Compliance Challenges in Meeting 1-Hour Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) NAAQS

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Oil&Gas Environmental Conference

COMPLIANCE CHALLENGES IN MEETING 1-HOUR NO_2 and SO_2 NAAQS

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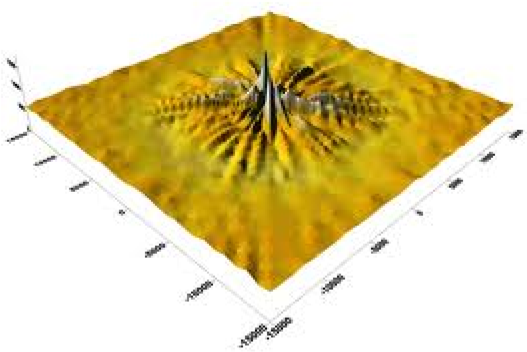
Challenges in Permitting New Sources

- **Demonstrating compliance with:**
  - 1 hour Nitrogen dioxide (NO_2) National Ambient Air Quality Standards (NAAQS)
  - 1 hour Sulfur dioxide (SO_2) NAAQS
  - New Ozone NAAQS of 70 ppb



1- hour NAAQS Standards

- 1-hour NAAQS Standard:
  - NO_2: 100 ppb based on
    - 3 year average of 98th percentile or 8th highest of daily maximum 1 hour concentration in a year
  - SO_2: 75 ppb based on
    - 3 year average of 99th percentile or 4th highest of daily maximum 1 hour concentration in a year
    - Old 24-hour and annual primary SO_2 NAAQS were revoked

Result…..

- Major obstacle to every new and pending permit
- Potential violations of these standards for both existing and new sources
- Non-attainment status with these standards would mean expensive controls
- **Culprits**: Smaller sources with short stacks in close proximity to the property boundary

EPA Guidance

Guidance Memos…

- June 29, 2010 – Guidance concerning 1-hour NO_2 NAAAQS for the PSD Permitting Program
- August 23, 2010 – Guidance concerning 1-hour SO_2 NAAQS for the PSD Permitting Program
- March 1, 2011 – Additional clarification regarding application of Appendix W modeling guidance for 1-hour NO_2 NAAQS
- April 2015 - TCEQ Air Quality Modeling Guidelines, APDG 6232
- October 1, 2015 – EPA Revised Ozone NAAQS – 70 ppb

Technical Challenges and Modeling Issues

Significant Impact Limit

- Significant Impact Limit (SIL) - basis to establish that the modeled concentration from the project does not cause or contribute to NAAQS violation
- If the project emissions meet the SIL, then it is not required to conduct a cumulative impact analysis (CIA) that includes off-site sources
- EPA established a significant impact limit (SIL) of 4 ppb for NO_2 and 3 ppb for SO_2 (4% of one-hour NAAQS)
- EPA recommends that the SIL is compared to the highest modeled yearly concentrations based on 5-years of meteorological data
- Highly conservative number and does not match with NAAQS standard
- NAAQS is a probabilistic standard versus SIL is a peak value

Cumulative Impact Analysis

- Includes modeling of facility and surrounding sources
- Results of modeling with surrounding sources are added to monitored background concentration to demonstrate compliance with NAAQS (double counting?)
- Even in attainment areas, the monitored background concentrations can be very close to the NAAQS
- Refining the background inventory places a heavy burden on industries

EPA solution:

- EPA allows for emergency equipment to be removed from CIA
- EPA has determined that it is acceptable to limit the CIA only to those receptors that have significant impacts based on SIL analysis
- EPA has also limited the inclusion of background sources of NO2 and SO2 to a 10-km radius although some states may request a larger radius (typically 50-km) that would produce and overly conservative result

Intermittent Emissions

- EPA allows compliance demonstration on only emission scenarios that can be assumed to be continuous or that occur frequently enough to contribute significantly to the annual distribution of daily maximum 1 hour concentrations.
- Applies for both project emissions and nearby background sources
- This determination will help exclude scenarios that may occur infrequently (start-up and shut-down activities)
- Example:
  - Intermittent source permitted to operate up to 500 hours per year but operates less than 500 hours per year on a random schedule can be considered as intermittent

Tier-specific Challenges – NO_2 compliance

Tier I Standard

- Traditionally, modeled concentrations are based on conservative assumptions of 100% NO_x to NO_2 conversion
- Can be applied without any justification to EPA
- EPA agrees that utilizing Tier I standard will result in overestimation of 1-hour NO_2 concentration
- Given the stringency of the standard, it is necessary to review other tiers
- EPA considers Tier II and III as a non-regulatory option and requires that industries seek approval for utilizing these tiers

