Attachment E

Information Submitted to the TCEQ for the San Miguel Electric Plant

Contents:

Part 1: *San Miguel Electric Cooperative FGD Upgrade Program Update*

Part 2: *San Miguel SO_2 Air Dispersion Modeling Report*

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Part 1: *San Miguel Electric Cooperative FGD Upgrade Program Update*

San Miguel Electric Cooperative FGD Upgrade Program Update

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June 30, 2014

Table of Contents

List of Tables

List of Figures

1.0 Introduction

This report discusses the results of the program that URS undertook with San Miguel beginning in 2009 to study ways to upgrade the SO2 removal performance of the FGD system and subsequently to implement those changes on all four modules. The first sections summarize the results of URS's engineering study to evaluate options to upgrade the SO_2 removal performance. The last section provides an interim update of the FGD system and how it has performed since the upgrades were implemented.

Prior to initiating this FGD upgrade study, URS reviewed a report provided by San Miguel on the SO_2 upgrade that was completed at the plant in 2006. The result of URS' review indicated that there were additional opportunities to possibly improve the scrubbers to boost removal and/or reduce the reliance on the additive DBA. The study confirmed that initial assessment. The first sections describe the scope of work and costs for two different upgrade alternatives – one a low-cost approach that could be completed in a relatively short period of time and a second, more comprehensive approach that involved more money and time, but which had the potential for greater benefits.

The rest of this report contains the following sections:

- Section 2 – Summary of Upgrade Options Considered;
- Section 3 – Process Analysis;
- Section 4 – Cost Estimate;
- Section 5 – Economic Analysis;
- Section 6 – Project Schedule; and
- Section 7 – Conclusions of the Study phase
- Section 8 - Interim Results of Implementation of Option 1 and 2 Improvements on FGD Performance

2.0 Summary of Upgrade Options Evaluated

The San Miguel FGD system consists of four modules that are typical of the first generation limestone FGD systems designed in the late 1970's and early 1980's. The modules have a venturi section for the first contact zone of flue gas and recycled slurry and an absorber section for the second contact zone where the majority of the SO_2 scrubbing is accomplished. The venturi section was originally intended to remove residual fly ash and some SO_2, and to saturate the flue gas prior to entering the tray section of the absorber. The absorber utilized two counter-current trays and a flooding spray header to distribute the recycle slurry to the trays. At the time of the study, both zones of the modules have been modified from their original designs – the venturi had been opened up to reduce its pressure drop and the recycle slurry fed to it was introduced in a down-flow, co-current-with-the-flue-gas manner. The absorber had its spray nozzles modified (wider spray angle).

When URS examined the layout of the recycle spray headers, good opportunities for improvement were identified. URS has been redesigning the internals of older FGD systems in the U.S. for many years. More recently URS has been focusing on how to improve gas/liquid contacting so that absorber towers can maximize SO_2 removal – often targeting upper 90 percent SO_2 removal efficiencies for absorbers without having to rely on organic acids like DBA. URS has also been designing and installing trays in some of these same towers, combining the synergy of the upgraded spray headers/nozzles with our new sieve tray designs to achieve high SO_2 removals.

Two basic upgrade options were identified and examined in the study phase of the program:

- Option 1 – Modification of Existing Absorber Spray Section; and
- Option 2 – Option 1 plus Moving Quench Spray to Absorber Section.

Both options included upgrading slurry spray headers to use the Lechler TwinAbsorb® spray nozzles. This nozzle has two outlets that produce intersecting hollow cone sprays, known as double hollow cones (DHC), which improves SO_2 removal as compared with standard spray nozzles. Figure 2-1 shows the intersecting sprays, which break up the drops and regenerate droplet surface area.

Research has shown that most of the SO_2 removal in a spray tower absorber occurs within 18" of the spray nozzle exit. Improved scrubbing results when the spray is turbulent in that zone and the number of droplet-to-droplet collisions are high. Experience has shown that the DHC nozzles provide maximum scrubbing efficiency when designed with a wider spray angle. The two DHC outlets each have 120-degree spray angles, but the two are tilted about 15° apart, which creates an oval pattern overall. URS has installed DHC nozzles in a number of FGD systems and the results have consistently shown an improved ability to scrub SO_2 compared to conventional single cone nozzles.

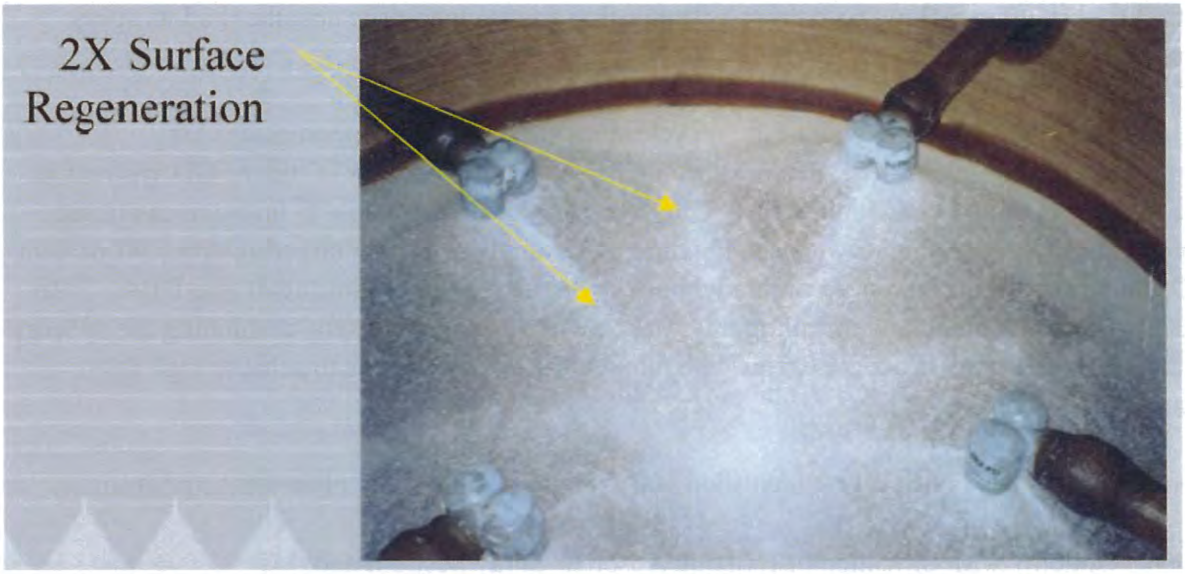
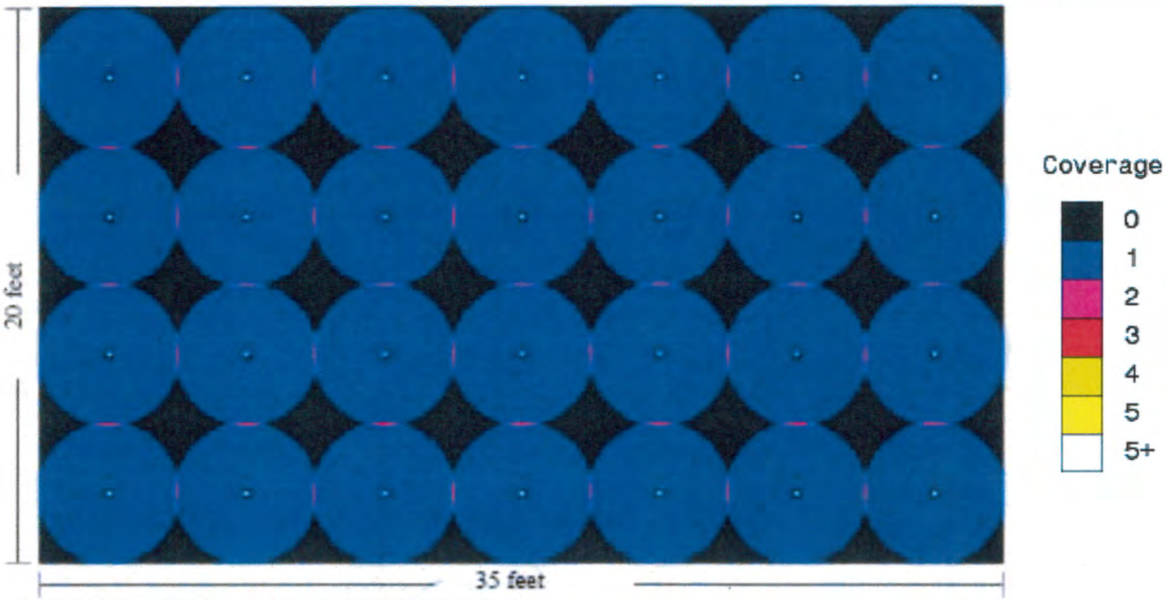


Figure 2-1. Spray Pattern from Proposed Double Hollow Cone Spray Nozzles

The summary of equipment modifications and construction scope of work associated with each of these basic options is presented below. The information presented below is for one absorber (four absorbers have been upgraded):

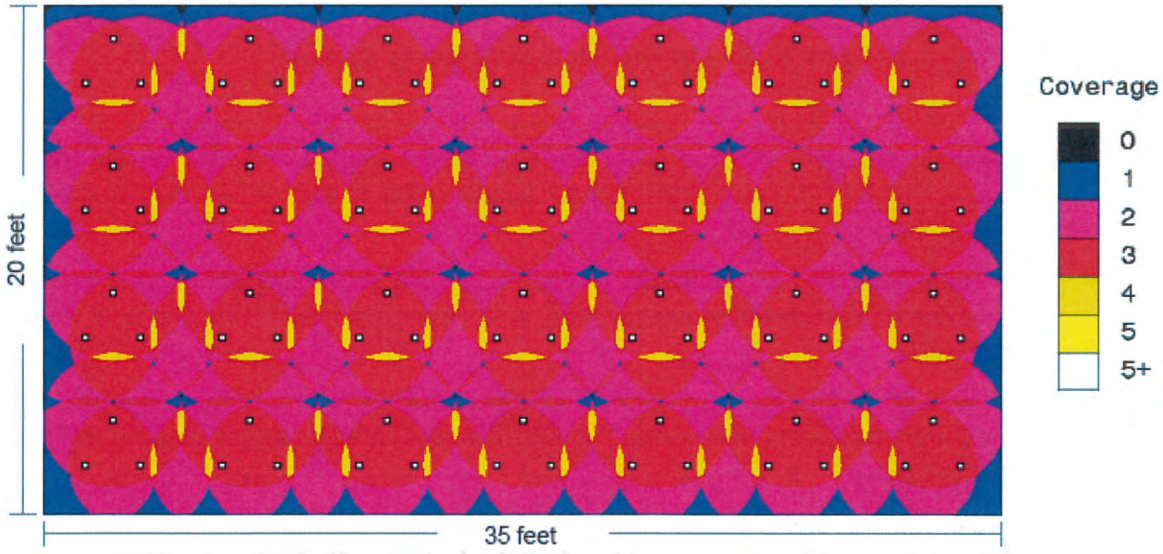
- Option 1 – Modification of Existing Absorber Spray Section (quantities are per absorber)
  - Remove the 28 existing six-inch spray nozzles
  - Install 28 2205 duplex stainless steel flow splitters or "spiders", one at each six-inch flange where the existing six-inch spray nozzles are currently located. The spiders are approximately two feet tall and split the flow from each six-inch connection (24,000 gpm / 28 = 857 gpm) so that it feeds three tangential four-inch nozzles at the bottom of the spider.
  - Install three new high-efficiency 4-inch silicon carbide DHC nozzles on each spider. Each DHC nozzle has 286 gpm of flow.
  - Install a spray impingement plate on the walls where the spray from the DHC nozzles hits the walls to protect the rubber lining from erosion.
  - Repair the existing rubber lining after the impingement plates were installed.

Figures 2-2 and 2-3 on the next page show the improvement in spray pattern with the spiders. The 28 original six-inch nozzles provided only 85% coverage of the cross-sectional area of the absorbers at a point 18 inches below the nozzles; the 84 four-inch nozzles on the spiders provide 265% coverage at the same distance. Figure 2-4 is a sketch of an individual spider arrangement.



Distance Below Header: 18"
Nozzles: 28
% Coverage: 85%

Figure 2-2. Spray Pattern from 28 Existing Six-Inch Nozzles in the Absorbers



Distance Below Header: 18"
Nozzles: 84
% Coverage: 265%

Figure 2-3. Spray Pattern from 28 Spiders, Each with Three Four-Inch DHC Nozzles

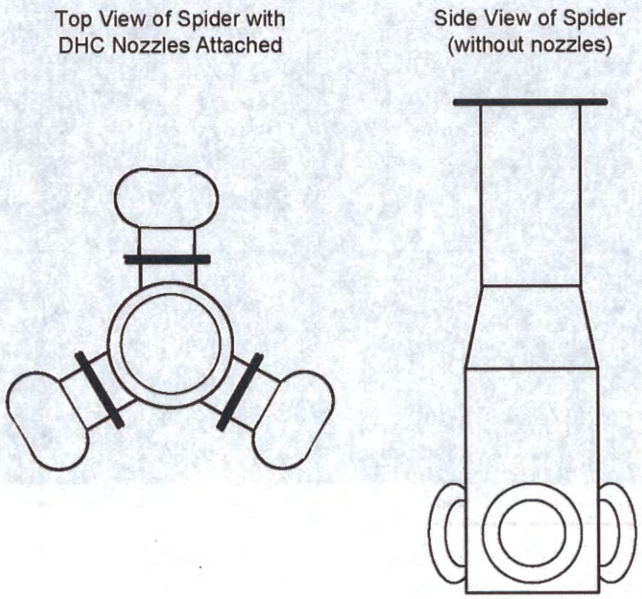
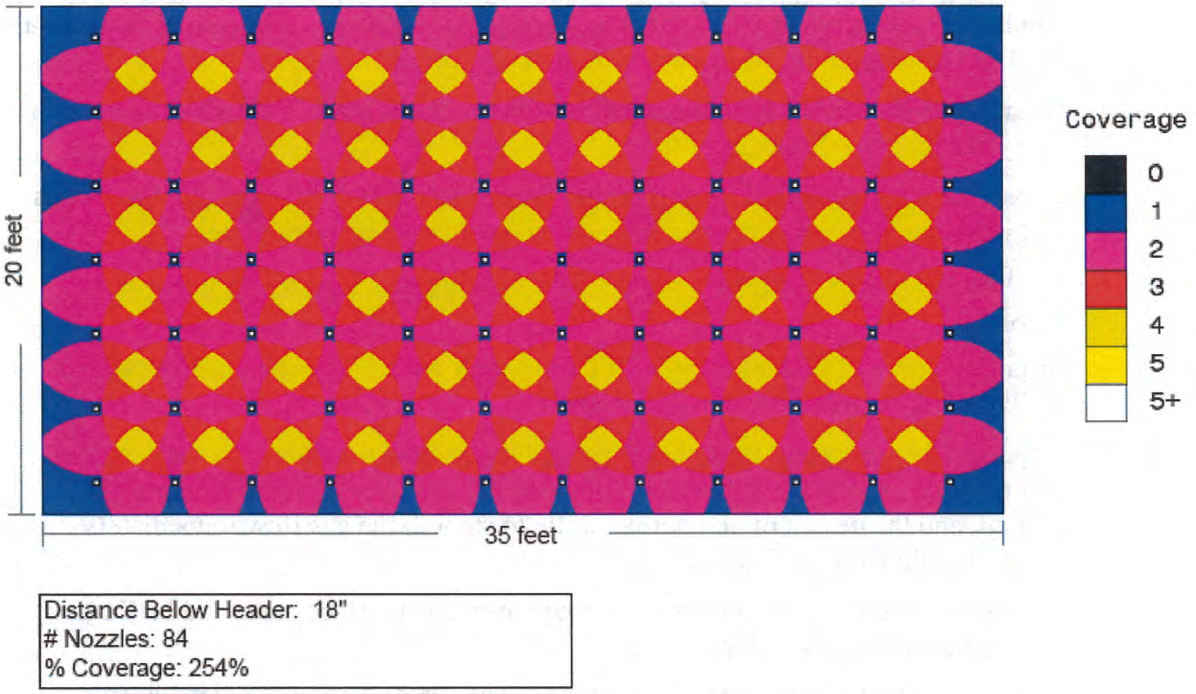


Figure 2-4. Sketch of the Spider

- Option 2 – Option 1 plus Move Quench Spray to Absorber Section.
  - Option 1 work scope
  - Remove the external FRP headers feeding the two existing quench spray levels and existing 20-inch FRP piping that fed those headers back to the 20-inch rubber-lined steel pipe flange.
  - Remove the existing internal headers, nozzles, and any non-structural internal beams or other items in the existing quench spray area. Repaired rubber lining at new wall penetrations.
  - Install new 20-inch abrasion-resistant FRP piping, supports, and expansion joints from the flange referred to above to the absorber section between the existing sprays and the top tray.
  - Relocate (raise by one foot) the existing absorber stiffener beams between the existing sprays and the top tray so they do not interfere with the new header/sprays described below.
  - Install six new 12-inch penetration spools (2205 duplex) and six new self-supporting internal headers and support brackets (2205 alloy) between the existing absorber spray and the top tray, approximately in the location of the existing internal absorber stiffener beams described above.

- Install 14 new high-efficiency 3-inch DHC nozzles on each of the six new internal headers for a total of 84 DHC nozzles. Each DHC nozzle has 133 gpm of flow for a total of 11,300 gpm for this new absorber spray section.
- Install 2205 duplex SS spray impingement plates on the walls just below the new spray headers/DHC nozzles.
- Repair the damage to the existing rubber lining incurred while relocating the beams and installing the new spray headers and the spray impingement plates.
- Remove the two existing trays. Reused the existing tray supports as much as possible.
- Install two new 2205 duplex high-efficiency trays with 37% net open area (versus 31.7% net open area for the existing trays).
- Conduct CFD modeling to evaluate gas and liquid flow patterns from the modified equipment to determine the extent of the wet-dry interface, alloy wall papering needed, and the design of an internal baffle to smooth the gas flow immediately upstream of the bottom tray.
- Install C-276 alloy wall papering in the new wet/dry interface areas and baffle as needed based on the CFD modeling.
- Remove existing rubber lining as needed to install the wall paper and the baffle.

