	6.16	6.16	6.16
600	155.5	510	5.66	5.66	5.66
700	185.9	610	5.30	5.29	5.29
800	216.4	710	5.01	5.01	5.01
900	246.9	810	4.78	4.78	4.78
1,000	277.4	910	4.59	4.59	4.58
1,100	307.9	1,010	4.42	4.42	4.42
1,200	338.3	1,110	4.28	4.28	4.28
1,300	368.8	1,210	4.16	4.15	4.15
1,400	399.3	1,310	4.04	4.04	4.04
1,500	429.8	1,410	3.94	3.94	3.94
1,600	460.3	1,510	3.85	3.85	3.85
1,700	490.7	1,610	3.77	3.76	3.76
1,800	521.2	1,710	3.69	3.69	3.69
1,850	536.5	1,760	3.65	3.65	3.65
1,900	551.7	1,810	3.62	3.62	3.61
2,000	582.2	1,910	3.55	3.55	3.55
2,100	612.7	2,010	3.49	3.49	3.49
2,200	643.1	2,110	3.44	3.43	3.43
2,300	673.6	2,210	3.38	3.38	3.38
2,400	704.1	2,310	3.33	3.33	3.33
2,450	719.3	2,360	3.31	3.30	3.30
2,500	734.6	2,410	3.28	3.28	3.28
2,550	749.8	2,460	3.26	3.26	3.26
2,600	765.1	2,510	3.24	3.24	3.23
2,650	780.3	2,560	3.22	3.21	3.21
2,700	795.5	2,610	3.20	3.19	3.19

P3, Alternative Site, Ormond Off the Beach
Predicted Calm Wind Plume Velocities
3 LMS100 (one set of paired stacks, third stack at a distance)

Table A-6-3 . Plume Top-hat Radius Calculation for a Single LMS100 Turbine[5]

Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine		
			Gas Turbine Plume Top-hat Radius (m)		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	3.89	3.92	3.92
300	64.0	210	8.77	8.79	8.79
400	94.5	310	13.65	13.67	13.67
500	125.0	410	18.52	18.55	18.55
600	155.5	510	23.40	23.42	23.42
700	185.9	610	28.28	28.30	28.30
800	216.4	710	33.15	33.18	33.18
900	246.9	810	38.03	38.06	38.06
1,000	277.4	910	42.91	42.93	42.93
1,100	307.9	1,010	47.78	47.81	47.81
1,200	338.3	1,110	52.66	52.69	52.69
1,300	368.8	1,210	57.54	57.56	57.56
1,400	399.3	1,310	62.41	62.44	62.44
1,500	429.8	1,410	67.29	67.32	67.32
1,600	460.3	1,510	72.17	72.19	72.19
1,700	490.7	1,610	77.05	77.07	77.07
1,800	521.2	1,710	81.92	81.95	81.95
1,850	536.5	1,760	84.36	84.38	84.38
1,900	551.7	1,810	86.80	86.82	86.82
2,000	582.2	1,910	91.68	91.70	91.70
2,100	612.7	2,010	96.55	96.58	96.58
2,200	643.1	2,110	101.43	101.45	101.45
2,300	673.6	2,210	106.31	106.33	106.33
2,400	704.1	2,310	111.18	111.21	111.21
2,450	719.3	2,360	113.62	113.65	113.65
2,500	734.6	2,410	116.06	116.08	116.08
2,550	749.8	2,460	118.50	118.52	118.52
2,600	765.1	2,510	120.94	120.96	120.96
2,700	795.5	2,610	125.81	125.84	125.84
2,800	826.0	2,710	130.69	130.71	130.71