Tier-specific Challenges - NO_2 compliance

Tier I Standard – CIA

- Uniform highest monitored background concentration applied without further justification; however, very conservative method and prone to double counting
- EPA recommends 98% (8^{th} highest value in a 365 day period) monitored value over three year average can be used to be less conservative.
- If ambient monitored concentration reflects a level of conservatism and the nearby source impacts are already accounted for, then analysis can include either monitored or modeled value to account for surrounding sources (negotiation)
- EPA agrees that pairing of modeled and monitored concentration based on diurnal and seasonal patterns (rush hour traffic contributions) – this allows for hourly or seasonal background concentrations to be used
- Pairing modeled and monitored concentration based on hour of the day should provide less conservative and realistic values and must be approved (negotiation)

Tier-specific Challenges - NO_2 compliance
Tier II Standard

- Commonly known as Ambient Ratio Method (ARM)
- NO2/NOx ratio – EPA recommends default ratio of 0.8 for 1-hour analysis instead of 0.75
- Investigations by American Petroleum Institute (API) and other organizations have determined that the highest NO2/NOx ratios are less than 0.2
- As NOx concentration increases, NO2/NOx ratio decreases
- Tier II standard may not be a viable method based on EPA's currently approved ratio of 0.8

Tier-specific Challenges - NO_2 compliance

Tier III Standard

Detailed screening method based on simple chemical mechanism of conversion of NO emissions to NO_2

$$NO + O_3 \qquad NO_2 + O_2$$

- Two screening methods: Ozone Limiting Method (OLM) and Polar Volume Molar Ratio Method (PVMRM)
- Both options account for conversion of NO to NO_2 in the presence of ozone
- OLM assumes that ambient ozone mixes completely with plume's NO to form NO_2 as long as there is available ozone
- PVMRM model assumes that mixing of ozone with NO occurs at the plume's centerline and available ozone for mixing is computed as a function of cross-sectional plume area.

Tier-specific Challenges - NO_2 compliance
Tier III Standard **(contd…)**

- EPA was initially planning to consider these methods on a case-by-case basis
- In order to ease the burden of the industry, EPA has accepted 0.5 as a default in-stack ratio of NO_2/NO_x as an AERMOD input, in the absence of site specific data
- The default ratio of 0.5 appears to be higher than actual value based on source testing appears to range from 0.08 – 0.24. CAPCOA Guidance and other source specific testing may come into play

Tier-specific Challenges - NO_2 compliance
Tier III Standard (contd...)

- Based on modeling experience, default value of 0.5 tends to over-predict concentration at the fence line
- Both OLM and PVMRM method assumes that there is instantaneous mixing of ozone and NO in the interior of the plume resulting in over-prediction of NO_2 formation
  - Initially NO reacts with the ozone at the outer edges of the plume and interior plume will have lower ozone concentration
  - Once the plume travels far downwind, center of the plume experiences higher ozone concentration
  - AERMOD's assumption of rapid reaction between ozone and NO tends to over-predict fence line impacts for sources with short stacks and located near fence line

Additional Modeling Strategies

- **Iteration of Source Parameters:** Isolate individual contributions from sources and perform iterative increases to stack height and velocity or make adjustments to spatial location of sources

- **Culpability Analysis:** AERMOD can create detailed files that analyze the individual maximum daily 1-hour contributions of each source at a receptor. This allows for each cumulative exceedance of the NAAQS to be analyzed at that specific location and time. This can be a very large amount of data and require lengthy agency review

AERMOD Dispersion Modeling
1-HR NO_2 Case Study

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Complex Terrain

Complex Terrain

- Up to 2,000 meters (~6,500 feet) of elevation relief within a 50 km (~31 mi) radius of the site.

- Site located in a valley creating challenging dispersion patterns.

- These conditions created a wide impact radius which lead to incorporating many surrounding sources.

- Surrounding source and facility emissions settled in the valley.