Figure 2-5 on the next page shows the spray pattern from the 84 new three-inch DHC nozzles in the new lower spray header in the absorber section. The new spray coverage, measured 18 inches below the nozzles, is 254%.



Distance Below Header: 18"
Nozzles: 84
% Coverage: 254%

Figure 2-5. Spray Pattern from the 84 Three-Inch DHC Nozzles at the New Lower Absorber Spray

3.0 Process Analysis

To evaluate the potential benefits of improving the scrubbers at San Miguel by the options described in the previous section, we used the EPRI (Electric Power Research Institute) FGDPRISM computer model. This model was developed by URS for EPRI to simulate a variety of lime and limestone FGD systems based on numerous investigations of laboratory, pilot, and full-scale FGD systems. Based on the data supplied from San Miguel on the current system design and operation, we applied the FGDPRISM model to the existing layout and operating conditions and matched the currently observed SO_2 removal efficiency by adjusting the model's liquid and gas-side mass transfer coefficients.

The different options being considered were then examined for operation at a higher inlet SO_2 level of 10.5 lb SO_2 / MMBtu. As described earlier, Option 1 consists of modifications where the absorber spray header systems are upgraded to provide improved gas/liquid contacting as well as a change-out of the type of spray nozzles to the higher performing double hollow cone designs. The second option includes Option 1 modifications plus additional changes where the quencher sprays are redirected to the absorber side and a second spray header installed above the two sieve trays and the quencher is essentially converted into straight-through ductwork. The existing trays are replaced with new, high efficiency trays having more open area to accommodate the additional slurry flow without excessive pressure drop.

Figure 3-1 is a plot of the FGDPRISM predictions for Options 1 and 2 with respect to SO_2 removal as a function of DBA concentration in the scrubbing liquor.

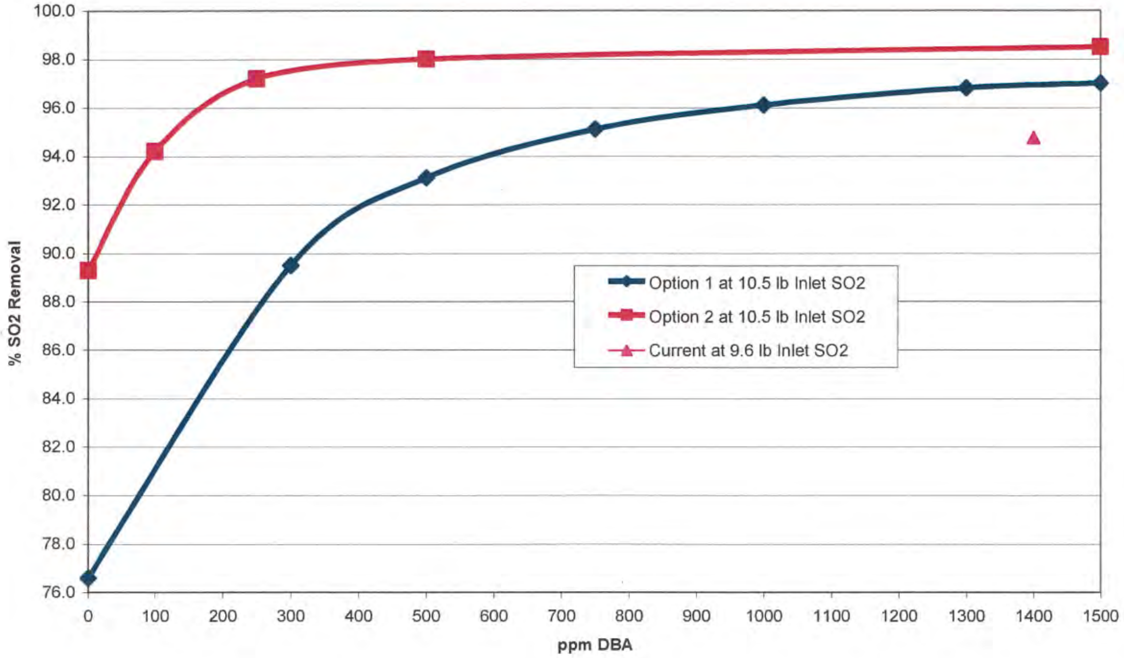


Figure 3-1. FGDPRISM Predictions for San Miguel FGD System Performance

Also shown in Figure 3-1 is the current operating point, 94.75% SO_2 removal using 1400 ppm DBA with an inlet SO_2 level of 9.6 lb SO_2 / MMBtu.

Results of the modeling indicated that the modifications associated with Option 1 would result in the SO_2 removal efficiency being maintained at the 94.75% level while allowing the DBA concentration to be dropped to about 725 ppm (about 50% of current operation level). The predicted DBA consumption rate for this concentration is about 1.62 million lbs/yr as compared to the current consumption rate of about 3 million lbs/yr.

The FGDPRISM modeling results for Option 2, which involves more extensive modifications to the absorbers, are also shown in Figure 3-1. The model predicted that the current removal level of 94.75% could be achieved with 10.5 lb inlet SO_2 using a DBA concentration of only 125 ppm. The predicted DBA consumption for this scenario is about 275,000 lbs/yr.

Table 3-1 presents a summary of the DBA concentrations and predicted consumptions rates for the cases modeled by FGDPRISM. The DBA losses are broken into the solution loss (the amount that is bled from the system with the product solids and liquid blowdown) and the degradation loss (the amount that degrades into CO_2 and H_2O or is co-precipitated with the calcium sulfite solids) components.

Table 3-1. San Miguel DBA Consumption Predictions

Summary of DBA Consumption Predictions						
			DBA Consumption, lb/ton SO2		Total Consumption	
Option	DBA Conc, ppm	% SO2 Rem	Soln Loss	Deg. Loss	lb/ton SO2	lb/yr
Current	1400	94.75	12.8	6.7	19.5	3,000,000
1	725	94.75	6.6	3.2	9.8	1,620,000
1	1500	97	13.4	6.4	19.8	3,390,000
2	125	94.75	1.1	0.5	1.6	275,000
2	240	97	2.1	1.0	3.1	538,000
2	500	98	4.4	2.1	6.6	1,140,000

Note: Current case is based on 9.6 lb SO_2 lignite; Options 1 & 2 are based on 10.5 lb SO_2 lignite.

4.0 Cost Estimate

Section 2 described the scope of work for the two upgrade options. Table 4-1 summarizes the purchased equipment and materials that were included in the Option 1 and 2 cost estimates. Table 4-2 presents the estimate for the total installed costs for each. The estimated total project cost (engineering, procurement, and construction) for Option 1 is $1,600,000 and for Option 2 is $8,800,000.

Table 4-1. Summary of Purchased Equipment and Materials

Description of Purchased Equipment and Materials

OPTION 1

Modification of Existing Recycle Slurry Spray Headers
- Spiders, 1-6" inlet with 3-4" outlets, flanged, 2205 Duplex
- DHC nozzles, 4", NBSC, 286 gpm each (includes 5% spares)
- Spray Impingement Plate, 2205 (includes wall attachment)
- Rubber Liner Repair at spray impingement plates

Fasteners & Gaskets
- 4" Nozzle Connections
  - Fasteners, 2205 (4 per nozzle, 5/8") (includes 5% spares)
  - Gaskets, EPDM (1 per conn., 1/8" thick) (includes 5% spares)
- 6" Spider Connections
  - Fasteners, 2205 (4 per nozzle, 3/4") (includes 5% spares)
  - Gaskets, EPDM (1 per conn., 1/8" thick) (includes 5% spares)

Material Indirect Cost
- Freight (3.5% of material cost)
- Vendor Field Services

OPTION 2 INCREMENT OVER OPTION 1

Lower Level Recycle Slurry Spray (re-routed from current quench section)
- External Recycle Slurry Pipe (20"), flanged, AR-FRP
- External Recycle Slurry Manifold (20"x16"x12"), flanged, AR-FRP
- Expansion Joints, 12", rubber, filled arch, (one at each absorber penetration)
- Absorber Wall Penetration Spools, 12", flanged, 2205
- Spray Headers, 12"x10"x8"x6" with 8-4" stubs for nozzles, flanged, 2205
- Spray Header Supports, wall bracket type, 2205
- DHC nozzles, 3", NBSC, 133 gpm each (includes 5% spares)
- Spray Impingement Plate, 2205
- Rubber Liner Repair at spray impingement plates
- Rubber Liner Repair at Spray Level (wall brackets and penetration spool repads)
- Rubber Liner Repair for Relocated Internal Stiffners

OPTION 2 INCREMENT OVER OPTION 1 (Continued)

Trays
- 37% Open Area Tray (2 per module; 4 modules total)
- Tray Level Supports (includes main beams, cross channels, and wall brackets)
- Rubber Liner Repair at Tray Level (1 ft high around perimeter per tray)

External Recycle Pipe Supports
- 20" Supports
- 16" Supports
- 12" Supports
- Spring Cans
- Structural Steel for Supports

Fasteners & Gaskets
- 3" Nozzle Connections
  - Fasteners, 2205 (4 per nozzle, 5/8") (includes 5% spares)
  - Gaskets, EPDM (1 per conn., 1/8" thick) (includes 5% spares)
- 12" Penetration Spool Connections (2 per spool)
  - Fasteners, 2205 (12 per conn., 7/8") (includes 5% spares)
  - Gaskets, EPDM (1 per conn., 1/8" thick) (includes 5% spares)
- 20" External Recycle Pipe Connections (2 total)
  - Fasteners, Galvanized CS (20 per conn., 1-1/8") (includes 5% spares)
  - Gaskets, EPDM (1 per conn., 1/4" thick) (includes 5% spares)

Relining of Absorber Internal Wall (wet/dry interface area only)
- Wall Paper, C276, 16 gauge, with 30% overlap

Modifications for Flow Distribution
- Bullnose at transition from quench tower to absorber tower, C276, 1/4" plate

Structural Modifications (Absorber Wall)
- Wall Stiffeners Modifications
- Wall Repads at new spray level penetrations, Internal, CS

Material Indirect Cost
- Freight (3.5% of material cost)
- Vendor Field Services

Table 4-2. Cost Estimate

	Scope of Work and Estimated Costs			
	Option 1		**Option 2**	
			(Includes Option 1)	
	Scope of Work		**Scope of Work**	
	a. New spiders to split the flow to 28 existing nozzles in absorber.		a. New spiders to split the flow to 28 existing nozzles in absorber.	
	b. 84 new DHC nozzles, mounted on new spiders		b. 84 new DHC nozzles, mounted on new spiders	
	c. Add spray impingement plates		c. Add spray impingement plates	
			d. External FRP piping to relocate existing quench flow to absorber, above top tray	
			e. New external FRP maniford, above top tray	
			f. New internal headers, above top tray	
			g. 48 new DHC nozzles on new headers	
			h. Replace existing trays with two new high-efficiency trays	
			i. Wall papering and assoc rubber lining removal	
			j. New bull nose to distribute gas to bottom tray more evenly (if CFD modeling confirms need)	
EP Contractor and Construction Contractor	**Estimated Cost, $**		**Estimated Cost, $**	
EP Contractor -- Engineering and Purchased Equipment				
Total EP Contractor Costs*		1,100,000		4,700,000
Construction Contractor -- Construction Materials and Labor**				
Wall papering and bull nose materials***	0		1,100,000	
Other construction materials	50,000		150,000	
Construction labor and fees	450,000		2,850,000	
Total Construction Contractor Costs		500,000		4,100,000
Total Project Cost (Engineering, Procurement, Construction, Guarantees)		1,600,000		8,800,000

Notes: * Includes 5% spares for nozzles, bolting and other small parts plus 15% contingency on purchased equipment. There is no markup on purchased equipment.

** The extent of wall papering and the materials need for the "bull nose" to more evenly distribute the gas to the first tray will not be known until a CFD study is completed as part of the detailed engineering design by the EP Contractor. This estimate assumes that the materials for wall papering and the bull nose will be purchased by the construction contractor (or by San Miguel) and will not be part of the equipment purchased by the EP Contractor.

*** Estimated cost for the wall papering materials, the bull nose, and associated construction labor is an approximation at this point.

5.0 Economic Analysis

Prior to the start of the upgrade program, the San Miguel FGD system required a DBA level of approximately 1400 ppm to achieve 94.75% SO_2 removal while firing lignite with an average sulfur content of 9.6 lb SO_2 per million Btu. This DBA level resulted in an annual consumption of around three million pounds of DBA (dry basis). At the then current DBA price of \$0.90 per pound (dry basis), the annual cost of DBA was about \$2.7 million dollars.

By installing the Option 1 upgrade described earlier, the required DBA level to achieve 94.75% SO_2 removal with a 10.5 lb SO_2 per million Btu fuel was predicted by the FGDPRISM process model to be about 725 ppm. Based on URS's experience that the DBA feed rate would decrease directly proportional to the concentration in the scrubbing slurry, the annual consumption would drop to about 1.62 million lb per year. At a DBA cost at \$0.90 per lb. this would be about \$1.46 million per year. An Option 1 upgrade was projected to reduce San Miguel's annual DBA cost by nearly \$1.3 million even with nearly 10% more sulfur in the lignite. With the Option 2 upgrade described earlier, the required DBA level to achieve 94.75% SO_2 removal with 10.5 lb SO_2 per million Btu lignite was projected to be about 125 ppm, the DBA use would be about 0.28 million lb per year, and the annual DBA cost at \$0.90 / lb. would be about \$0.25 million. The Option 2 upgrade was projected to reduce San Miguel's DBA cost by nearly \$2.5 million, again, at the higher sulfur level in the lignite.

Table 5-1 on the next page summarizes the cost savings for these two options, the associated costs of the upgrades, and the simple payback period of each for the current 94.75% SO_2 removal situation. This analysis does not consider potential benefits from the sale of SO_2 allowances should a trading program be established in Texas. The payout for Option 1 is around 1.3 years and for Option 2 it is around 3.6 years.

Table 5-1. Comparative Economics for Original (pre-2010) FGD Operations versus Upgrade Options 1 and 2

SO2 Removal	94.75%					97.0%					98.0%				
DBA Price, $/lb dry	0.90					0.90					0.90				
	DBA Use Million Lb/yr	DBA Cost $Million	Cost Savings $Million/yr	Upgrade Cost $Million	Upgrade Payback Period Years	DBA Use Million Lb/yr	DBA Cost $Million	Cost Savings $Million/yr	Upgrade Cost $Million	Upgrade Payback Period Years	DBA Use Million Lb/yr	DBA Cost $Million	Cost Savings $Million/yr	Upgrade Cost $Million	Upgrade Payback Period Years
Case															
Current equipment	3.00	2.70		0		NA	NA		NA		NA	NA		NA	
Option 1	1.62	1.46		1.60		3.39	3.05		1.60		NA	NA		NA	
Option 2	0.28	0.25		8.80		0.54	0.48		8.80		1.14	1.03		8.80	
Option 1 vs Current	-1.38	-1.24	1.24	1.60	1.29	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Option 2 vs Current	-2.73	-2.45	2.45	8.80	3.59	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Option 2 vs Option 1	-1.35	-1.21	1.21	7.20	5.93	-2.85	-2.57	2.57	7.20	2.80	NA	NA	NA	NA	NA
DBA Price, $/lb dry	1.20					1.20					1.20				
	DBA Use Million Lb/yr	DBA Cost $Million	Cost Savings $Million/yr	Upgrade Cost $Million	Upgrade Payback Period Years	DBA Use Million Lb/yr	DBA Cost $Million	Cost Savings $Million/yr	Upgrade Cost $Million	Upgrade Payback Period Years	DBA Use Million Lb/yr	DBA Cost $Million	Cost Savings $Million/yr	Upgrade Cost $Million	Upgrade Payback Period Years
Case															
Current equipment	3.00	3.60		0		NA	NA		NA		NA	NA		NA	
Option 1	1.62	1.95		1.60		3.39	4.07		1.60		NA	NA		NA	
Option 2	0.28	0.33		8.80		0.54	0.65		8.80		1.14	1.37		8.80	
Option 1 vs Current	-1.38	-1.65	1.65	1.60	0.97	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Option 2 vs Current	-2.73	-3.27	3.27	8.80	2.69	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Option 2 vs Option 1	-1.35	-1.62	1.62	7.20	4.45	-2.85	-3.42	3.42	7.20	2.10	NA	NA	NA	NA	NA

6.0 Project Schedule

Based on vendor inquiries URS had made at the time of the study, all of the material needed for both options could be delivered by the March 2010. However, there was not enough time for URS to complete enough detailed design work to be able to order all the equipment needed for Option 2. The schedule did allow time to implement Option 1 during the March 23 - April 30, 2010 outage.

7.0 Study Conclusions

Based on the process model results the two options evaluated offered San Miguel the ability to substantially reduce absorber DBA concentration and therefore consumption with the current lignite sulfur content of 9.6 lb SO_2 / MMBtu coal and the current SO_2 removal level of 94.75%. Option 1 was the lowest cost and was recommended for implementation first. Option 2 being higher in cost was not implemented until 2012 and as described below was aimed primarily at achieving compliance with the original version of the Cross State Air Pollution Rule promulgated in 2011.

8.0 Addendum – Interim Results of Implementation of Option 1 and 2 FGD Improvements

This section presents and discusses the results of upgrading the San Miguel FGD system with both Options 1 and 2 since the improvements were implemented up to the current date of June 27, 2014. While successful in achieving the desired reduction in DBA concentration, the process has taken much longer and proven more challenging than expected. URS has had to expend significant costs and resources to achieve the performance improvements. San Miguel has supported the URS initiatives by providing the labor to install equipment modifications that have been necessary and assisting in additional testing of the absorbers. The work has been a joint and cooperative with both parties participating in a collaborative fashion.