Table A-6-4 . Merged Plume Velocity for Three Single LMS100 Turbines

Inputs		Distance between stacks (m):	7.00	No. of stacks	2
Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine		
			Gas Turbine Plume Top-hat Radius (m)		
	Height above stacktop (m)	Height above stacktop (ft)	Cold 100% Load	Avg 100% Load W/Evap	Avg 100% Load W/O Evap
100	3.1	10	N/A	N/A	N/A
200	33.5	110	Not Merge	Not Merge	Not Merge
300	64.0	210	9.94	9.97	9.96
400	94.5	310	8.23	8.24	8.23
500	125.0	410	7.33	7.33	7.32
600	155.5	510	6.73	6.73	6.73
700	185.9	610	6.30	6.29	6.29
800	216.4	710	5.96	5.96	5.95
900	246.9	810	5.69	5.68	5.68
1,000	277.4	910	5.46	5.45	5.45
1,100	307.9	1,010	5.26	5.26	5.26
1,200	338.3	1,110	5.09	5.09	5.09
1,300	368.8	1,210	4.94	4.94	4.94
1,400	399.3	1,310	4.81	4.80	4.80
1,500	429.8	1,410	4.69	4.68	4.68
1,600	460.3	1,510	4.58	4.57	4.57
1,700	490.7	1,610	4.48	4.48	4.47
1,800	521.2	1,710	4.39	4.38	4.38
1,850	536.5	1,760	4.35	4.34	4.34
1,900	551.7	1,810	4.30	4.30	4.30
2,000	582.2	1,910	4.23	4.22	4.22
2,100	612.7	2,010	4.15	4.15	4.15
2,200	643.1	2,110	4.09	4.08	4.08
2,300	673.6	2,210	4.02	4.02	4.02
2,400	704.1	2,310	3.96	3.96	3.96
2,450	719.3	2,360	3.93	3.93	3.93
2,500	734.6	2,410	3.91	3.90	3.90
2,550	749.8	2,460	3.88	3.87	3.87
2,600	765.1	2,510	3.85	3.85	3.85
2,700	795.5	2,610	3.83	3.82	3.82
2,800	826.0	2,710	3.80	3.80	3.80

Note:
5. N^0.25 approximation for merged stacks was based on methodology for merged plume, detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental

P3, Alternative Site, Ormond Off the Beach
Predicted Calm Wind Plume Velocities
5 LM6000 (5 stacks evenly spaced)

Table A-7-1 . Input Parameters of Single LM 6000 Turbine for the Plume Velocity Calculation

Equipment		LM 6000 Gas Turbine
Inputs	Ambient Temperature (F)	59
	Ambient Temperature (k)	288.150
	Stack Height (m)	24.38
	Stack diameter (m)	3.66
	Stack Velocity (m/s)	30.17
	Exhaust Temperature (K)	629.30
	Gravity g=	9.81
	Critical Velocity	5.3
Calculations	Zv Virtual source Height (m)[2]	7.40
	F^0 initial stack buoyancy (m^4/s^3)[3]	537.32
	$(V*a)_0$[4]	37.36

Note:
1. The above calculation are based on the methodology detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental
2. Zv=6.25D[1-(θe/θs)^0.5], here θ~=T
3. F=g*Vs*ds^2*[(Ts-Ta)/(4*Ts)]
4. (Va)0=Vexit*D/2*(θe/θs)^0.5

Table A-7-2 . Plume Velocity Calculation for a Single LM 6000 Turbine

Height Above Ground Level (ft)	Equipment: Height above stacktop (m)	Equipment: Height above stacktop (ft)	LM 6000 Gas Turbine: Plume Velocity, m/s
100	6.1	20	N/A
200	36.6	120	9.65
300	67.1	220	6.74
400	97.5	320	5.72
500	128.0	420	5.14
600	158.5	520	4.74
700	189.0	620	4.45
800	219.5	720	4.22
900	249.9	820	4.03
1,000	280.4	920	3.87
1,100	310.9	1,020	3.74
1,200	341.4	1,120	3.62
1,300	371.9	1,220	3.51
1,400	402.3	1,320	3.42
1,500	432.8	1,420	3.34
1,600	463.3	1,520	3.26
1,700	493.8	1,620	3.19
1,800	524.3	1,720	3.13
1,850	539.5	1,770	3.09
1,900	554.7	1,820	3.07
2,000	585.2	1,920	3.01
2,100	615.7	2,020	2.96
2,200	646.2	2,120	2.91
2,300	676.7	2,220	2.87
2,400	707.1	2,320	2.82
2,450	722.4	2,370	2.80
2,500	737.6	2,420	2.78
2,550	752.9	2,470	2.76
2,600	768.1	2,520	2.75
2,650	783.3	2,570	2.73
2,700	798.6	2,620	2.71

P3, Alternative Site, Ormond Off the Beach
Predicted Calm Wind Plume Velocities
5 LM6000 (5 stacks evenly spaced)

Table A-7-3 . Plume Top-hat Radius Calculation for a Single LM 6000 Turbine[5]