- Initial modeling without further refinements resulted in very unfavorable modeled concentrations that initially made the project appear unviable

Passing The 1-Hour NO_2 NAAQS

- Requires a 3-tiered approach that typically leads to advanced techniques for refining NO_2/NO_x ratios

- Agency supported use of OLM modeling for Tier 3 analysis and CRA made technical arguments for the lowest possible in-stack NO_2/NO_x ratios using CAPCOA guidance

- Even with these techniques, additional modifications had to be made to stack heights and proposed source locations

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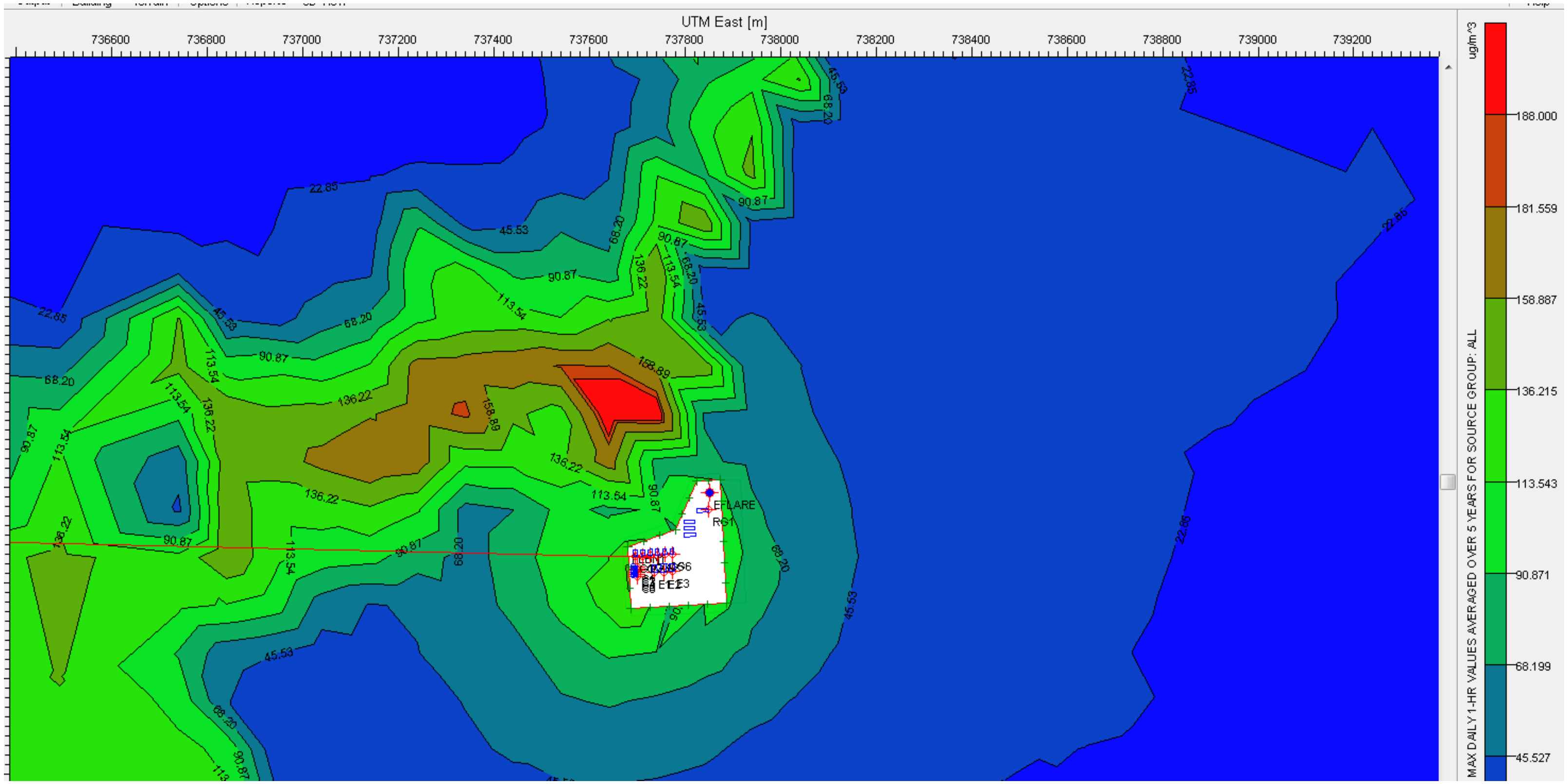
Initial Run – Significant Impact Analysis



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Passing The 1-Hour NO_2 NAAQS