San Miguel contracted with URS to install the Option 1 improvements in all four modules during the spring 2010 scheduled unit outage. The system was tested shortly after startup and the performance met or exceeded guarantees. To achieve an average SO_2 removal efficiency of about 95% removal prior to the Option 1 improvements required the absorbers to operate at a DBA concentration of about 1,400 ppm. The absorbers were able to operate at a DBA concentration of around 700 ppm and achieve 95% SO_2 removal, effectively cutting in half the required levels of DBA.

Not long after the Option 1 improvements were installed, the Clean Air Interstate Rule (CAIR) was replaced by the Cross State Air Pollution Rule (CSAPR) in the summer of 2011. This rule required significant reductions in the annual SO2 emissions from San Miguel unit. URS was contracted in September 2011 to begin work on the detailed engineering of the Option 2 improvements described above in Table 4.1 so that the unit could be kept in compliance with the new CSAPR requirements.

At the time, San Miguel conducted with URS's assistance a test of the FGD system to quantify the performance of the absorbers after 1.5 years of operation and in a "seasoned" condition, meaning partially scaled and plugged components in the absorber internals (nozzles, spray headers, trays, mist eliminators, etc.). This test which was done in August 2011 revealed that the SO2 removal performance of the absorbers had degraded measurably relative to the performance test done shortly after the Option 1 improvements were installed in April 2010. Given the very high inlet sulfur dioxide concentrations in the flue gas entering the San Miguel FGD system, this result is not surprising. Any shortfall in the gas/liquid contact area is magnified to a much greater extent than in the typical FGD system in the U.S.

The test results from August 2011 showed that the absorbers required over 50% more DBA in solution to maintain a nominal SO_2 removal efficiency of 95% as compared to the testing conducted shortly after the Option 1 improvements were made in the spring of 2010.

The Option 2 improvements were installed in the spring outage of 2012.

Table 8.1 presents results of a number of tests which were conducted over the course of time from when both the upgrades had been completed until present day. The first line in the Table shows the baseline SO_2 removal efficiency and required DBA concentration for the FGD system prior to the absorbers being upgraded. As mentioned earlier, under typical conditions, the absorbers needed about 1,400 ppm of DBA to achieve nominally 95% SO_2 removal.

Results from the first test conducted shortly after the spring outage of 2012 and after the Option 2 improvements were installed indicated that the absorbers were not performing anywhere near expectations. At that time, URS initiated a significant corrective action program to identify the reason for the performance shortfall and to come up with the best solutions.

This work identified a number of possible causes for the performance shortfall including:

1) Low tray pressure drop
2) Trays coming detached from their supports allowing flue gas bypass and/or uplifting in the center area
3) The new wall ring obstructing flow of recycle slurry to the top tray
4) Low recycle pump flow due to eroded impellors
5) Poor quencher and absorber tank agitation
6) Short circuiting of slurry in the recycle tanks
7) Mal-distribution of slurry to the upper tray
8) Mal-distribution of flue gas from absorber to absorber

Date	Load, MW	Average Absorber DBA, mg/L	Stack CEMS SO2, lbs/MMBtu	Average Module pH	Measured FGD Removal Efficiency, %	Guaranteed FGD Removal Efficiency, %	Measured vs Guaranteed Performance
Pre Upgrade	430	1400	0.50	5.9	94.8%	-	-
4/26/2012	430	1670	0.71	5.9	93.2%	98.5%	-5.3%
1/16/2013	430	710	0.63	5.9	93.0%	97.5%	-4.5%
4/15/2013	430	230	0.61	6.15	93.5%	91.5%	2.0%
10/31/2013	435	838	0.31	6.1	96.9%	97.9%	-1.0%
10/31/2013	431	841	0.25	6.1	97.5%	97.9%	-0.4%
11/1/2013	430	782	0.29	6.15	97.1%	97.8%	-0.7%
11/1/2013	430	663	0.62	5.96	93.8%	97.5%	-3.7%
5/15/2014	415	504	0.39	5.96	96.1%	96.0%	0.1%
5/25/2014	431	250	0.56	5.95	93.8%	91.8%	2.0%
6/20/2014	432	275	0.69	5.94	91.9%	92.5%	-0.6%
6/21/2014	431	530	0.56	5.95	93.4%	96.0%	-2.6%
6/25/2014	435	430	0.45	6.02	94.7%	95.4%	-0.7%

Table 8.1. Results of FGD testing from April 2012 through June 2014

The first problem that was solved was the lower than expected pressure drop. This required the reduction in the open area of the trays using thin pieces of stainless steel to block off holes. The result was some improvement in the system SO2 performance but not as much as expected.

Inspections of the internals of the absorbers revealed that some of the trays had come loose from their supports allowing them to lift and therefore bypass flue gas around this critical scrubbing zone. An improved method of attaching the trays to their supports solved this problem around the perimeter of the tower and also clamps were installed in the center of the tower to make sure the trays remained flat. These improvements were added in the fall of 2012. Significant performance improvements were not seen after these were added.

URS conducted CFD modeling of both the absorber and quencher tanks to investigate if there was any short-circuiting of slurry from the down-comers directly to the recycle pump suctions. Short-circuiting can be very detrimental to SO2 removal and can lead to rapid scaling inside the absorbers and in downstream equipment. The CFD results did not identify any problems and showed that the agitators were providing very good mixing in each tank. San Miguel replaced all the original tank agitators in the 2011 to 2012 time frame with newer models that give better tank agitation. URS modeled the power inputs and prop speed of these new agitators. Figure 8.1 is an example output from this tank modeling.

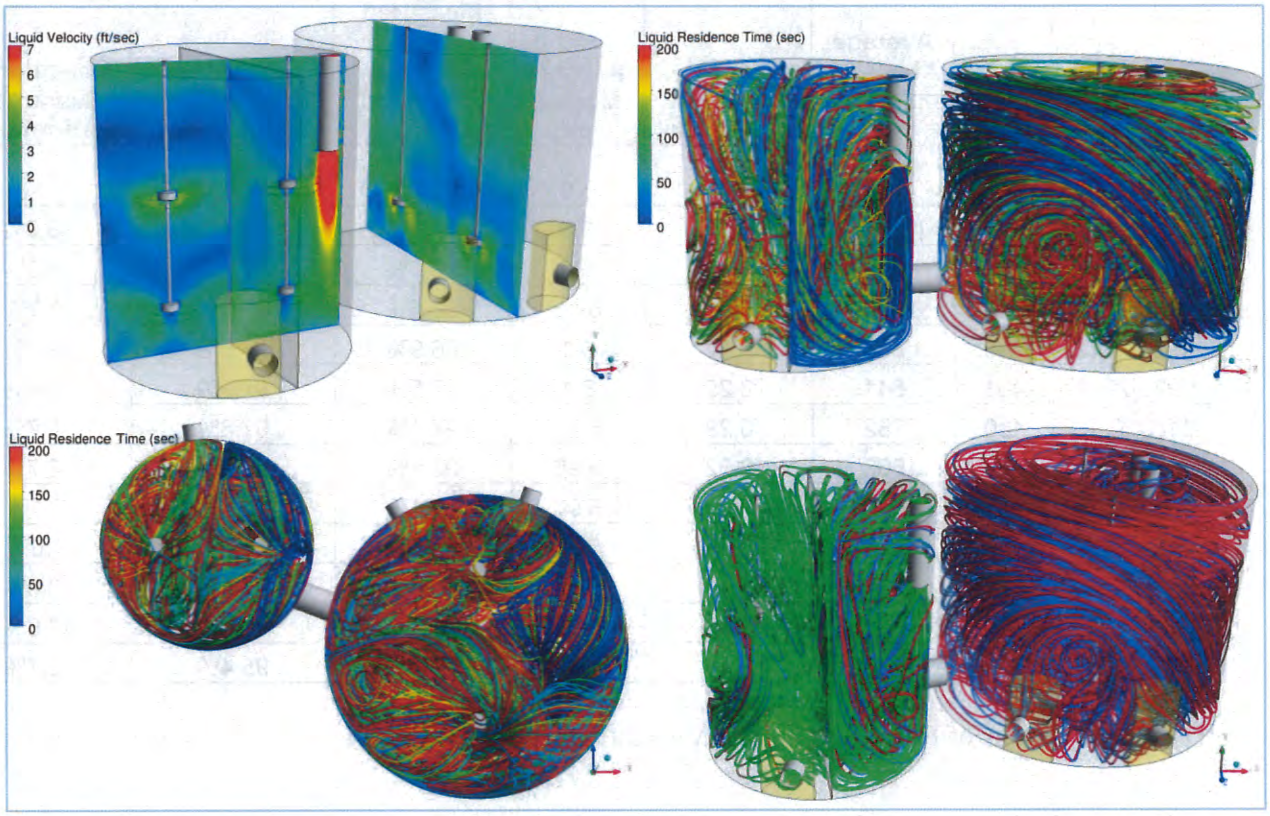


Figure 8.1. Graphics from CFD modeling study of San Miguel FGD reaction tanks

To determine if there were any problems with gas/liquid distribution inside the absorber in the key scrubbing zones around the spray headers and counter-flow trays, URS conducted a CFD study in that area of the system. This modeling did turn up a potential problem in that the new high efficiency double hollow cone spray nozzles could be impacting the walls of the towers and channeling slurry down to the tray in an irregular fashion. The new spray nozzles are designed for a 120 degree cone angle, which is wider than the old nozzles. The wider angle nozzles are important to maximize SO2 scrubbing from the spray headers. URS has used these exact nozzles and a very specific nozzle-to-nozzle spacing to achieve maximum SO2 removal efficiency from absorbers with limited recycle pump capacity as at San Miguel. There were no detrimental effects in these other absorbers, but then again they do not operate anywhere near the fuel sulfur levels at San Miguel.

The consequence of using the wider cone angle nozzle can be seen in Figure 8.2.

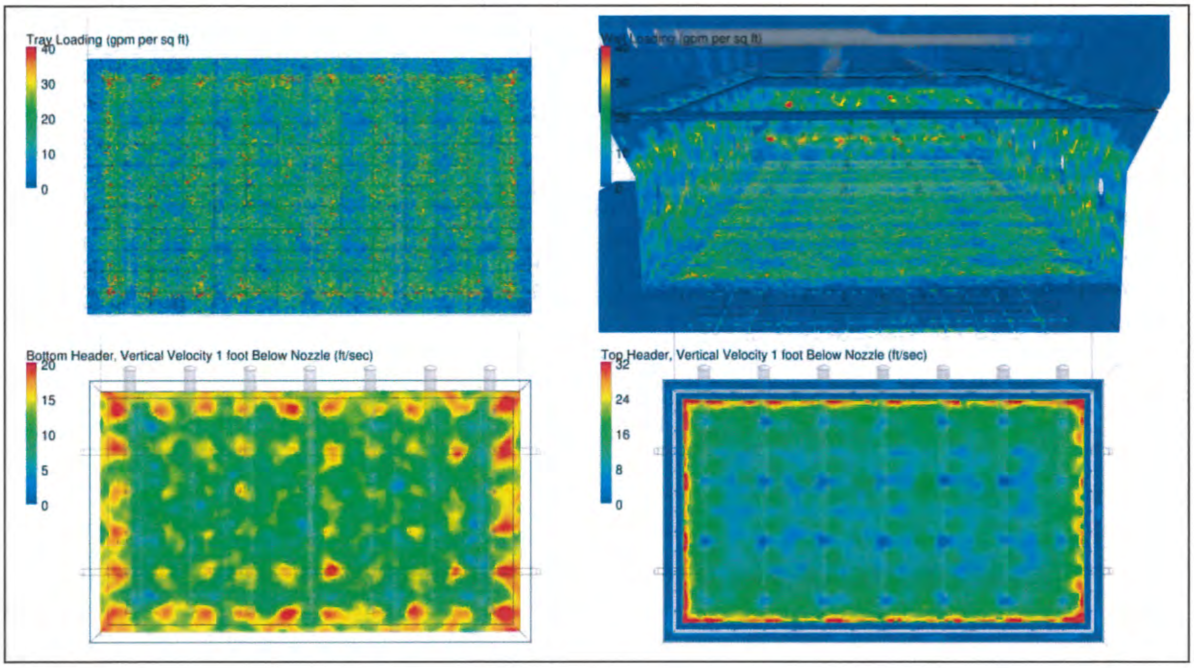


Figure 8.2. Results of CFD study of San Miguel absorber internals

The upper right CFD image shows that there is a fairly significant amount of slurry from the two spray headers that impacts the walls of the towers. While this is a normal occurrence in many other spray/tray FGD systems, the conditions at San Miguel with the much higher incoming SO2 means that highly efficient gas/liquid mixing must occur in all areas of the tower with no margin. So URS redesigned the upper tray to minimize the number and height of the partition walls on the outer areas of the tray. Modeling showed that the new trays would even out the recycle slurry distribution on the tray, allowing slurry coming down the walls to spread out horizontally and evenly flood the tray. Figures 8.3 and 8.4 show the before and after slurry distribution to the upper tray, respectively. Given the flow improvement that could be achieved by redesigning about half of the upper tray compartments, URS procured new sets in late 2013 for installation in the spring 2014 outage.

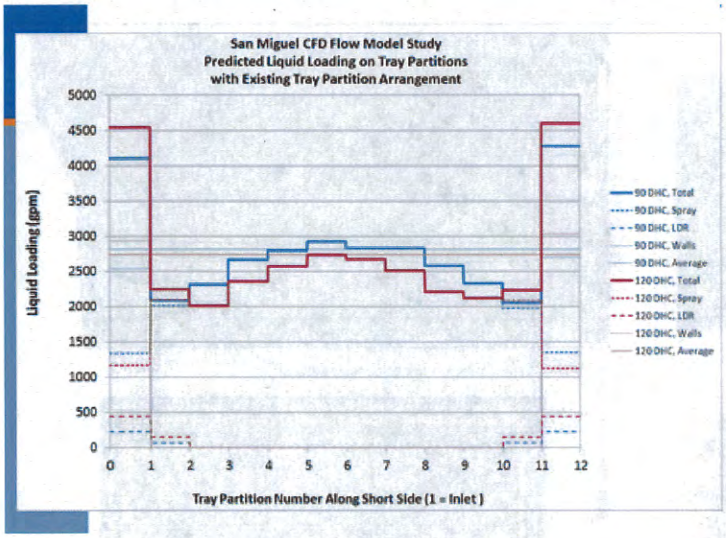


Figure 8.3. Results of CFD evaluation showing uneven distribution of slurry to the upper tray

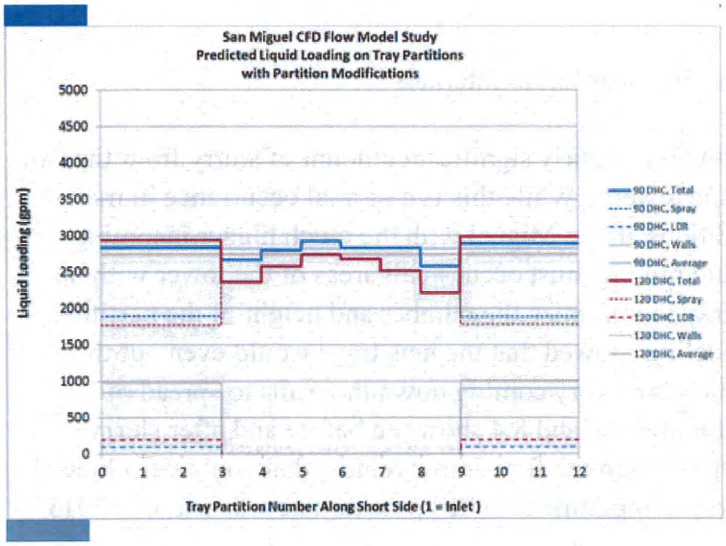


Figure 8.4. Results of CFD evaluation showing improved distribution of slurry to modifed upper tray

Numerous times during the last two years URS has conducted traverses of each of the four absorber outlet ducts in an effort to determine if one or more of the absorbers was having a problem causing the stack SO2 to be elevated. There were no problems that were clearly identified from this work. It did show that in general the gas flowing near the outer areas of the absorber walls had very low SO2 concentrations as compared to the inner area where the SO2 was highest. Figure 8.5 is an example of the SO2 profile that was typically seen during these traverses.

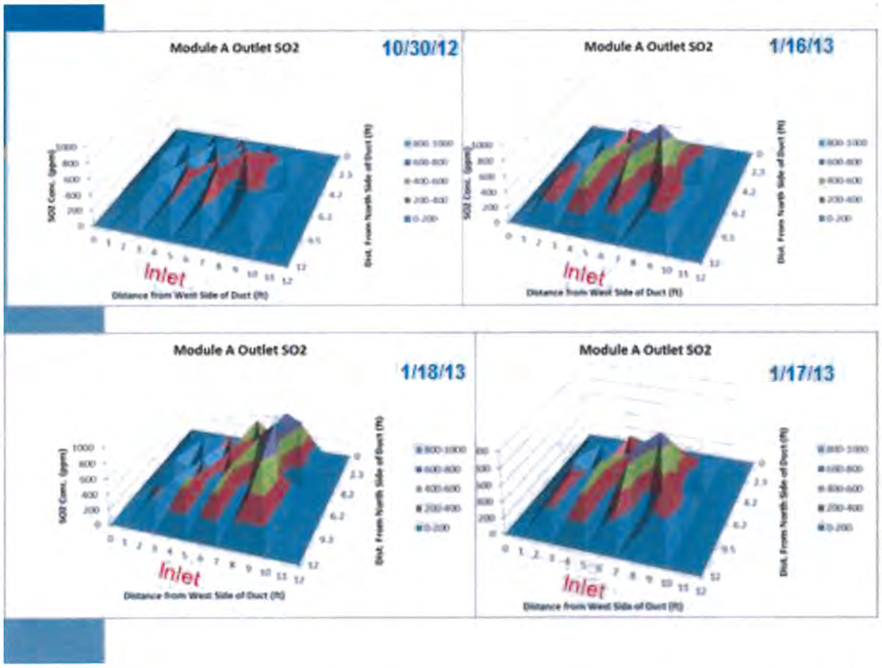


Figure 8.5. Example of SO2 gas traverses of the outlet duct of the A module

The results in the figure graphically show how the flue gas in the center part of the duct just above the absorber mist eliminators has much more SO2 in the middle area as compared to the perimeter. This supported the CFD modeling results of the absorber internals discussed earlier. Those results showed a significant portion of the recycle slurry was trapped around the outer areas of the trays. This heavy slurry loading on the outer regions of the tray would provide better SO2 scrubbing in that area. However, the heavy loading will force flue gas into the middle areas of the tray where there is less resistance due to a lower slurry loading. The combination of more flue gas passing through the center of the tray and proportionally less slurry there would have an overall detrimental effect on SO2 removal. These observations supported URS's decision to pay for new trays in an effort to solve this problem and help boost overall SO2 removal by improving gas/slurry contact. These trays were installed by plant personnel during the recent spring 2014 outage.