Height Above Ground Level (ft)	Equipment		LM 6000 Gas Turbine
	Height above stacktop (m)	Height above stacktop (ft)	Gas Turbine Plume Top-hat Radius (m)
100	6.1	20	N/A
200	36.6	120	4.67
300	67.1	220	9.55
400	97.5	320	14.42
500	128.0	420	19.30
600	158.5	520	24.18
700	189.0	620	29.05
800	219.5	720	33.93
900	249.9	820	38.81
1,000	280.4	920	43.68
1,100	310.9	1,020	48.56
1,200	341.4	1,120	53.44
1,300	371.9	1,220	58.31
1,400	402.3	1,320	63.19
1,500	432.8	1,420	68.07
1,600	463.3	1,520	72.94
1,700	493.8	1,620	77.82
1,800	524.3	1,720	82.70
1,850	539.5	1,770	85.14
1,900	554.7	1,820	87.58
2,000	585.2	1,920	92.45
2,100	615.7	2,020	97.33
2,200	646.2	2,120	102.21
2,300	676.7	2,220	107.08
2,400	707.1	2,320	111.96
2,450	722.4	2,370	114.40
2,500	737.6	2,420	116.84
2,550	752.9	2,470	119.27
2,600	768.1	2,520	121.71
2,700	798.6	2,620	126.59
2,800	829.1	2,720	131.47

Table A-7-4 . Merged Plume Velocity for Five Single LM 6000 Turbines

Inputs		Distance between stacks (m):	40.90
		No. of Stacks	5
Height Above Ground Level (ft)	Equipment		LMS 100 Gas Turbine
			Gas Turbine Plume Top-hat Radius (m)
	Height above stacktop (m)	Height above stacktop (ft)	0
100	6.1	20	N/A
200	36.6	120	Not Merge
300	67.1	220	Not Merge
400	97.5	320	Not Merge
500	128.0	420	Not Merge
600	158.5	520	Not Merge
700	189.0	620	Not Merge
800	219.5	720	Not Merge
900	249.9	820	Not Merge
1,000	280.4	920	5.79
1,100	310.9	1,020	5.59
1,200	341.4	1,120	5.41
1,300	371.9	1,220	5.25
1,400	402.3	1,320	5.11
1,500	432.8	1,420	4.99
1,600	463.3	1,520	4.87
1,700	493.8	1,620	4.77
1,800	524.3	1,720	4.67
1,850	539.5	1,770	4.63
1,900	554.7	1,820	4.58
2,000	585.2	1,920	4.50
2,100	615.7	2,020	4.43
2,200	646.2	2,120	4.35
2,300	676.7	2,220	4.29
2,400	707.1	2,320	4.22
2,450	722.4	2,370	4.19
2,500	737.6	2,420	4.16
2,550	752.9	2,470	4.13
2,600	768.1	2,520	4.11
2,700	798.6	2,620	4.08
2,800	829.1	2,720	4.05

Note:
5. N^0.25 approximation for merged stacks was based on methodology for merged plume, detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone

Attachment A-8

P3, Alternative Site, Ormond Off the Beach
Predicted Calm Wind Plume Velocities
5 LM6000 (two sets of paired stacks, fifth stack at a distance)

Table A-8-1 . Input Parameters of Single LM 6000 Turbine for the Plume Velocity Calculation

Equipment		LM 6000 Gas Turbine
Inputs	Ambient Temperature (F)	59
	Ambient Temperature (k)	288.150
	Stack Height (m)	24.38
	Stack diameter (m)	3.66
	Stack Velocity (m/s)	30.17
	Exhaust Temperature (K)	629.30
	Gravity g=	9.81
	Critical Velocity	5.3
Calculations	Zv Virtual source Height (m)[2]	7.40
	F^0 initial stack buoyancy (m^4/s^3)[3]	537.32
	$(V^*a)_0$[4]	37.36

Note:

1. The above calculation are based on the methodology detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone Environmental
2. Zv=6.25D[1-(θe/θs)^0.5], here θ~=T
3. F=g*Vs*ds^2*[(Ts-Ta)/(4*Ts)]
4. (Va)0=Vexit*D/2*(θe/θs)^0.5