Recommend In-stack NO2/NOx Ratios				
Refer #	**Fuel**	**Equipment Category (Controls)**	**Range of Ratios (%)**	**Recommended Ratio (%)**
Boilers				
1	NG	Default	10	10
2		6.6 MMBtu/Hr (Force Draft)*L	0.0 – 2.90	1.58**
2		7.6 MMBtu/Hr (SCR / FGR)*	3.45 – 15.79	9.65**
2		11.4 MMBtu/Hr (Force Draft)*L	1.81 – 3.51	2.68**
Compressor IC Engines				
1	NG	Default	60	60
2a		225 BHP IGN Timing BTC 17***	11.61 – 11.86	11.76**
2a		350 BHP IGN Timing BTC 18***	4.37 – 4.83	4.66**
2a		550 BHP IGN Timing BTC 20***	0.93 – 2.98	1.96**
2a		625 BHP IGN Timing BTC 10***	10.97 – 11.96	11.6**
2a		773 BHP IGN Timing BTC 9***	58.04 – 58.54	58.3**
2a		773 BHP IGN Timing BTC 20***	72.65 – 73.42	73.12**
2a		880 BHP IGN Timing BTC 8***	9.79 – 14.14	11.93**
2a		880 BHP IGN Timing BTC 15***	0.7 – 8.28	2.52**
2a		1500 BHP IGN Timing BTC 12***	10.32 – 12.03	11.47**
2a		1500 BHP IGN Timing BTC 6.5***	18.42 – 21.33	19.97**
2a		4000 BHP IGN Timing BTC 5***	22.36 – 25.69	23.82**
2a	Waste Gas (Field Gas)	880 BHP IGN Timing BTC 20***	1.77 – 6.10	3.86**
2a		1000 BHP***	0.40 – 0.81	0.64**
Dryer				
	NG	20 MMBTU/Hr (Milk -Tower Dryer)*	3.85 – 11.11	6.88**
Glass Furnace				
2	NG	Glass Furnace	2.45 – 11.59	4.32**
Heaters				
2	NG / Refinery Gas	14.1 MMBTU/Hr (John Zink PSMR)*	11.54 – 52.63	32.0**

Source: October 27, 2011 California Air Pollution Control Officers Association Guidance *"Modeling Compliance of The Federal 1-Hour NO_2 NAAQS"*

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Passing The 1-Hour NO_2 NAAQS

Recommend In-stack NO2/NOx Ratios				
Refer #	**Fuel**	**Equipment Category (Controls)**	**Range of Ratios (%)**	**Recommended Ratio (%)**
IC Engines				
2	Biogas	200 BHP*	0.0 – 1.90	0.37**
1	Diesel	Default	20	20
		322 BHP (WP)*	0.0 – 50.0	15.64**
4	NG	Default – Lean Burn	5-10	10
2		120 BHP (3-Way Catalyst)*	0.1 – 2.83	0.9**
2		162 BHP (catalytic converter, air/fuel ratio)*	0.0 – 12.5	1.81**
2		165 BHP (3-Way Catalyst)*	0.0 – 17.58	3.16**
2		180 BHP (NSCR)*	1.02 – 3.41	1.82**
2		208 BHP (catalytic converter, air/fuel ratio)*	0.0 – 1.44	0.48**
2		1,070 BHP (LB/WP–Turbocharger/Intercooler)*	20.91 – 39.62	34.41**
2		1,529 BHP (LB - CO Catalyst, SCR)*	2.70 – 4.58	3.59**
2		2,775 BHP (SCR)*	14.53 – 26.33	19.46**
2		4,175 BHP (SCR,CO & VOC Catalysts)*	0.0 – 21.28	1.15**

Transportation Refrigeration Units (TRUs)

Refer #		Equipment Category	Fuel	Eng Speed	Exhaust	NO_2/ NO_x Ratio
5		CARB= CARB Diesel GTL = Gas To Liquid	CARB	High	Muffler	15.37
			GTL	High	Muffler	16.17
			CARB	High	pDPF	25.71
			CARB	Low	Muffler	22.66
			GTL	Low	Muffler	25.12
			CARB	Low	pDPF	12.98

Refer #	Fuel	Equipment Category (Controls)	Range of Ratios (%)	Recommended Ratio (%)
Truck / Cars				
6	Gas/Diesel	Light / Medium Duty	16-25	25
	Diesel	Heavy Duty	6-11	11
Turbines				
3	NG	GE Turbines	8.33 – 9.1	9.1