Another area that could cause lower SO2 removal of the upgraded system was the physical condition of the absorber recycle pumps. These large capacity pumps need to be running at or near their rated outputs to allow the upgraded system to perform as designed. A common problem with older recycle pumps is worn impellors. Figure 8.6 shows a photo of one of the pump impellors taken during the fall 2012 outage. This impellor has significant wear and would not be expected to be able to pump at design capacity. Plant maintenance staff keep track of the conditions of the pumps and this particular pump impellor was in line for replacement. San Miguel made a concerted effort to inspect and replace all excessively worn pump impellors to return the pumps to good operation condition. Subsequently, new pressure gauges were installed on the recycle pump discharge piping to confirm that the pumps are operationg satisfactorily. These have been tracked over the past year and for all pumps, the pressures indicate that the pumps are flowing at design levels.


SMEC FGD Pump Inspection Showing Worn Impellor

Figure 8.6. Inspection of San Miguel FGD Recycle Pump Showing Worn Impellor

9.0 Summary

Significant troubleshooting efforts have been completed by URS and San Miguel since the Option 2 improvements were installed in the spring outage of 2012. From all available information (flue gas and pump flows, absorber chemistry, absorber internals, CFD and process modeling, etc.), it appears the FGD system is currently operating as intended both from a chemical and physical design standpoint. Referring back to Table 8.1, the most recent performance data collected with the unit at full load during May and June, shows that the FGD system is achieving 94 to 95% SO2 removal efficiency at absorber DBA concentrations of about 400 ppm. As mentioned earlier, prior to the Option 1 and 2 upgrades, to achieve 94 to 95% removal typically required an absorber DBA concentration of 1,400 ppm.

The current required DBA concentration of about 400 ppm is what was expected from the absorber upgrades for a target SO2 removal in the range of 94 to 95%. The various re-work items described above completed in the past two years each contributed to achieving the goal. The redesigned trays were the latest improvement and resulted in the final incremental boost in performance.

It should also be noted that improvements made in the FGD area, specifically in the rake upgrade in the T1 tank and conveyor improvements in the filter building, have allowed the absorbers to be controlled at higher thiosulfate concentrations and therefore lower sulfite oxidation levels. This is very important since it has proven very challenging to maintain consistent control of the absorber chemistry – in particular sufficient concentrations of thiosulfate in the absorber slurry – to keep the sulfite oxidation levels in the desired range which is 5 to 10%, to minimize chemical scaling inside the absorbers. This scaling would occur whenever the thickeners or T1 had to be bypassed for cleaning due to pluggage of the equipment, or failure of the drum filters/conveyors/pug mill in FGD. The root cause of the problem was that the desirable, low oxidation conditions also brought with them the production of more pure calcium sulfite crystals, which settled much more rapidly causing problems with the dewatering systems that were not originally designed to handle them.

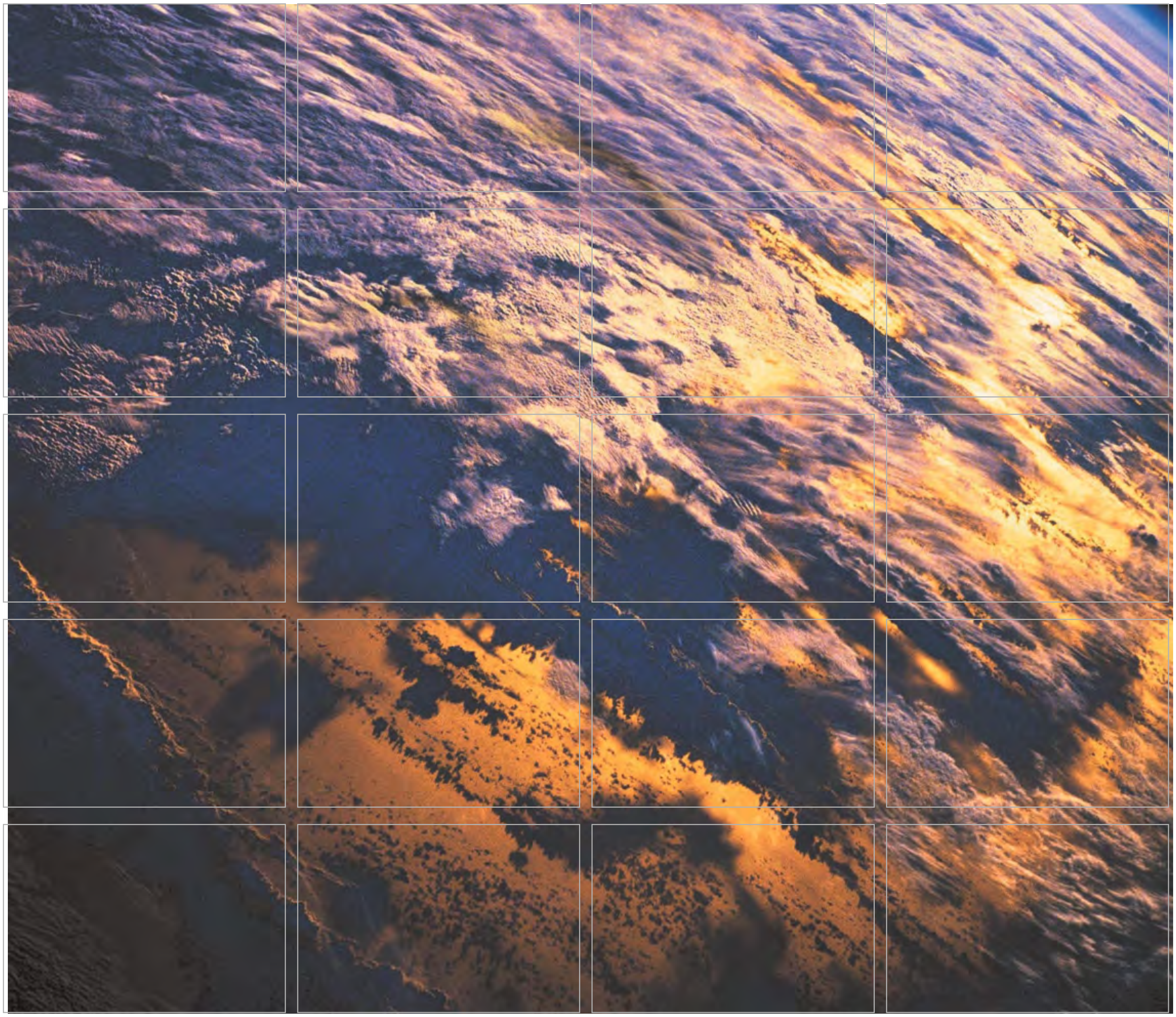
Since the upgrades to the dewatering system, the feed rate of emulsified sulfur has been much more regular and there have been fewer cases of absorber blowdown slurry being sent directly to the pond which increases chemical consumption rates. Consistent operation of higher thiosulfate residuals in the quencher and absorber tanks has been the result. This will maintain cleaner conditions within the absorber towers and help the overall system to operate more efficiently for longer periods of time.

URS and San Miguel recently conducted a final performance test in association with the FGD upgrade program. The tests were completed on 6/27/14 and within a month from that date the results should be available for review.

Attachment E

Information Submitted to the TCEQ for the San Miguel Electric Plant

Part 2: *San Miguel SO_2 Air Dispersion Modeling Report*



SO_2 Air Dispersion Modeling Report for San Miguel Electric Cooperative Inc.

August 2015

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SO_2 Air Dispersion Modeling Report for San Miguel Electric Cooperative Inc.

August 2015

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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Unlike previous National Ambient Air Quality Standard (NAAQS) attainment demonstrations, EPA has decided to make 1-hour SO_2 NAAQS attainment determinations using ambient air monitoring data and/or air dispersion modeling. The final 1-hour SO_2 Data Requirements Rule (DRR) allows the use of modeling in situations where representative monitoring data are not available. EPA also issued guidance in its draft "Modeling Technical Assistance Document" (TAD)[1] on how modeling for the purpose of determining the compliance status of an area should be performed. The Modeling TAD sets forth a significantly different technical approach compared to conventional regulatory modeling prescribed by 40 CFR Part 51, Appendix W (EPA's *Guideline on Air Quality Models*). The approach laid out in the SO_2 Modeling TAD is designed to meet the requirements of EPA's 1-Hour SO_2 DRR.

Environmental Resources Management (ERM) performed air dispersion modeling to estimate the ambient impact of Sulfur Dioxide (SO_2) emissions from San Miguel Electric Cooperative Inc.'s (San Miguel) electric generating unit following the guidance in the Modeling TAD. The cumulative modeling analysis evaluated the impacts on ambient air quality from SO_2 emissions at San Miguel when added to existing background represented by ambient monitoring values. In addition, although the approach for considering cumulative ambient impacts with other major sources in the region is not specifically covered in the rule, ERM considered all other major sources of SO_2 within 50 kilometers to determine the need for source specific inclusion in the modeling.

The model results demonstrate that maximum model-predicted SO_2 impacts are in attainment with the 1-hour SO_2 NAAQS. This analysis, designed to fulfill the requirements of the DRR, shows that the ambient air quality in the vicinity of San Miguel which is currently undesignated for the 1-hour SO_2 NAAQS is within the NAAQS and should be identified as "attainment" in the next cycle of designations.

This modeling report describes the methodology that was used to evaluate potential impacts of SO_2 emissions from San Miguel on ambient air quality. Section 2 of this report provides a description of the facility and the emissions included in the modeling. Model selection and the methodology used in the modeling are described in Section 3. The modeling results are presented in Section 4. References are provided in Section 5. Copies of the modeling files are provided in Appendix A, the Electronic Modeling Archive.

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[1] http://epa.gov/oaqps001/sulfurdioxide/pdfs/SO2ModelingTAD.pdf

2.0 FACILITY DESCRIPTION AND REGULATORY SETTING

2.1 FACILITY LOCATION

The San Miguel electric generating unit is located in the town of Christine, Texas. The station is located about 6 miles south-southeast of downtown Christine. The site is accessed by FM 3387 south of Christine, TX. The station is approximately 50 miles south of San Antonio, Texas and 90 miles northwest of Corpus Christi, Texas. Approximate site coordinates are 28.704° North Latitude, 98.477° West Longitude. The Universal Transverse Mercator ("UTM") coordinates of the facility are 551,040 Easting and 3,175,345 Northing (using North American Datum of 1983 - NAD83) in UTM Zone 14. The base elevation of the facility is 325′ (99.06m) above sea level. Figure 2-1 shows the site location marked on a United States Geological Survey ("USGS") 7.5-minute topographic map.

2.2 SO_2 ATTAINMENT STATUS

In July 2013, EPA designated 29 counties or partial counties as non-attainment for 1-hour SO_2 NAAQS. However, the vast majority of the country was not designated by EPA at that time due to the lack of monitors, or poor siting of existing monitors, for the purpose of capturing source based maximum ambient SO_2 concentrations. None of the counties surrounding San Miguel, including Atascosa, the county in which San Miguel is located, have been designated as attainment or non-attainment for the 1-hour SO_2 NAAQS.

2.3 SOURCE PARAMETERS AND ACTUAL EMISSION RATES

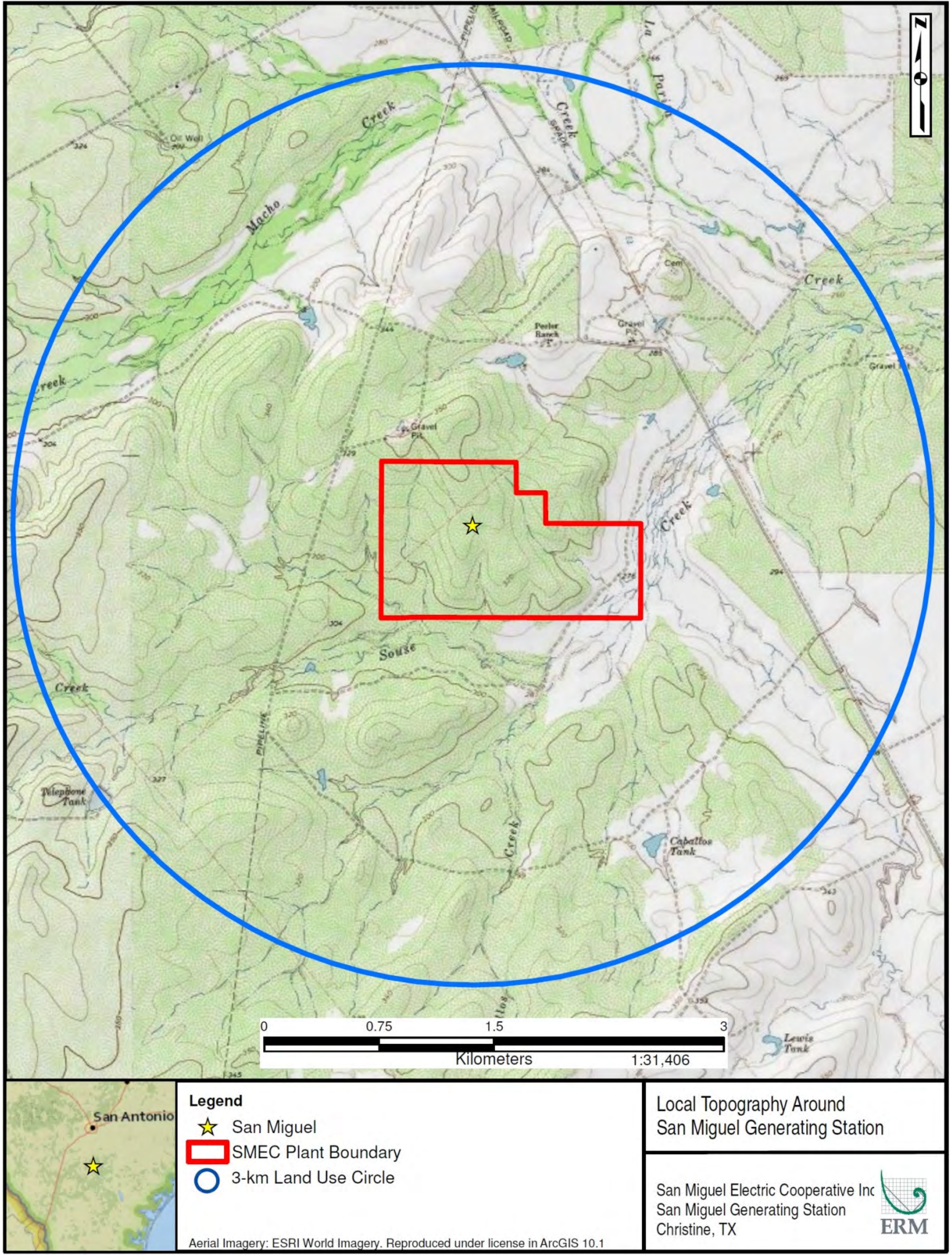
For this 1-hour SO_2 NAAQS modeling demonstration, the only significant source of SO_2 emissions at the facility was Boiler Stack (EPN 6). Per the 1-hour SO_2 Data Requirements Rule and SO_2 Modeling TAD, the most recent 3 years of actual emissions data, along with the actual stack height of the Boiler Stack, were used in the modeling. The following provides a description of all San Miguel SO_2 emission sources. Table 2-1 summarizes the characteristics of San Miguel Boiler Stack.

TABLE 2-1: San Miguel Boiler Stack – Stack Parameters

Description	*Model Source*	*Stack Height*		*Exit Temperature*		*Exit Velocity*		*Stack Diameter*	
		(ft)	*(m)*	*(F)*	*(K)*	*(ft/sec)*	*(m/s)*	*(ft.)*	*(m)*
Boiler Stack[1]	STACK	450	137.16	---	---	---	---	20.0	6.10

1. Exit temperature and exit velocity varied on an hourly basis based on actual emissions data.

FIGURE 2-1: San Miguel Station Local Topography



The actual emissions data used in the modeling are described below:

- Boiler Stack (Source ID: STACK). This unit is a coal fired utility boiler that produces steam for the generation of electricity. For this unit, three years (2012-2014) of actual hourly emissions, stack temperature, and exhaust flow rate data were input into the model. These data were provided by San Miguel based on CEMS data collected at the site. As per the 1-hour SO2 Data Requirements Rule, the actual height of the stack was represented in the model.
- Other sources at the site include emergency engines and fire pumps. These sources are used exclusively in emergency situations except for approximately one hour/week testing. Therefore, in accordance with USEPA guidance for intermittent sources[2], the emergency generator and fire pump engine were not included in the modeling demonstration for the 1-hour SO_2 NAAQS.

2.4 *SOURCE PARAMETERS AND MSS EMISSION RATES*

To supplement the actual emission rate model results, the maintenance, startup, and shutdown (MSS) emission rate of 5,967.7 lb/hr was modeled to demonstrate compliance with the 1-hour SO_2 NAAQS under facility maximum emission rates. The modeled MSS stack parameters are shown in Table 2-2 below.