Table A-8-2 . Plume Velocity Calculation for a Single LM 6000 Turbine

Height Above Ground Level (ft)	Equipment		LM 6000 Gas Turbine
	Height above stacktop (m)	Height above stacktop (ft)	Plume Velocity, m/s
100	6.1	20	N/A
200	36.6	120	9.65
300	67.1	220	6.74
400	97.5	320	5.72
500	128.0	420	5.14
600	158.5	520	4.74
700	189.0	620	4.45
800	219.5	720	4.22
900	249.9	820	4.03
1,000	280.4	920	3.87
1,100	310.9	1,020	3.74
1,200	341.4	1,120	3.62
1,300	371.9	1,220	3.51
1,400	402.3	1,320	3.42
1,500	432.8	1,420	3.34
1,600	463.3	1,520	3.26
1,700	493.8	1,620	3.19
1,800	524.3	1,720	3.13
1,850	539.5	1,770	3.09
1,900	554.7	1,820	3.07
2,000	585.2	1,920	3.01
2,100	615.7	2,020	2.96
2,200	646.2	2,120	2.91
2,300	676.7	2,220	2.87
2,400	707.1	2,320	2.82
2,450	722.4	2,370	2.80
2,500	737.6	2,420	2.78
2,550	752.9	2,470	2.76
2,600	768.1	2,520	2.75
2,650	783.3	2,570	2.73
2,700	798.6	2,620	2.71

P3, Alternative Site, Ormond Off the Beach
Predicted Calm Wind Plume Velocities
5 LM6000 (two sets of paired stacks, fifth stack at a distance)

Table A-8-3 . Plume Top-hat Radius Calculation for a Single LM 6000 Turbine[5]			
	Equipment		LM 6000 Gas Turbine
Height Above Ground Level (ft)	Height above stacktop (m)	Height above stacktop (ft)	Gas Turbine Plume Top-hat Radius (m)
100	6.1	20	N/A
200	36.6	120	4.67
300	67.1	220	9.55
400	97.5	320	14.42
500	128.0	420	19.30
600	158.5	520	24.18
700	189.0	620	29.05
800	219.5	720	33.93
900	249.9	820	38.81
1,000	280.4	920	43.68
1,100	310.9	1,020	48.56
1,200	341.4	1,120	53.44
1,300	371.9	1,220	58.31
1,400	402.3	1,320	63.19
1,500	432.8	1,420	68.07
1,600	463.3	1,520	72.94
1,700	493.8	1,620	77.82
1,800	524.3	1,720	82.70
1,850	539.5	1,770	85.14
1,900	554.7	1,820	87.58
2,000	585.2	1,920	92.45
2,100	615.7	2,020	97.33
2,200	646.2	2,120	102.21
2,300	676.7	2,220	107.08
2,400	707.1	2,320	111.96
2,450	722.4	2,370	114.40
2,500	737.6	2,420	116.84
2,550	752.9	2,470	119.27
2,600	768.1	2,520	121.71
2,700	798.6	2,620	126.59
2,800	829.1	2,720	131.47

Table A-8-4 . Merged Plume Velocity for Five Single LM 6000 Turbines			
Inputs		Distance between stacks (m):	38.50
		No. of Stacks	4
	Equipment		LMS 100 Gas Turbine
Height Above Ground Level (ft)	Height above stacktop (m)	Height above stacktop (ft)	Gas Turbine Plume Top-hat Radius (m) 0
100	6.1	20	N/A
200	36.6	120	Not Merge
300	67.1	220	Not Merge
400	97.5	320	Not Merge
500	128.0	420	Not Merge
600	158.5	520	Not Merge
700	189.0	620	Not Merge
800	219.5	720	Not Merge
900	249.9	820	5.70
1,000	280.4	920	5.48
1,100	310.9	1,020	5.28
1,200	341.4	1,120	5.12
1,300	371.9	1,220	4.97
1,400	402.3	1,320	4.84
1,500	432.8	1,420	4.72
1,600	463.3	1,520	4.61
1,700	493.8	1,620	4.51
1,800	524.3	1,720	4.42
1,850	539.5	1,770	4.38
1,900	554.7	1,820	4.34
2,000	585.2	1,920	4.26
2,100	615.7	2,020	4.19
2,200	646.2	2,120	4.12
2,300	676.7	2,220	4.05
2,400	707.1	2,320	3.99
2,450	722.4	2,370	3.97
2,500	737.6	2,420	3.94
2,550	752.9	2,470	3.91
2,600	768.1	2,520	3.88
2,700	798.6	2,620	3.86
2,800	829.1	2,720	3.83

Note:

5. N^0.25 approximation for merged stacks was based on methodology for merged plume, detailed in "AVIATION SAFETY AND BUOYANT PLUMES", Best et al, 2003, Katestone