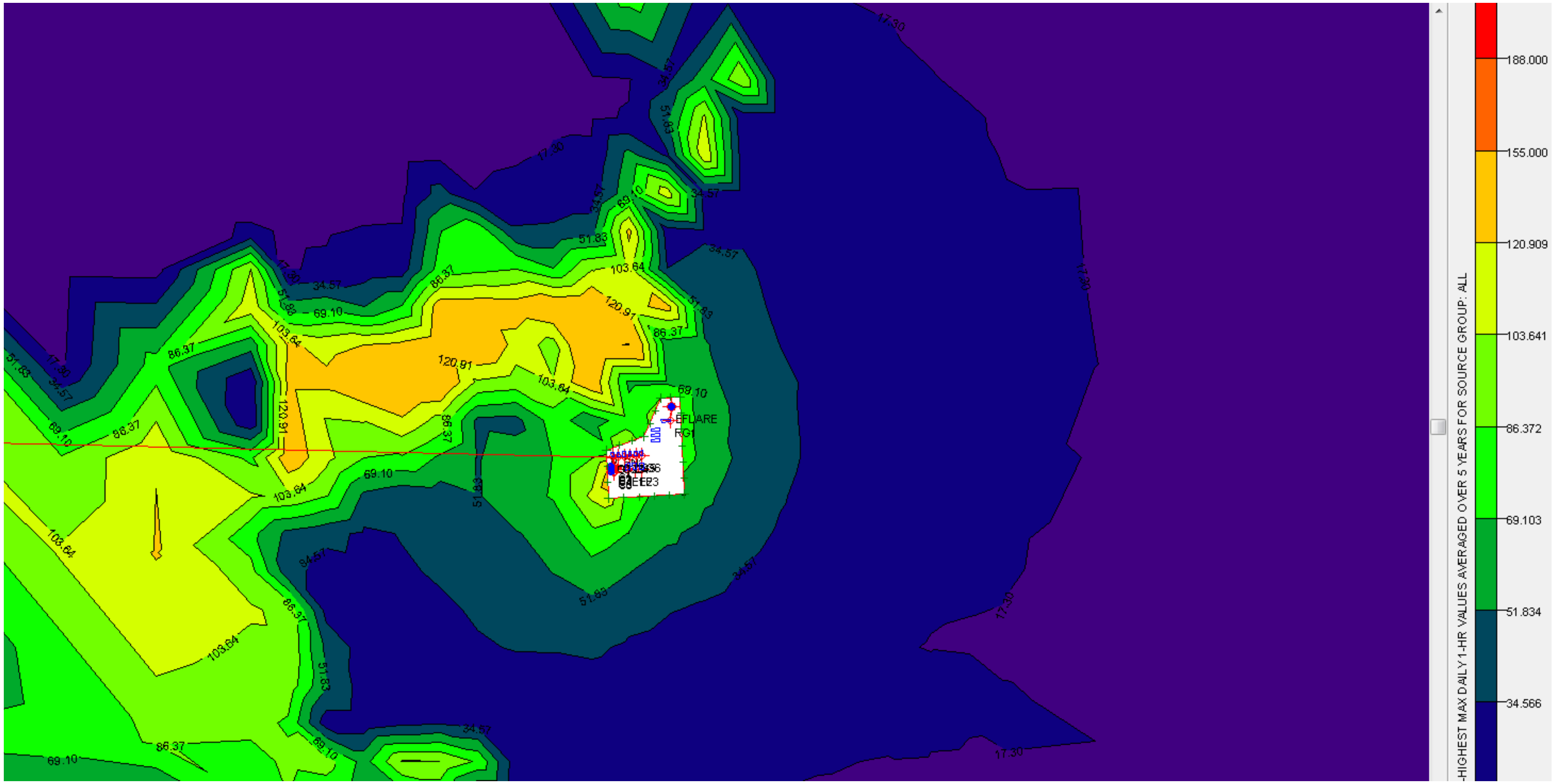
Source: October 27, 2011 California Air Pollution Control Officers Association Guidance *"Modeling Compliance of The Federal 1-Hour NO_2 NAAQS"*