TABLE 2-2: San Miguel Boiler Stack – MSS Stack Parameters

Description	*Model Source*	*Stack Height*		*Exit Temperature*		*Exit Velocity*		*Stack Diameter*	
		(ft)	*(m)*	*(F)*	*(K)*	*(ft/sec)*	*(m/s)*	*(ft.)*	*(m)*
Boiler Stack	STACK	450	137.16	165	347	119.1	36.3	20.0	6.10

Figure 2-2 presents a site plan of the San Miguel facility.

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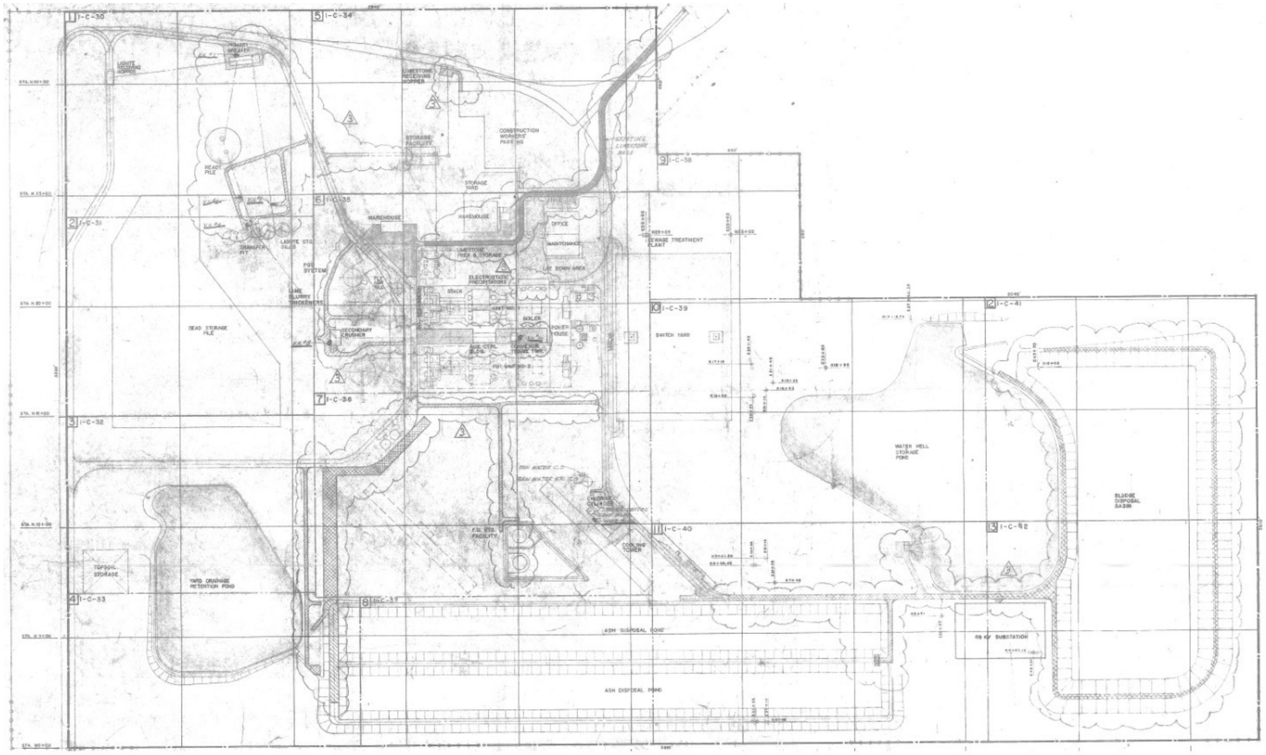
[2] http://www.epa.gov/scram001/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf

FIGURE 2-2: San Miguel Station Site Plan



3.0 AIR DISPERSION MODELING ANALYSIS

EPA specifies that the approaches described in the SO_2 Modeling TAD are designed to "reflect a view that designations are intended to address current actual air quality (i.e., modeling simulates a monitor), and thus are unlike attainment planning modeling, which must provide assurances that attainment will occur." EPA's modeling guidance for the DRR utilizes several important differences from the modeling for permitting and/or attainment planning purposes including but not limited to the following:

- Simulating actual emissions and exhaust conditions (e.g., temperature and flowrate) on an hourly basis reflecting actual operations for a specified historical time period;
- Representing actual stack heights, irrespective of the GEP heights;
- Limiting modeled ambient air receptors to locations where monitoring could actually take place by excluding waterways, roadways, railways, restricted access property, and other locations that would conventionally be considered "ambient air" for regulatory and permitting purposes; and
- Simulating a three-year period of meteorological and background monitoring data, concurrent with the actual operating conditions and emissions, to meet EPA's objective that "modeling simulates monitoring" in this context.

Some of the above methodologies are specifically discussed in the DRR, while the less commonly used modeling approaches are not.

ERM conducted the modeling analysis for San Miguel to estimate maximum ambient 1-hour SO_2 concentrations for comparison with the NAAQS following the proposed approach described in the SO_2 Modeling TAD. ERM's assessments were conducted in a manner consistent with United States Environmental Protection Agency (EPA) and Texas Commission on Environmental Quality (TCEQ) air quality regulations and modeling guidelines, including the following EPA documents:

- *Guideline on Air Quality Models* – 40 CFR Part 51, Appendix W, Revised November 9, 2005.
- AERMOD Implementation Guide, Revised March 19, 2009;
- "SO_2 NAAQS Designations Modeling Technical Assistance Document (Draft)," December 2013;
- "SO_2 NAAQS Designations Monitoring Technical Assistance Document (Draft)," December 2013; and
- "Data Requirements Rule for the 1-Hour Sulfur Dioxide (SO_2) Primary National Ambient Air Quality Standard (NAAQS)," Pre-publication Final rule, August 11, 2015).

As well as:

- "Air Quality Modeling Guidelines, APDG 6232", TCEQ, April, 2015.

The steps that were undertaken by ERM to conduct the air dispersion modeling analyses are summarized below:

- Compiled information on the parameters and characteristics for the main boiler stack emissions at San Miguel;
- Developed a comprehensive receptor grid to capture the maximum off-site impacts from San Miguel sources using AERMAP (v.11103);
- Reviewed regional ambient background monitors to determine the most appropriate ambient background concentration data for SO_2 to represent sources not explicitly included in the modeling runs;
- Developed 3 years (2012-2014) of meteorological data using surface observations from South Texas Regional Airport in Hondo, TX with upper air data from Corpus Christi International Airport in Corpus Christi, TX using the most recent version (v.15181) of AERMET, the meteorological data processor for AERMOD, and its two preprocessors: AERSURFACE (v.13016) and AERMINUTE (v.14237);
- Reviewed all major sources of SO_2 within 50 kilometers of San Miguel for possible inclusion in the cumulative modeling analysis using the 2011 National Emission Inventory Database[3], based on guidance included in the SO_2 Modeling TAD.
- Conducted an air dispersion modeling analysis using the most recent version of EPA's regulatory dispersion model, AERMOD (v.15181) and 3 years (2012-2014) of actual emissions data from San Miguel, consistent with the methodology described in the SO_2 Data Requirements Rule and SO_2 Modeling TAD.
- Summarized the results and compared them with the 1-hour SO2 NAAQS to determine a recommended attainment designation for the vicinity of San Miguel.

3.1 MODEL SELECTION AND APPLICATION

The latest version of USEPA's AERMOD model (v.15181) was used for predicting ambient impacts for 1-hour SO_2. Regulatory default options were used in the analysis. Model predicted impacts were combined with an ambient background concentration and compared to the 1-hour SO_2 NAAQS to determine the recommended attainment status of the area in the vicinity of the facility.

3.2 THE 1-HOUR SO_2 NAAQS

This study focuses on the maximum model-predicted 1-hour SO_2 impacts associated with emissions from San Miguel and compares them to the 1-hour SO_2 NAAQS. The new standard came into effect in August, 2010. The form of the

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[3] http://www.epa.gov/ttnchie1/net/2011inventory.html

standard is the 99th percentile of the 3-year average 1-hour daily maximum concentration, and the standard was set to 75 ppb (196.5 μg/m^3).

3.3 *METEOROLOGICAL DATA*

Guidance for regulatory air quality modeling recommends the use of one year of on-site meteorological data or five years of representative off-site meteorological data. The SO_2 Modeling TAD however, specifies that three years of meteorological data concurrent to the actual emissions data being input into the model be used. Since on-site data are not available for the San Miguel site, meteorological data available from the National Weather Service (NWS) were used in this analysis.

Three years (2012-2014) of surface observations from the NWS tower at South Texas Regional Airport in Hondo, TX (WBAN No. 12962) and concurrent upper air data from Corpus Christi, TX (WBAN No. 12924) were processed with AERMET (v.15181), the meteorological preprocessor for AERMOD, along with the two pre-processors to AERMET: AERSURFACE (v.13016) and AERMINUTE (v.14237). AERMET was applied to create the two meteorological data files required for input to AERMOD.

AERMET requires specification of site characteristics including surface roughness (z_o), albedo (r), and Bowen ratio (B_o). These parameters were developed according to the guidance provided by TCEQ using AERSURFACE. The area within 1 km of the facility was analyzed to determine the surface characteristics around the main stack. AERMET uses the surface characteristics in the sector from which the wind approaches the stack as part of the meteorological data processing for each hour.

In AERSURFACE, the various land cover categories are linked to a set of seasonal surface characteristics. As such, AERSURFACE requires specification of the seasonal category for each month of the year. The following five seasonal categories are offered by AERSURFACE:

1. Midsummer with lush vegetation;
2. Autumn with unharvested cropland;
3. Late autumn after frost and harvest, or winter with no snow;
4. Winter with continuous snow on ground; and
5. Transitional spring with partial green coverage or short annuals.

The AERSURFACE run was performed using the annual temporal resolution option. The seasonal default values were broken down as follows:

- January, December, February: Winter with no snow.
- March, April, May: Transitional spring.
- June, July, August: Midsummer

- September, October, November: Autumn

The precipitation was assigned to "Average" for the purpose of Bowen Ratio calculations during each month.

Additionally, 1-minute ASOS wind data, collected at the South Texas Regional Airport meteorological tower, were processed using the AERMINUTE pre-processor for AERMET. The data characteristics of South Texas Regional Airport are shown in Table 3-1. Figure 3-1 shows the relative location of South Texas Regional Airport and San Miguel, and Figure 3-2 shows the 3-year wind rose for South Texas Regional Airport.

TABLE 3-1: Characteristics of the South Texas Regional Airport Meteorological Data

Distance from San Miguel Station	61.8 miles
Average Wind Speed	4.14 m/s
Percent Calm Hours	1.72%
Data Completeness	98.75%

All files associated with the meteorological data processing are included in Appendix A: The Electronic Modeling Archive.

FIGURE 3-1: Relative Location of San Miguel and South Texas Regional Airport

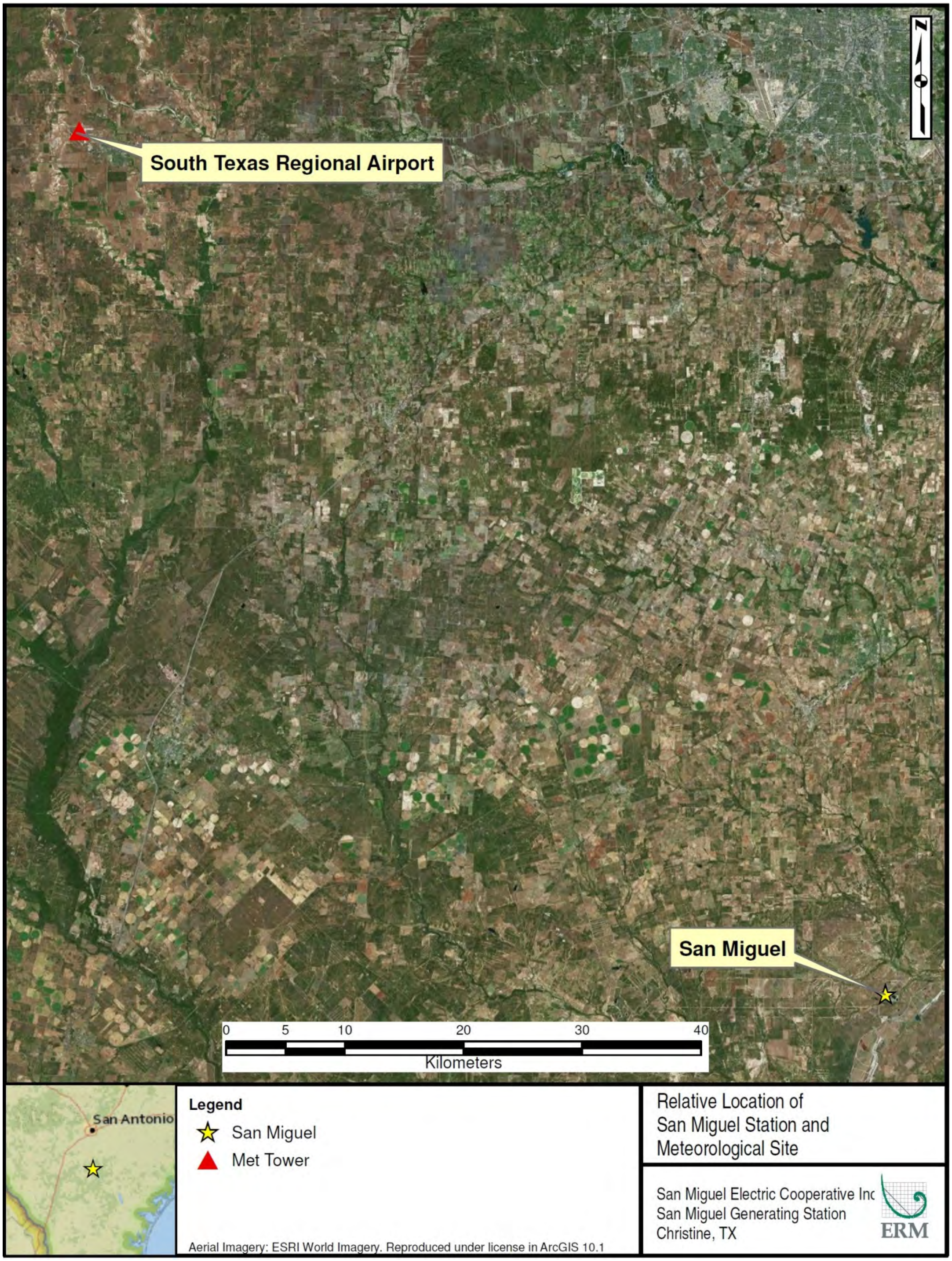


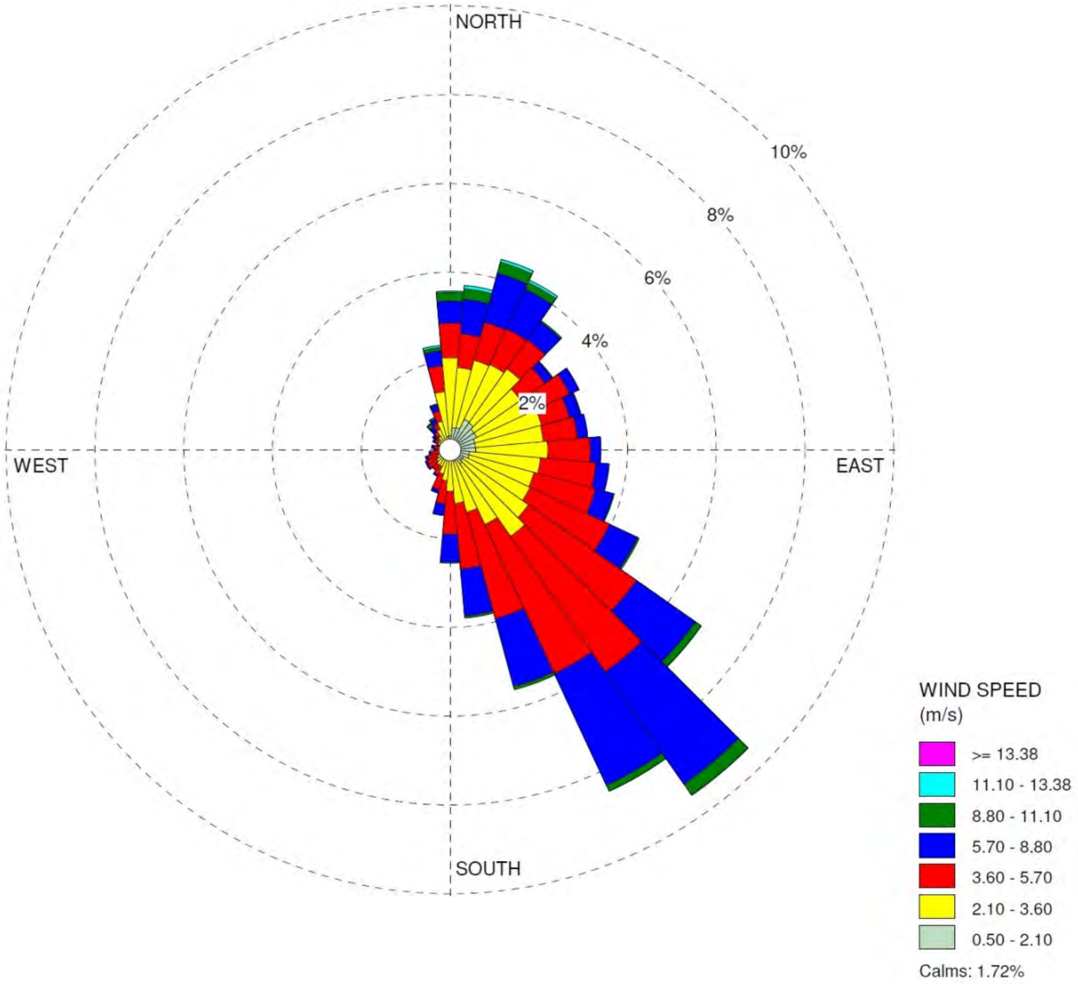
FIGURE 3-2:   Three-year Wind Rose (2012-2014): South Texas Regional Airport

WIND ROSE PLOT:

3-Year WInd Rose: South Texas Regional Airport
2012-2014

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:

Start Date: 1/1/2012 - 00:00
End Date: 12/31/2014 - 23:00

COMPANY NAME:

ERM

MODELER:

Dustin Pittman

CALM WINDS:

1.72%

TOTAL COUNT:

25975 hrs.