Passing The 1-Hour NO_2 NAAQS

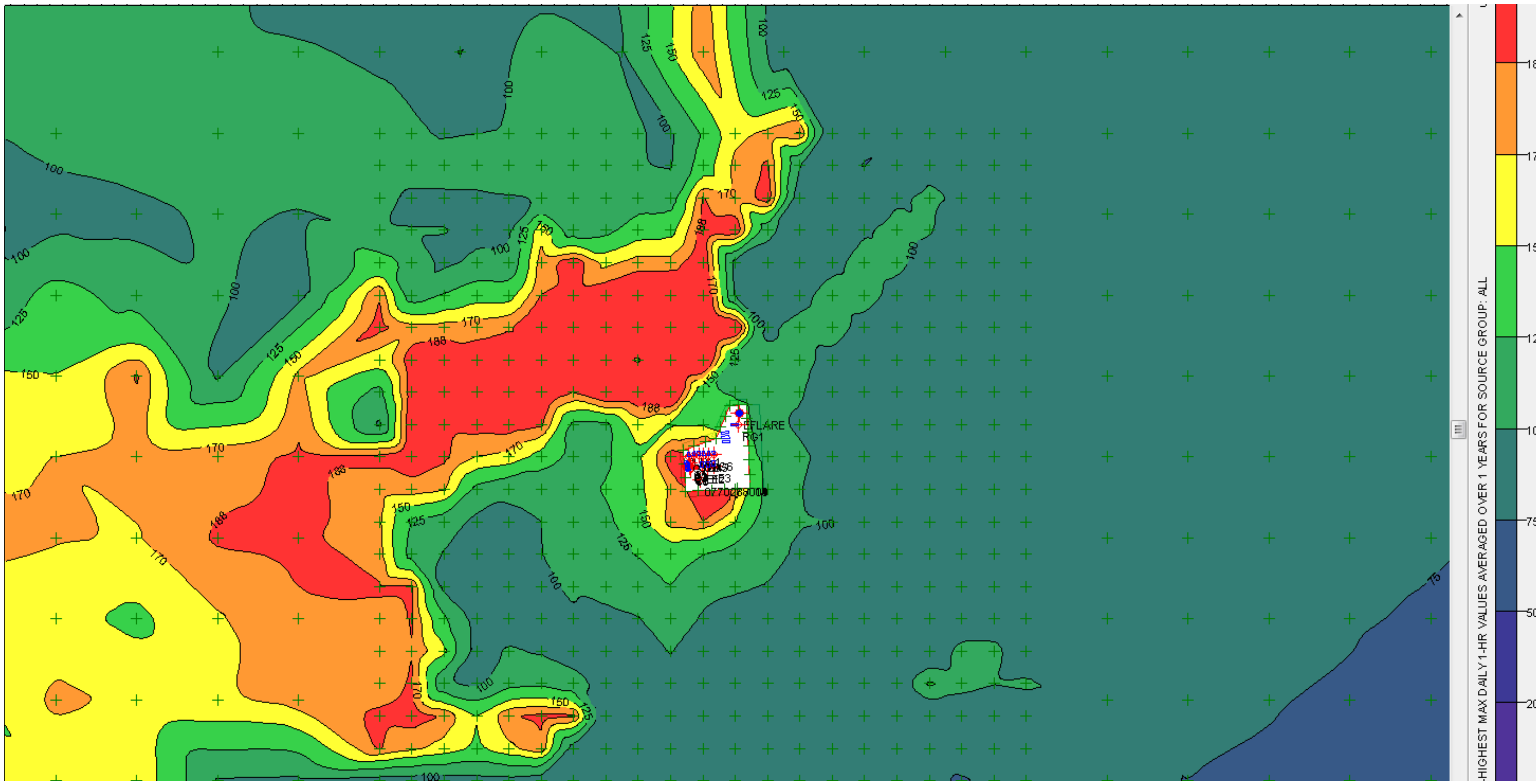
- In-stack ratio was lowered to between 10-50% depending on source type.

- Lean burn engines were set at 20%, turbines were set at 10% and all other sources were set to default EPA ratio of 50%.

Applying Refined In-Stack Ratio to Significant Impact Analysis



Cumulative Impact Analysis with Surrounding Sources

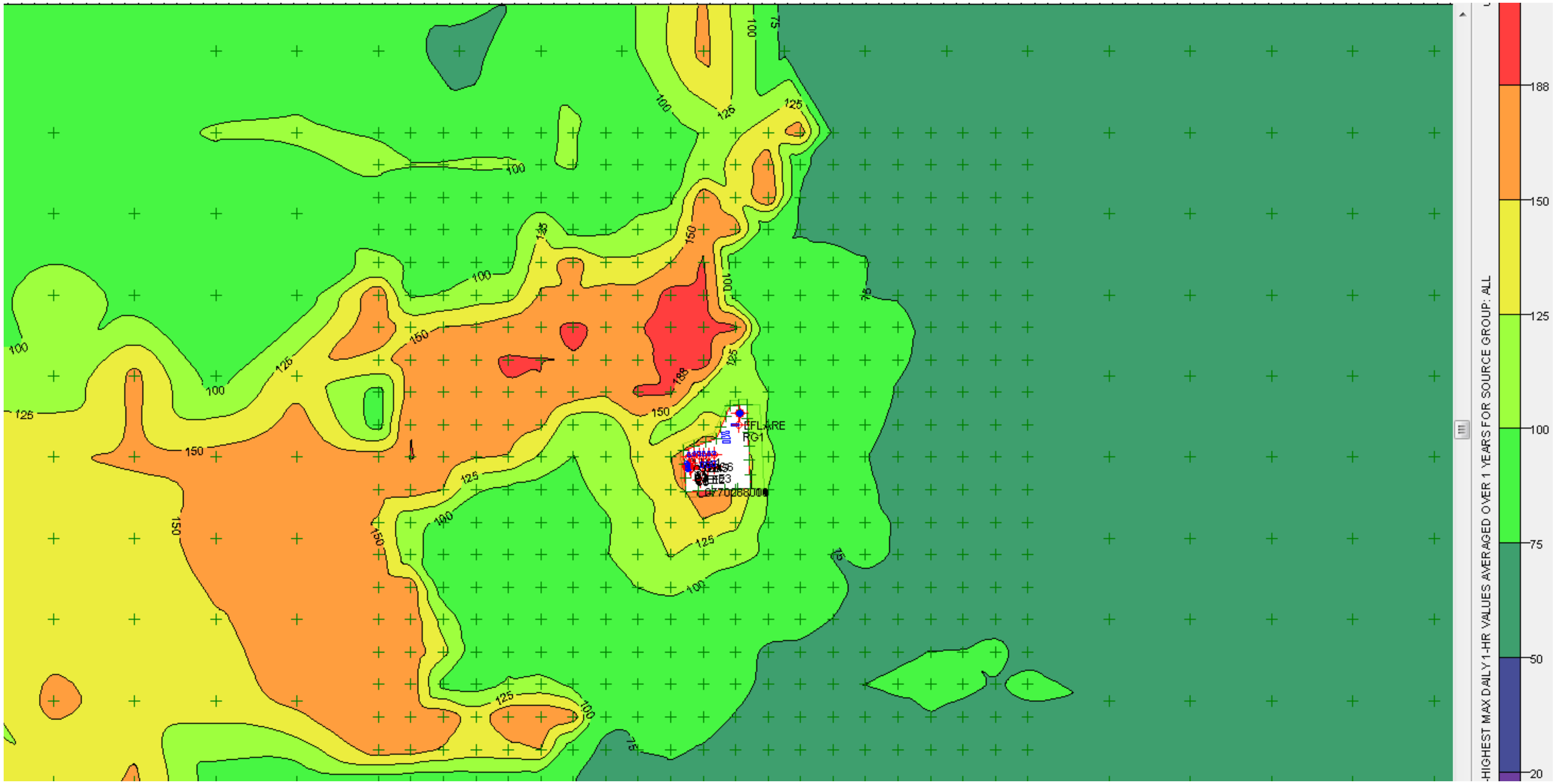


Passing The 1-Hour NO_2 NAAQS

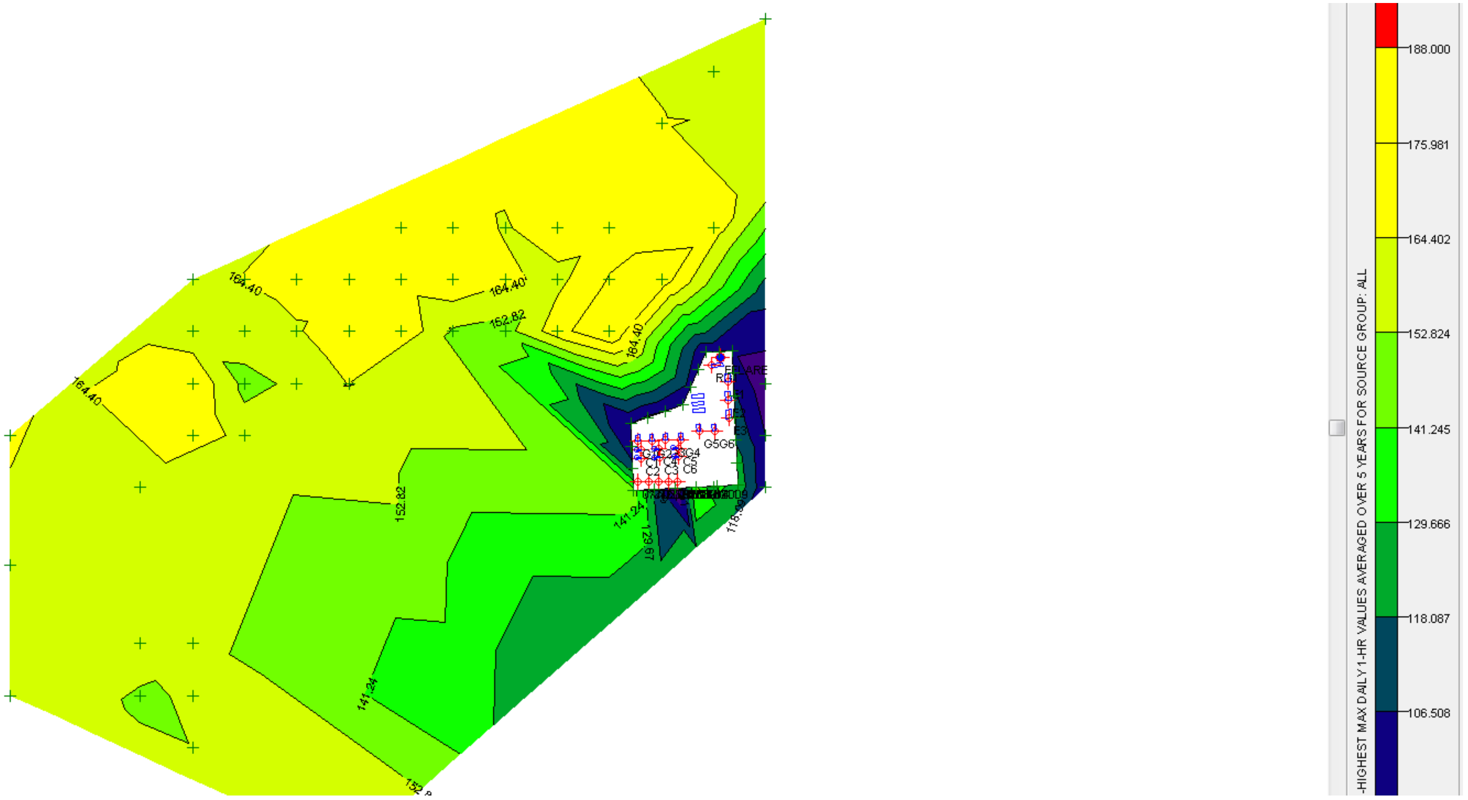
- OLM method in-stack ratios applied to all facility and surrounding sources.