AVG. WIND SPEED:

4.14 m/s

DATE:

8/19/2015

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

3.4 *RECEPTOR GRID*

A comprehensive Cartesian receptor grid extending out to approximately 50 kilometers (km) from San Miguel was used in the AERMOD modeling analysis to assess maximum ground-level 1-hour SO_2 concentrations. The SO_2 Modeling TAD states that the receptor grid must be sufficient to determine ambient air quality in the vicinity of the source being studied. The 50-kilometer receptor grid is more than sufficient to resolve the maximum 1-hour SO_2 impacts, and it clearly illustrates decreasing SO_2 concentration gradients in relation to the plant in all directions out to the edge of the grid.

The Cartesian receptor grid consisted of the following receptor spacing:

- 25-meter spacing along the facility fence line;
- 25-meter spacing extending from the fence line to 300 meters;
- 100-meter spacing extending from 300 meters to 1 kilometers;
- 500-meter spacing extending from 1 to 5 kilometers; and
- 1,000-meter spacing extending from 5 to 50 kilometers.

The above receptor data was used without modification in the modeling. Per the SO_2 Modeling TAD, a number of receptors located over the Choke Canyon Reservoir could have been excluded from the modeling domain because ambient monitors could not reasonably be placed at these locations, but these receptors were retained in this analysis as a measure of conservatism.

Terrain elevations from National Elevation Data ("NED") from USGS were processed using the most recent version of AERMAP (v.11103) to develop the receptor terrain elevations required by AERMOD. NED data files contain profiles of terrain elevations, which in conjunction with receptor locations are used to generate receptor height scales. The height scale is the terrain elevation in the vicinity of a receptor that has the greatest influence on dispersion at that location and is used for model computations in complex terrain areas. The near-field (within 5 kilometers) and far-field (full 50 km grid) receptor grids are shown in Figures 3-3 and 3-4, respectively.

3.5 GOOD ENGINEERING PRACTICE STACK HEIGHT ANALYSIS

Good engineering practice ("GEP") stack height is defined as the stack height necessary to ensure that emissions from the stack do not result in excessive concentrations of any air pollutant as a result of atmospheric downwash, wakes, or eddy effects created by the source, nearby structures, or terrain features.

A GEP stack height analysis was performed for the Boiler Stack using the Building Profile Input Program (BPIP) in accordance with USEPA's guidelines (USEPA 1985). Per the guidelines, the physical GEP height, (H_{GEP}), is determined from the dimensions of all buildings which are within the region of influence using the following equations, depending on the construction data of the stack:
For stacks in existence on January 12, 1979 and for which the owner or operator had obtained all applicable permits or approvals required,
$H_{GEP} = 2.5H$,
provided the owner or operator produces evidence that this equation was actually relied on in establishing an emission limitation;
For all other stacks:

HGEP = H + 1.5L

where:

H = height of the structure within 5L of the stack which maximizes H_{GEP}; and

L = lesser dimension (height or projected width) of the structure.

For a squat structure, i.e., height less than projected width, the formula reduces to:

$$H_{GEP} = 2.5H$$

In the absence of influencing structures, a "default" GEP stack height is creditable up to 65 meters (213 feet).

A summary of the GEP stack height analyses is presented in Table 3-2. As described in the SO_2 Modeling TAD, when modeling actual emissions in order to determine the attainment status of the facility when compared to the 1-hour SO_2 NAAQS, the full height of all stacks is allowed in the modeling regardless of their GEP Formula Heights. Since the San Miguel stack does not exceed GEP, the SO_2 Modeling TAD guidance did not alter the allowable modeled height of the stack; the stack was modeled with its actual stack height in the analysis. The heights and locations of all structures included in the GEP analysis, as well as the main stack, are shown in Figure 3-5.

FIGURE 3-3: Near-Field Model Receptors

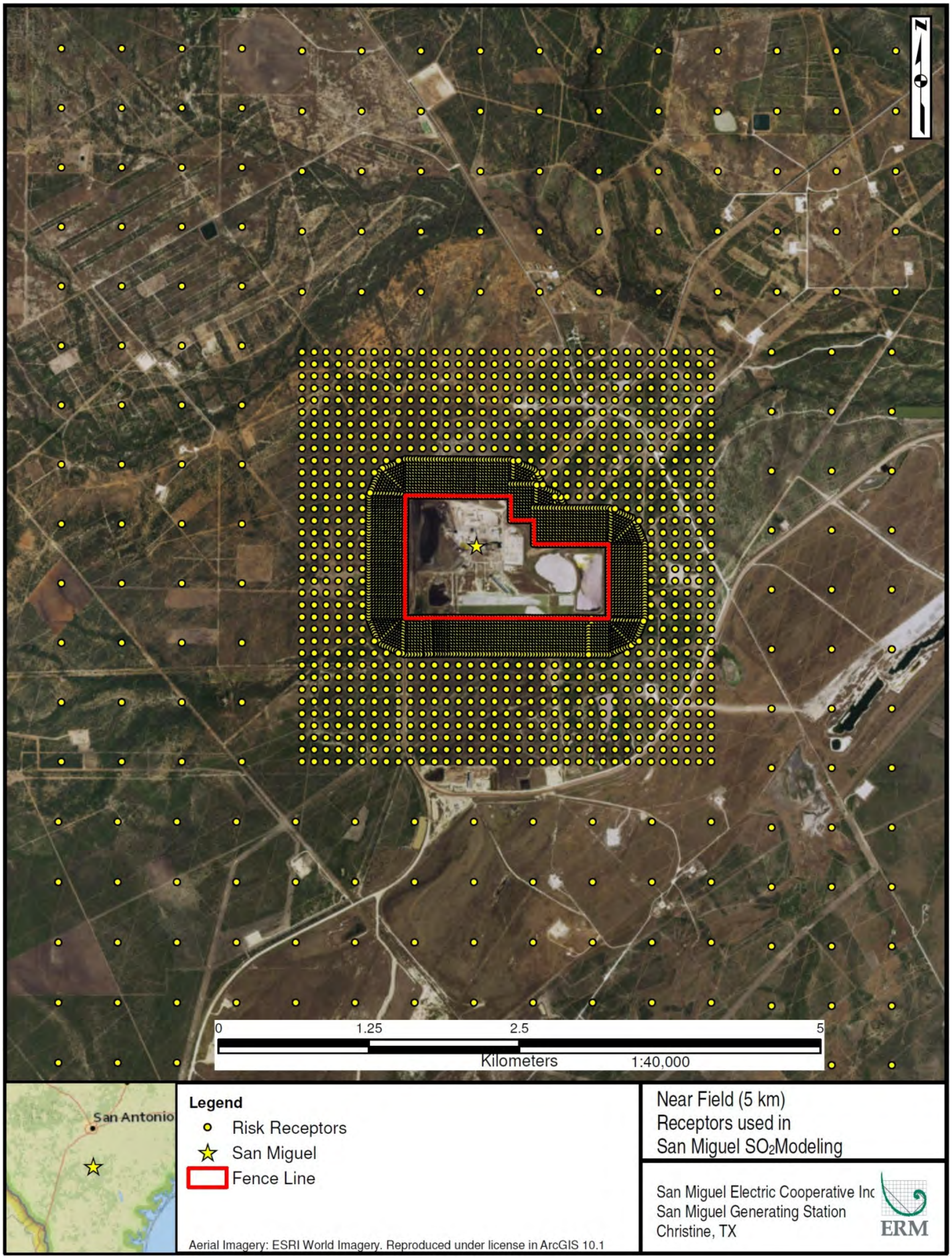


FIGURE 3-4: Far-Field Model Receptors

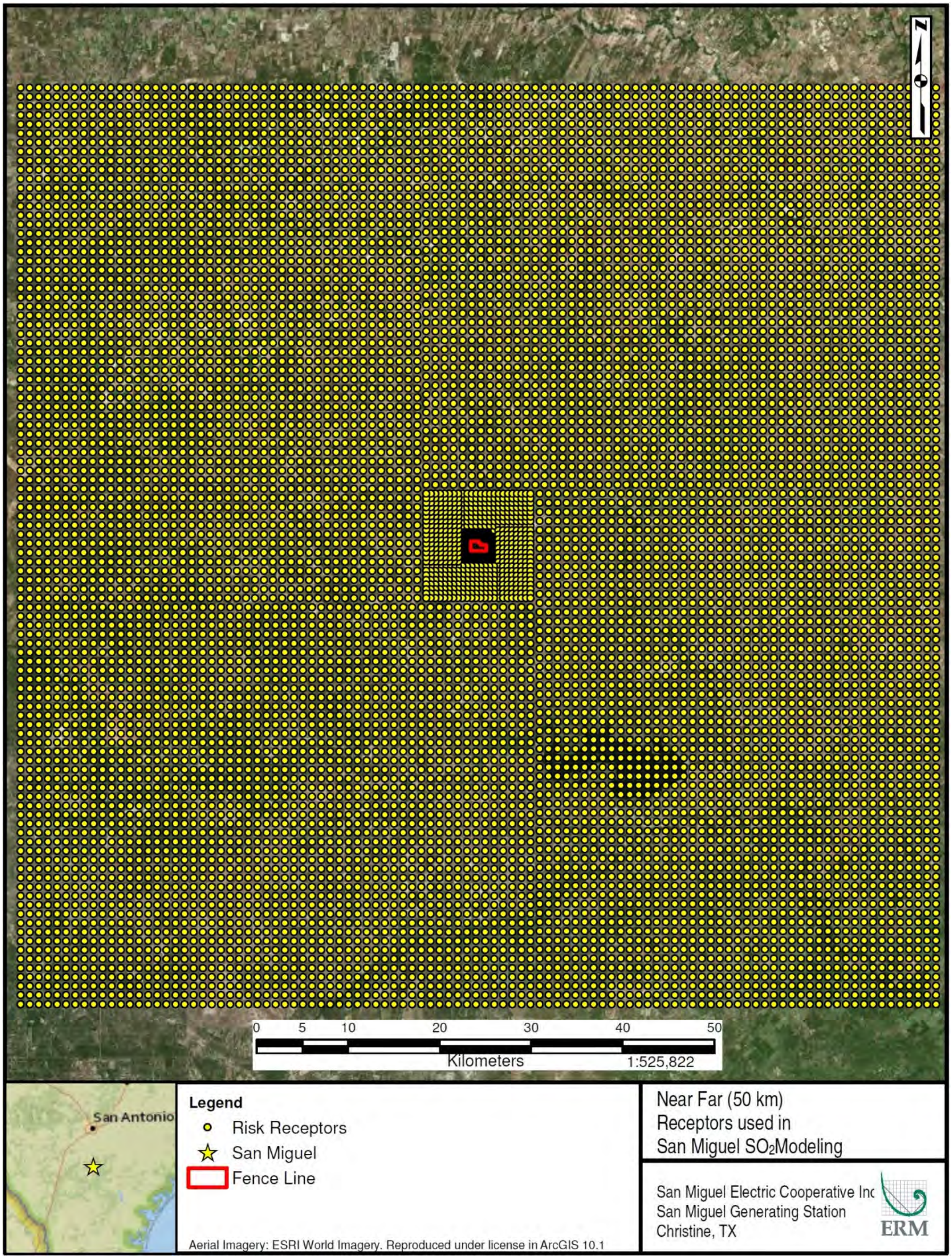
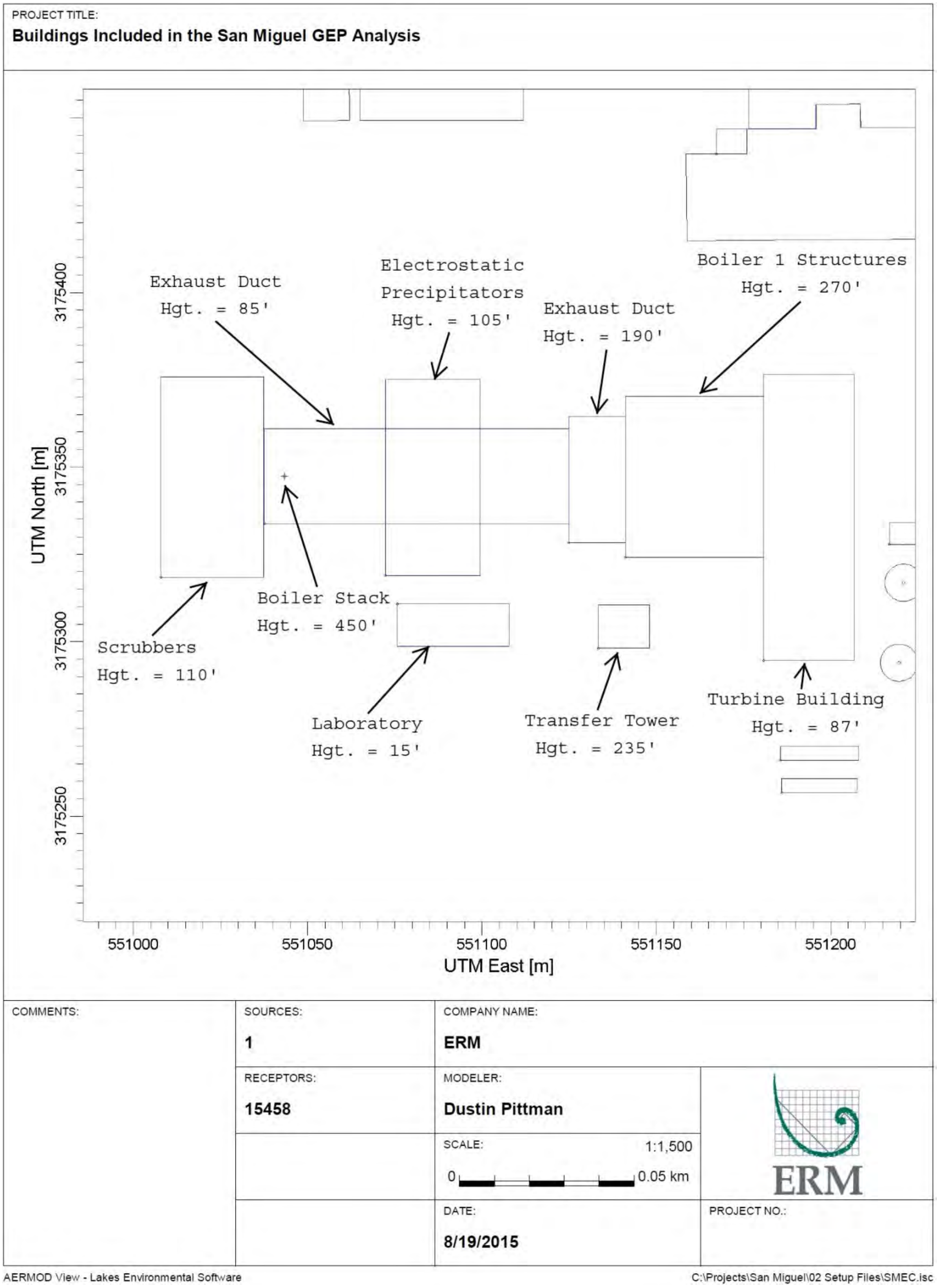


FIGURE 3-5: Structures Included in the San Miguel GEP Analysis


PROJECT TITLE:
Buildings Included in the San Miguel GEP Analysis

COMMENTS:

SOURCES:
1

COMPANY NAME:
ERM

RECEPTORS:
15458

MODELER:
Dustin Pittman

SCALE: 1:1,500
0 0.05 km

DATE:
8/19/2015

PROJECT NO.:

AERMOD View - Lakes Environmental Software
C:\Projects\San Miguel\02 Setup Files\SMEC.isc

TABLE 3-2: Summary of San Miguel Station GEP Analysis

Emission Source	*Stack Height (m)*	*Controlling Buildings / Structures*	*Building Height (m)*	*Projected Width (m)*	*GEP Formula Height (m)*
STACK	137.16	Boiler 1 Structures	82.30	46.08	151.42

3.6 AMBIENT SO_2 BACKGROUND DATA FOR CUMULATIVE MODELING

In addition to assessing impacts from the San Miguel stack, the impact from other sources of SO_2 in the region was considered in order to demonstrate that the air quality in the region is in attainment with the NAAQS. In order to account for other sources of SO_2 in the area an ambient background concentration was added to model-predicted impacts from San Miguel for comparison to
the NAAQS.

The criteria for determining the monitor best suited to characterize air quality at a given location include:

- Stations with similar influencing SO_2 sources as the source being modeled (not necessarily the closest).
- Avoid stations influenced by the source being modeled to prevent double-counting impacts.
- Avoid stations influenced by sources not likely to interact with the source being modeled.
- Consider predicted concentration patterns for source being modeled, along with wind frequency, to assist in selection.

FIGURE shows the location of the ambient monitors in the vicinity of San Miguel, as well as the location of all other SO_2 sources in the region that emitted more than 2,000 tons of SO_2 according to the 2011 EPA National Emissions Inventory. The figure shows that there are no sources that emitted over 2,000 tons of SO_2 in 2011 within 50 km. of San Miguel. Additionally, all of the monitors sited in the region are located to the north of San Miguel, approaching the San Antonio area, or farther to the north of San Antonio, approaching the Waco area.