- Even with use of OLM, numerous iterations of stack adjustments and source location changes were needed to bring the modeled ambient NO2 concentrations below the NAAQS.

Cumulative Impact Analysis with Surrounding Sources



Cumulative Impact Analysis with Surrounding Sources



Modified Passing Layout

- 1-Hour NO_2 was brought below the NAAQS of 100 ppb (188 µg/m^3)

- Modified layout was presented to engineering team to make appropriate permitting decisions

- 1-Hour NO_2 model passed 8^{th} high concentration.

- Difficult standards can make basic NAAQS modeling almost as complicated as full PSD modeling.

Maximum Daily Contribution

- AERMOD can create files that compile all of the individual impacts from each source

- Useful when dealing with numerous surrounding sources causing NAAQS exceedances

- Allows facility to demonstrate culpability for an exceedances of NAAQS is due to surrounding source and not the facility

- If impacts from facility are below SIL for each exceedance then there is no exceedance of the NAAQS

Maximum Daily Contribution

Source	Impact (ppb)
Surrounding Sources	97.85
Facility Engine 1	0.83
Facility Engine 2	0.67
Facility Reboiler 1	0.46
Facility Turbines	0.17
Facility Flare	0.05
TOTAL IMPACT	**100.03**
FACILITY IMPACT	*2.18 < 4.0*

- Since Facility sources are below SIL – they are not a culpable source and do not contribute significantly to the NAAQS.

Summary

- States are required to develop and implement SIP to demonstrate attainment, mostly by controlling stationary sources.
- 1-hour NAAQS demonstration has very low margin of error and the modeling input parameters need to be carefully evaluated (default options will not work)
- Run the model with varying conditions until compliance plan is developed
- AERMOD tends to over predict NO_2 impacts. Selecting appropriate Tier will minimize over prediction
- Regulatory agencies need to make the approval process easier for refined tiers
- Default in-stack NO_2/NO_x ratio requires close evaluation and justification
- All possible techniques may need to be utilized, including detailed culpability analysis

EPA Ozone Standards Update

- On Oct. 1, 2015, the EPA strengthened NAAQS for ground-level ozone from the 2008 standard of 75 ppb to 70 ppb
- Recommendations on attainment status of counties within the state with regard to the 2015 standard are due to EPA by October 1, 2016.
- Nonattainment designations for the 2015 standard are scheduled to be finalized by October 1, 2017. These are likely to be based on the 2014-2016 air quality data.

- **Impacts**
- Major modifications will be subject Non-attainment new source review requirements.
- Stringent emissions controls
- The new ozone standard will cause many parts of the country to fall into nonattainment status.
- PSD projects may require additional modeling to demonstrate compliance

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