ERM evaluated 3 monitors to determine their representativeness: Calaveras Lake (Monitor ID# 48-029-0059) to the north of San Miguel, Heritage Middle School (Monitor ID# 48-029-0622), located north of San Miguel, and Waco (Monitor ID# 48-309-1037), located northeast of San Miguel.

The first monitor evaluated was the Calaveras Lake (CAMS 59) monitor. This monitor is the closest to San Miguel in terms of proximity, located 65.4 km to the north northeast. A review of the most recent (2012-2014) years of hourly concentrations at the monitor vs. the wind direction at the time the concentration was reported, shown in Figure 3-6, shows that virtually all of the highest concentrations at the monitor occur when the wind is blowing from the direction of the Calaveras Power Plant (CPS Plant) towards the monitor.

The Calaveras Lake monitor is strongly influenced by impacts north of the monitor, specifically CPS Plant, which is the opposite direction of San Miguel to the monitor. The CPS Plant is much closer to the monitor than it is to San Miguel and therefore is having a greater impact on the monitor than any source in the vicinity of San Miguel would have. Thus, the monitor is not useful to represent non-facility related impacts in the region and would grossly overestimate San Miguel's contribution to the regional ambient air quality.

FIGURE 3-6: SO_2 Sources and Monitors in the Region

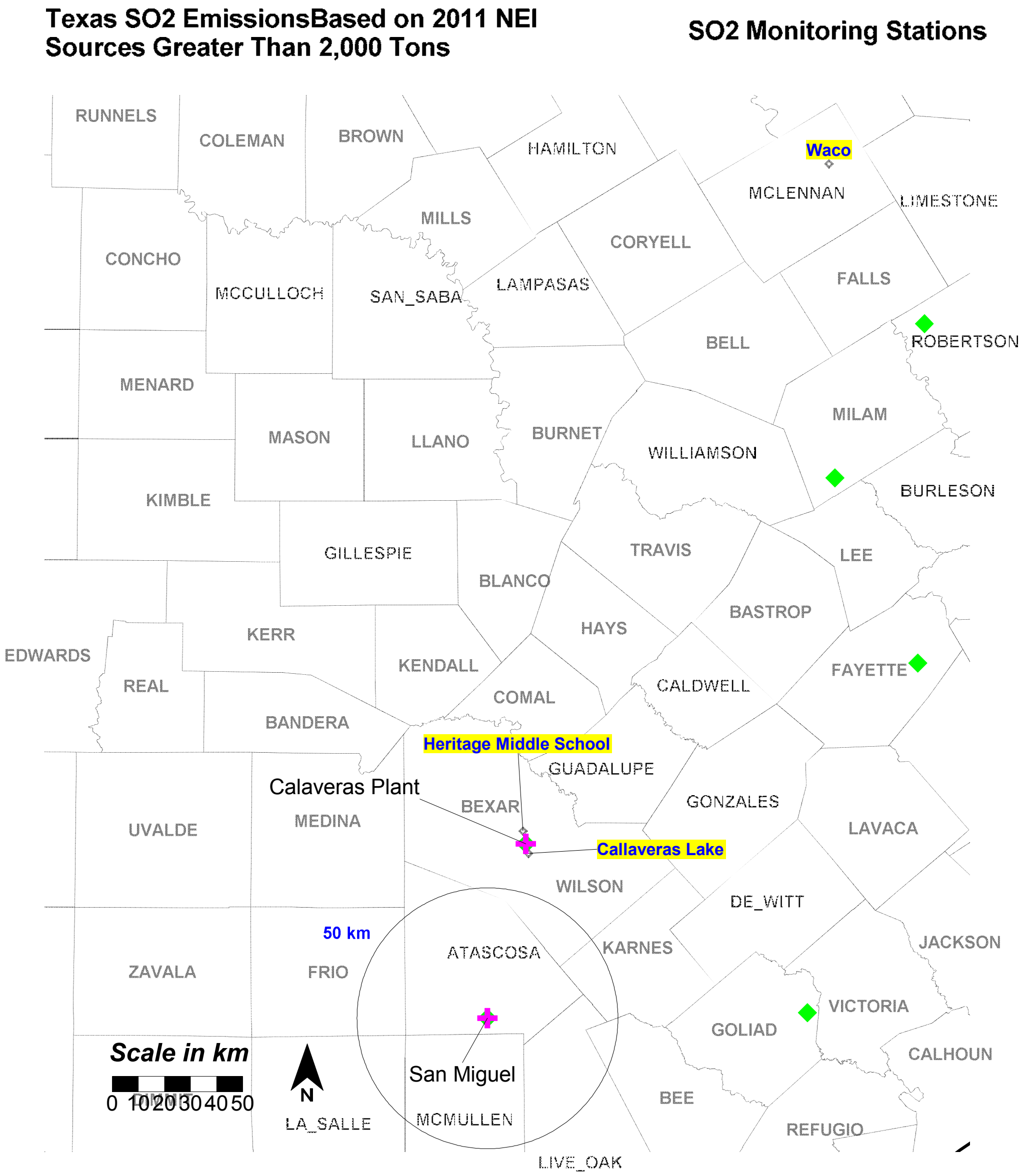
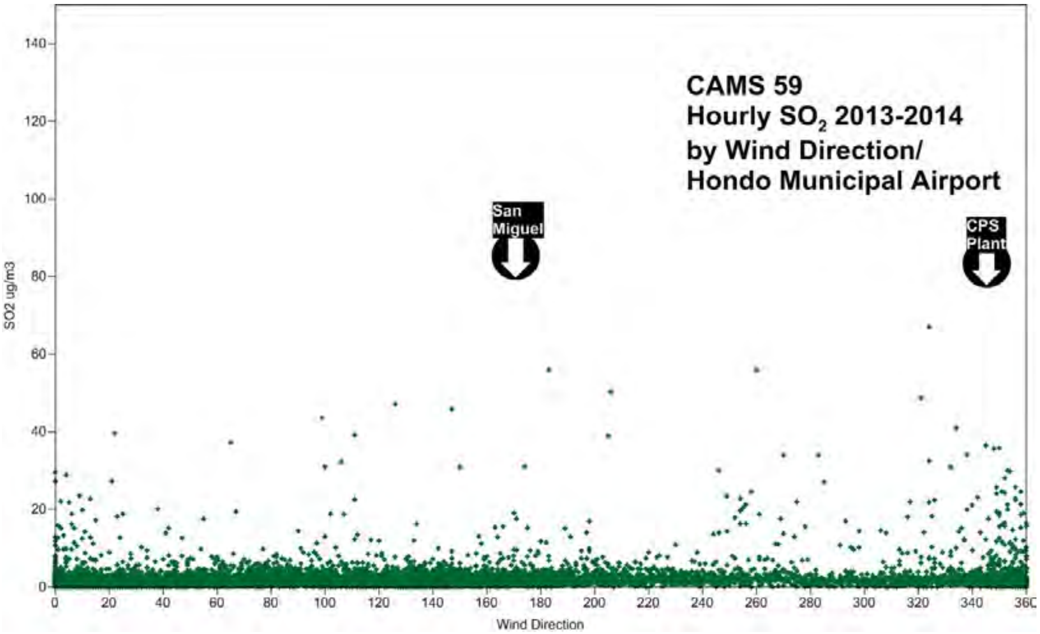


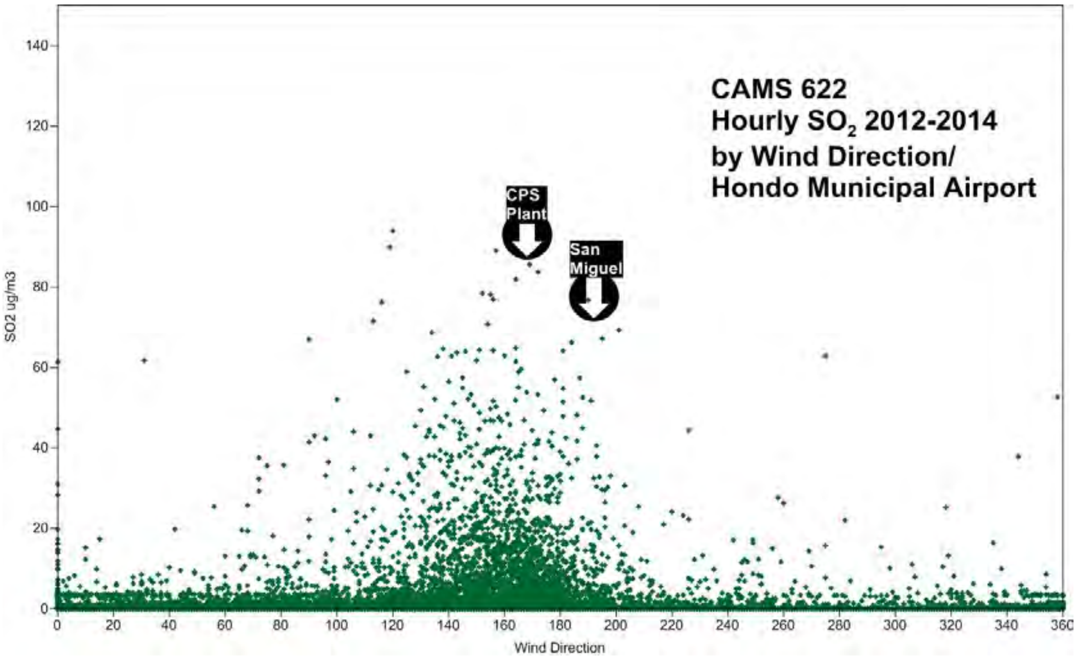
FIGURE 3-7: SO_2 Concentration vs. Wind Direction at Calaveras Lake Monitor



The second monitor evaluated was the Heritage Middle School (CAMS 622) monitor. This monitor is north northwest of the Calaveras Lake monitor and located 73.3 km to the north northeast of San Miguel. A review of the most recent (2012-2014) years of hourly concentrations at the monitor vs. the wind direction at the time the concentration was reported, presented in Figure 3-8, shows that virtually all of the highest concentrations at the monitor occur when the wind is blowing from the direction of CPS Plant towards the monitor, similar to the Calaveras Lake monitor.

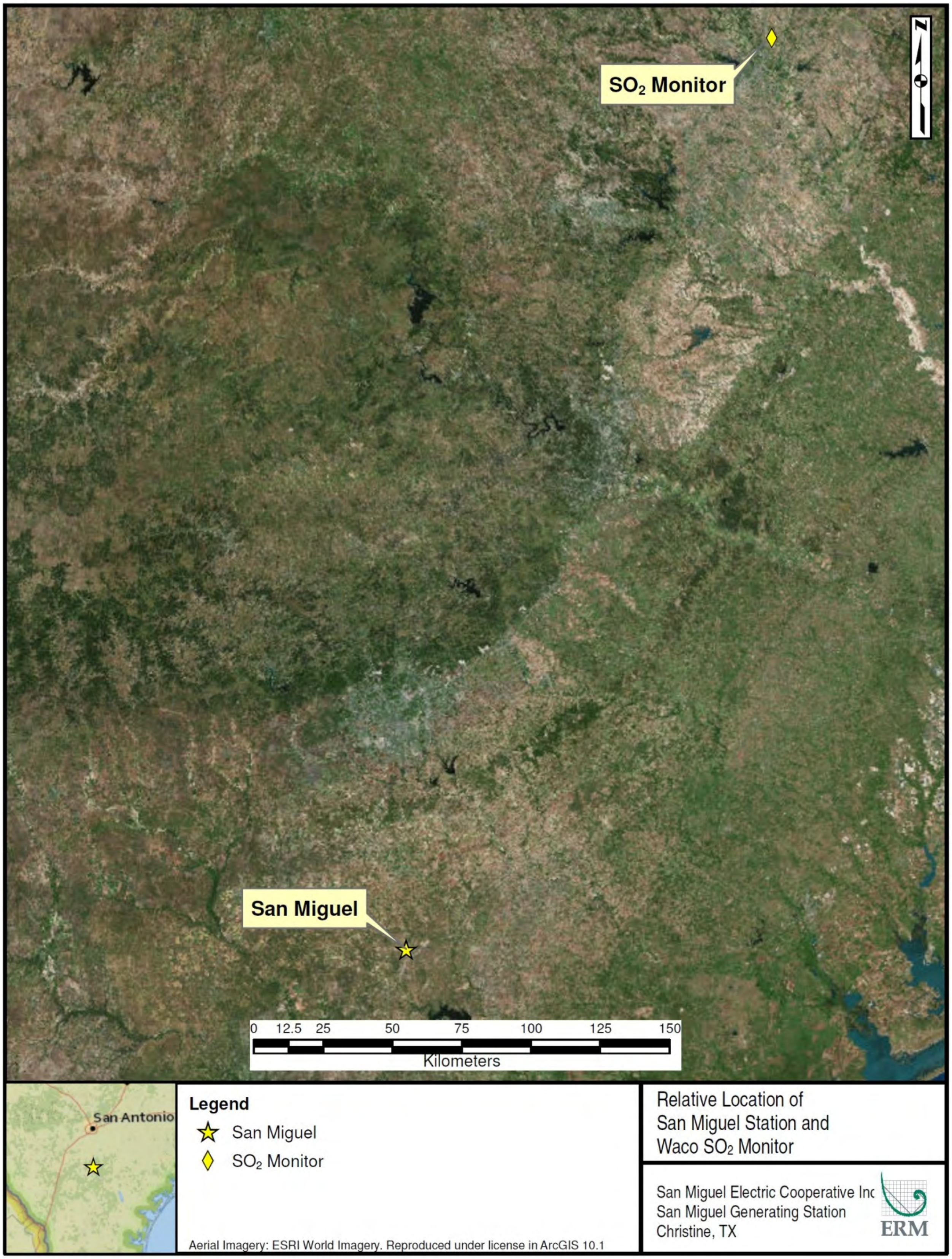
The Heritage Middle School monitor is strongly influenced by impacts south of the monitor, specifically CPS Plant as shown in Figure 3-7. The CPS Plant is much closer to the monitor than it is to San Miguel and therefore CPS has a greater impact on the monitor than any source in the vicinity of San Miguel would have. Thus, the monitor is not useful to represent non-facility related (background) impacts in the region around San Miguel.

FIGURE 3-8: SO₂ Concentration vs. Wind Direction at Heritage Middle School Monitor



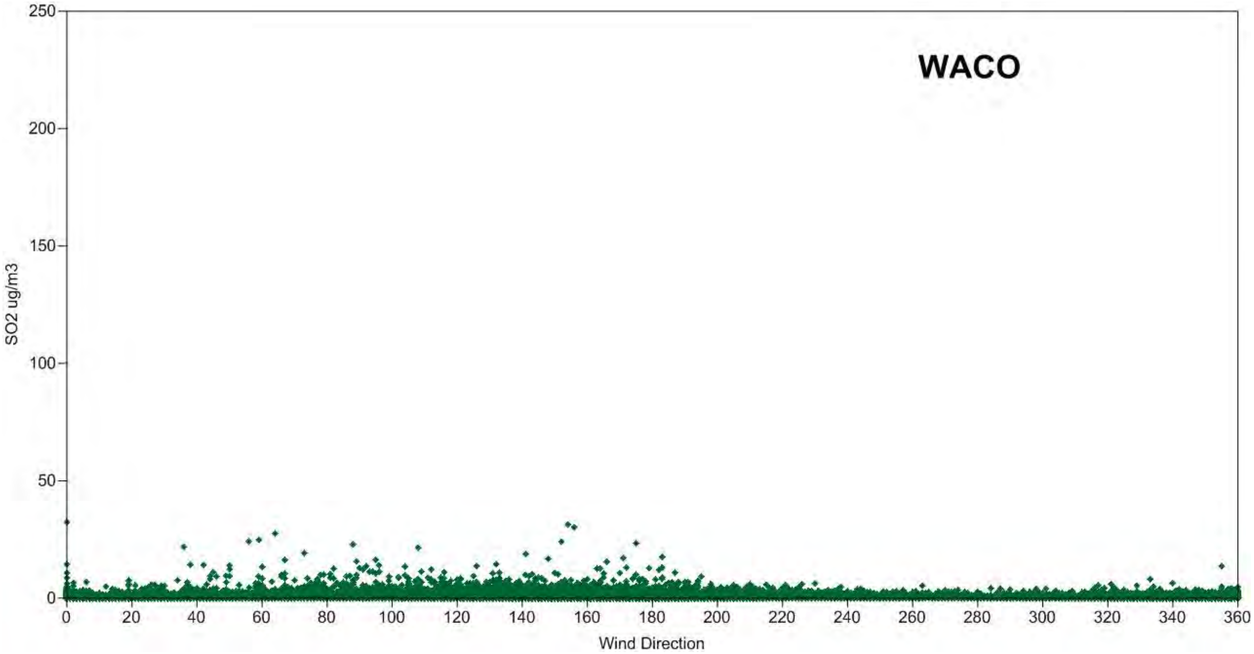
The final monitor reviewed was the Waco (CAMS 1037) monitor, located 354.6 km northeast of San Miguel as shown in Figure 3-8, and oriented in a downwind direction from San Miguel such that impacts from San Miguel itself are no longer noteworthy. As shown in Figure 3-9, the concentrations recorded at the monitor do not appear to be highly influenced by any large sources, as would be the case near San Miguel, and the CPS Plant slightly over 50 km from San Miguel.

FIGURE 3-9: Relative Location of San Miguel Station and Waco Monitor



Aerial Imagery: ESRI World Imagery. Reproduced under license in ArcGIS 10.1

FIGURE 3-10: SO_2 Concentration vs. Wind Direction at Waco Monitor



Sources that do not meet the 2,000 tons/year level were also considered. The TAD recommends that smaller sources be reviewed to determine the total magnitude of emissions and whether the smaller sources can be considered to be accounted for by background concentrations and whether they are clustered in areas where collectively the total magnitude may reach or exceed the 2,000 ton level.

TABLE ***3-3*** provides a summary of the total SO_2 emissions within certain distance ranges of San Miguel, and a summary of the total SO_2 emissions within certain distance ranges of the monitors discussed above. Based on this analysis, the Waco monitor most closely matches the SO_2 emissions in the area around San Miguel.

TABLE 3-3: Comparison of SO_2 Emissions near San Miguel and Monitors

Site	***SO_2 tpy (NEI 2011) within:***		
	0-10 km	***10-25 km***	***25-50 km***
San Miguel	0.0	0.0	787.0
Calaveras Lake	23,269.0	9.0	1,213.0
Heritage Middle School	23,246.0	719.0	532.0
Waco Mazanec	0.0	1,020.0	387.0

Lastly, in the initial screening modeling for San Miguel the highest impacts were to the north and northwest of the plant. Thus any interaction with other sources during these events would have to come from the south and southeast of San Miguel, and the Waco monitor is more representative than Lake Calaveras in representing ambient impacts coming from that direction. The Heritage Middle School monitor was also considered, but the monitor is heavily impacted by the CPS Plant which is greater than 50 km away from San Miguel and the pattern of SO_2 emissions is less similar to that of San Miguel than Waco. For all of the reasons described here, Waco was chosen as the monitor most representative of the ambient air quality in the area around San Miguel.

EPA guidance allows the use of background values that vary by season and hour of day. Combining background values that vary by season and hour of day with model predicted values, which also are variable, reduces the overly conservative approach of adding two maximum values together regardless of the time they occurred.

The modeling was performed with a set of seasonal diurnal values developed using the methodology described in the USEPA March 1st, 2011 Clarification Memorandum for 1-hour NO_2 Modeling. Though this memorandum primarily addresses NO_2 modeling, page 20 describes the process for developing seasonal diurnal background values for SO_2 as well. The seasonal diurnal values that were used in the modeling are shown on the next page in Table 3-4.

3.7 REVIEW OF NON-FACILITY SOURCES FOR CUMULATIVE INVENTORY

Section 4.1 of the SO_2 Modeling TAD discusses the criteria for the addition of major SO_2 sources in the region for cumulative modeling purposes when determining the recommended attainment status of the area surrounding a facility as described in the 1-hour SO_2 Data Requirements Rule. The TAD describes sources that should be included in the modeling as those expected to have an impact on the air quality in the vicinity of the source being studied, in this case San Miguel. Additionally, the TAD states that except in cases where numerous smaller sources are close together in the study area, consideration of sources to include should begin at sources with emissions in excess of the threshold selected in the Data Requirements Rule (2,000 tpy).

The 2011 EPA National Emissions Inventories (NEI) was reviewed to determine candidate major sources. For the purpose of this study, all major sources of SO_2 within 50 kilometers of San Miguel that had at least 2,000 tons of SO_2 emissions were considered for inclusion in the modeling. No facilities within 50 kilometers were found to have emitted at least 2,000 tons of SO_2 in 2011. In fact, the only source with greater than 100 tons of SO_2 within 50 km of San Miguel was Pawnee Gas Plant, located 48.6 km away in Pawnee, TX, with 480 tons. Pawnee Gas Plant was not explicitly included in the modeling for the following reasons:

- Pawnee Gas Plant had emissions far lower than that of the SO_2 Data Requirements Rule threshold.

TABLE 3-4: *Seasonal Diurnal Ambient SO_2 Concentrations (μg/m³)*

Hour[1]	*Winter*	*Spring*	*Summer*	*Fall*
1	3.05	3.23	3.40	4.80
2	2.70	2.88	3.75	9.60
3	2.97	2.97	3.32	9.07
4	1.83	1.66	2.36	2.53
5	2.18	1.40	2.36	2.70
6	1.92	1.48	2.01	3.23
7	1.83	1.40	1.83	2.62
8	2.70	2.09	4.19	3.75
9	4.01	4.19	7.33	7.77
10	11.34	5.32	6.54	13.44
11	13.26	3.40	4.80	9.07
12	12.74	3.14	5.24	7.68
13	12.13	4.28	5.06	8.99
14	7.07	4.01	4.01	7.15
15	8.73	4.19	3.66	7.33
16	8.64	3.75	4.10	6.81
17	6.81	3.66	3.40	7.07
18	7.77	3.49	3.75	6.81
19	4.54	6.63	4.80	9.34
20	4.54	6.63	4.80	9.34
21	4.54	4.45	8.81	7.33
22	3.05	4.89	6.02	6.20
23	3.75	5.93	4.36	5.50
24	2.88	3.58	3.66	8.46

1. Hours in AERMOD are defined as hour-ending. i.e., Hour 1 is the period from midnight through 1 AM, etc.

- The March 1st, 2011 EPA clarification memorandum for modeling NO_2 and SO_2[4] states that "Even accounting for some terrain influences on the location and gradients of maximum 1-hour concentrations, these considerations suggest that the emphasis on determining which nearby sources to include in the modeling analysis should focus on the area within about 10 kilometers of the project location in most cases…" Pawnee Gas Plant is more than 4 times that distance from San Miguel.

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[4] http://www.epa.gov/scram001/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf

- The relative locations of the facilities: Wind blowing from San Miguel to Pawnee Gas Plant is on a bearing of 100 degrees, while wind blowing from Pawnee Gas Plant to San Miguel would be on a bearing of 281 degrees. A review of the 3 years of wind data (2012-2014) used in the modeling shows that the wind blows between the two facilities only about 4 percent of the time, and of that 4 percent none of the hours during the 3 years of data had sufficient wind speed (13.4 m/s) to carry a plume from one facility to the other in one hour.
- The concentration gradient from San Miguel impacts drops sharply to the east of the facility (See Figure 4-1), such that the impacts from San Miguel would not be expected to interact with those from Pawnee Gas Plant.
- The Waco ambient monitor was shown to be conservative in Section 3.6

Therefore, no other facilities were explicitly included in the modeling, but instead the appropriate seasonal diurnal ambient concentration from the Waco monitor was added to the impacts from San Miguel to represent other sources in the area.

4.1 MODELING RESULTS

4.2 MODELING RESULTS FOR ACTUAL EMISSIONS

The design value represents the modeled 3-year average of the 99th percentile, maximum daily 1-hour average impact. Design values for both San Miguel alone and for San Miguel combined with monitored background values are presented in Table 4-1.

TABLE 4-1: 1-hour SO2 Modeling Results for San Miguel with Actual Emissions

Source	*San Miguel Only*	*San Miguel and Background*	*1-hr. SO_2 NAAQS*	*Below NAAQS?*
San Miguel	110.3	122.2	196.5	Yes

Contours of the predicted impacts, as well as the location of the maximum predicted impact of 122.6 µg/m^3, are shown in Figure 4-1. The table shows that model predicted impacts from San Miguel, when modeled using the most recent three years of actual emissions data and added to representative ambient background concentrations, are below the level of the 1-hour SO_2 NAAQS.

4.3 MODELING RESULTS FOR MSS EMISSIONS

The modeling results when the MSS emission rate is assumed throughout the modeling period are shown in Table 4-3 below. The design value represents the modeled 3-year average of the 99th percentile, maximum daily 1-hour average impact. Design values for both San Miguel alone and for San Miguel combined with monitored background values are presented in Table 4-2.

TABLE 4-2: 1-hour SO2 Modeling Results for San Miguel with MSS Emissions

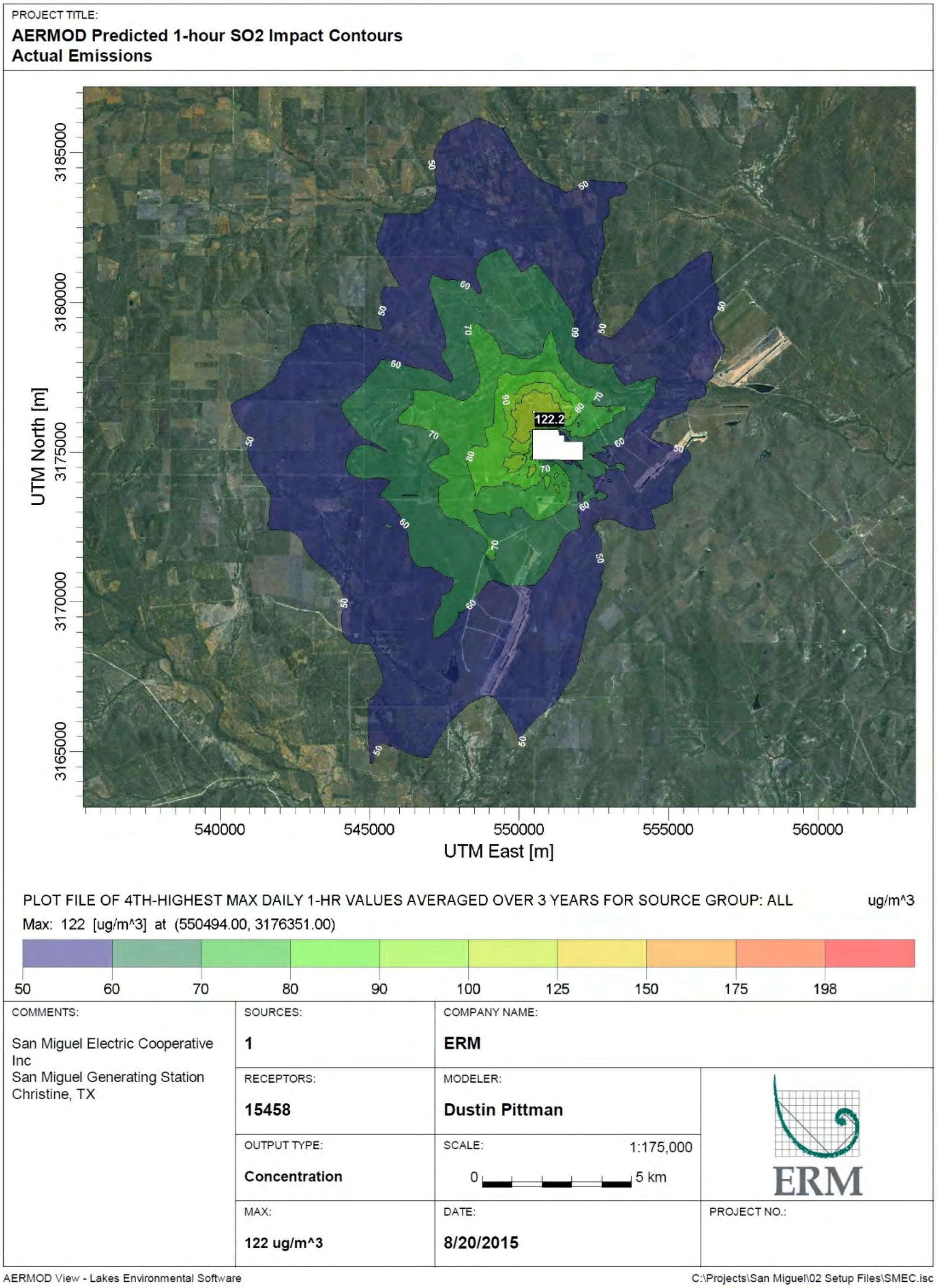
Source	*San Miguel Only*	*San Miguel and Background*	*1-hr. SO_2 NAAQS*	*Below NAAQS?*
San Miguel	168.8	174.5	196.5	Yes

Contours of the predicted impacts, as well as the location of the maximum predicted impact of 174.0 µg/m^3, are shown in Figure 4-2. The table shows that model predicted impacts from San Miguel, when modeled using the most recent three years of MSS emissions data and added to representative ambient background concentrations, are below the level of the 1-hour SO_2 NAAQS.

4.4 CONCLUSIONS

The air dispersion modeling performed as described in this report shows that the SO_2 emissions from **San Miguel's Electric Generating Unit when combined with representative background concentrations result in maximum predicted impacts within the 1-hour SO_2 National Ambient Air Quality Standard.** Therefore, an attainment designation for Atascosa County and the surrounding area is recommended.

FIGURE 4-1: San Miguel Station Actual Emissions 1-hour SO_2 Impact Contours



PROJECT TITLE:

AERMOD Predicted 1-hour SO2 Impact Contours
Actual Emissions

PLOT FILE OF 4TH-HIGHEST MAX DAILY 1-HR VALUES AVERAGED OVER 3 YEARS FOR SOURCE GROUP: ALL

Max: 122 [ug/m^3] at (550494.00, 3176351.00)

COMMENTS:
San Miguel Electric Cooperative Inc
San Miguel Generating Station
Christine, TX

SOURCES: **1**

COMPANY NAME: **ERM**

RECEPTORS: **15458**

MODELER: **Dustin Pittman**

OUTPUT TYPE: **Concentration**

SCALE: 1:175,000

MAX: **122 ug/m^3**

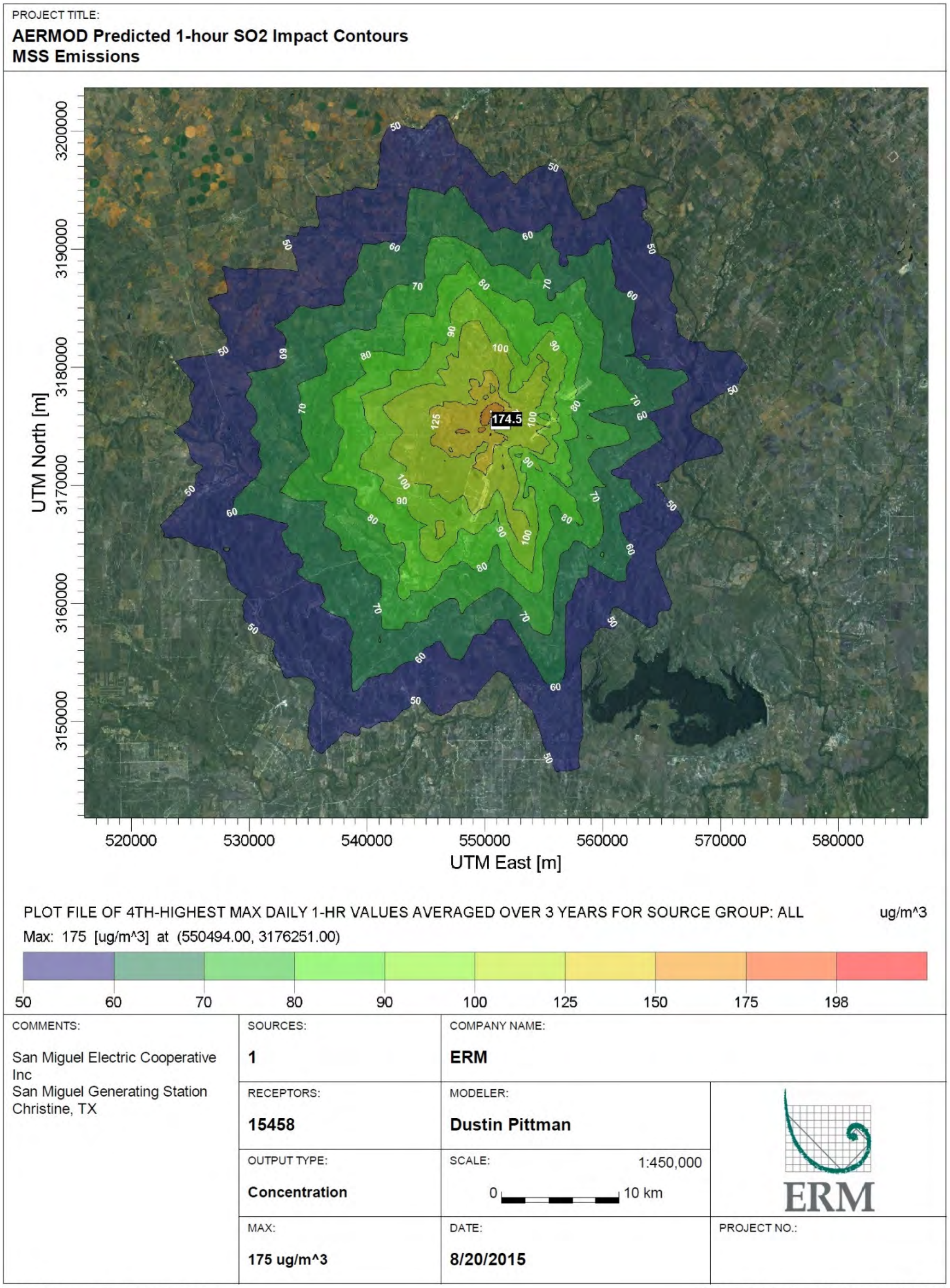
DATE: **8/20/2015**

PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Projects\San Miguel\02 Setup Files\SMEC.isc

FIGURE 4-2: San Miguel Station MSS Emissions 1-hour SO_2 Impact Contours



PROJECT TITLE:

AERMOD Predicted 1-hour SO2 Impact Contours
MSS Emissions

PLOT FILE OF 4TH-HIGHEST MAX DAILY 1-HR VALUES AVERAGED OVER 3 YEARS FOR SOURCE GROUP: ALL

Max: 175 [ug/m^3] at (550494.00, 3176251.00)

COMMENTS:
San Miguel Electric Cooperative Inc
San Miguel Generating Station
Christine, TX

SOURCES: **1**

COMPANY NAME: **ERM**

RECEPTORS: **15458**

MODELER: **Dustin Pittman**

OUTPUT TYPE: **Concentration**

SCALE: 1:450,000 0 10 km

MAX: **175 ug/m^3**

DATE: **8/20/2015**

PROJECT NO.:

ERM

AERMOD View - Lakes Environmental Software

C:\Projects\San Miguel\02 Setup Files\SMEC.isc

5.0 REFERENCES

U.S. Environmental Protection Agency. (USEPA 2005) Guideline on Air Quality Models (GAQM, 40CFR Appendix W), November, 2005

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U.S. Environmental Protection Agency. (USEPA 2014) "SO_2 NAAQS Designations Modeling Technical Assistance Document (Draft)," December 2013;

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Texas Commission on Environmental Quality (TCEQ 2015) "Air Quality Modeling Guidelines, APDG 6232", April, 2015.

Electronic Modeling Archive

Appendix A