Tucson Electric Power Company Irvington (Sundt) Generating Station: Air Quality Dispersion Modeling Protocol

Tucson Electric Power Company

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1. Introduction

1.1 Project Overview

The Tucson Electric Power Company ("TEP") owns and operates the Irvington Generating Station ("IGS"), also known as the H. Wilson Sundt Generating Station, pursuant to Class I Air Quality Permit No. 1052 issued by the Pima County Dept. of Environmental Quality ("PDEQ"). The facility currently comprises six electric generating units with a combined, nominal, net generating capacity of 470 megawatts ("MW").

TEP is requesting a revision to the Class I permit for the IGS, an authorization pursuant to the preconstruction Prevention of Significant Deterioration ("PSD") permitting regulations to expand the IGS, and an approval of construction of new affected sources under federal National Emissions Standards for Hazardous Air Pollutants ("NESHAP"). As part of the proposed expansion project, TEP proposes to install up to ten natural gas-fired, reciprocating internal combustion engines ("RICE"), each with a nominal net generating capacity of 19 MW. In conjunction with the RICE project, TEP will permanently cease operation of Units 1 and 2 at IGS, leaving the facility with a nominal, net generating capacity of 498 MW.

The proposed RICE project will modernize and expand the IGS by replacing two 1950's era electric utility steam generating units (IGS Unit 1 and 2) with ten high-efficiency, fast-responding, state-of-the-art RICE, each having a generating capacity of 19 MW (nominal). TEP's basic purpose and fundamental objective for the RICE project is to meet a critical need in its resource portfolio: reliable, efficient, grid-balancing resources which can ramp up quickly and provide 100 percent of their effective load carrying capability (ELCC) during multiple peak periods of any length. In conjunction with Energy Storage Systems (ESS) projects and other efforts described in the 2017 Integrated Resource Plan (IRP), the RICE project will support the integration of renewable resources, consistent with TEP's 30 percent target by 2030. Tangential benefits of the proposed RICE project include anticipated reductions in the capacity factors of the less-efficient steam generating units at IGS and improved overall environmental performance, including decreased water usage and wastewater discharge.

1.2 Purpose of Modeling Protocol

The purpose of this document is to present the proposed methodology for air dispersion modeling analyses that will be performed in support of the air permit application for the RICE project. Modeling methods and assumptions, including model selection and options, meteorological data and source parameters to be used in the modeling analyses, are presented in this document for review and approval by Pima County Department of Environmental Quality (PDEQ). PDEQ does not have their own dispersion modeling guidelines. PDEQ has informed TEP that they will defer to the United States Environmental Protection Agency's (EPA's) Appendix W.

1.3 Contents of the Modeling Protocol

Section 2 of this protocol document contains a project description, including information regarding the equipment, location and the expected air pollutant emissions. Sections 3 through 5 present a detailed

description of the modeling approach proposed to be used in evaluating air quality impacts of the proposed IGS project including model selection criteria, good engineering practice stack height determination, refined modeling analyses, ambient air quality compliance, and additional impacts analyses. Section 6 presents the description of the results analysis that will be submitted to PDEQ in support of the PSD permit application.

2. Project Description

2.1 Project Location and Layout

The proposed RICE project will be constructed at the existing IGS located in Tucson, Arizona, approximately 2 miles northeast of Tucson International Airport. The coordinates of the IGS are 509,448.00 meters Easting, 3,557,910.00 meters Northing in Universal Transverse Mercator (UTM) Zone 12 referenced to NAD 83. An aerial map of the site region is provided in **Figure 2-1**. This figure shows the project location, which is located only about 450 meters from existing units at the plant.

The terrain surrounding IGS is generally flat within 10 kilometers before the landscape changes with the addition of rolling hills, rugged canyons and mountain peaks. **Figure 2-2** shows the varying elevations associated with these features near IGS.

2.2 Description of the Proposed Engines

The proposed modification at IGS includes the installation of ten RICEs, each with a nominal net generating capacity of 19 MW. These engines will only be fired with natural gas. The ten engines will be grouped into two sets of five engines as shown in **Figure 2-3**. The five stacks from each group will be modeled as two sets of merged stacks; one merged stack that combines 3 RICE stacks with a separation less than one stack diameter from each other, and a second merged stack that combines the remaining 2 RICE stacks (with a separation less than one stack diameter; as depicted in **Figure 2-4**) in the group of 5 RICEs. This method is consistent with EPA Model Clearinghouse Memo 91-II-01[1], creating the appearance of four new stacks at IGS. In consultation with the reviewing agencies, EPA Region 9 has granted TEP approval to use this configuration of 3-and-2 stacks for each group of 5 stacks in the model (Appendix A of this modeling protocol), as the stacks being merged are separated by a distance that is less than their diameter. Further justification supporting this more accurate characterization of the sources is provided in Appendix B of this modeling protocol.

Each of the ten RICE installed at IGS will be equipped with two air pollution control devices:

- An oxidation catalyst system to control emissions of volatile organic compounds ("VOC"), carbon monoxide (CO), and organic hazardous air pollutants such as formaldehyde; and,
- A selective catalytic reduction ("SCR") system to control emissions of nitrogen oxides (NO_X). Aqueous ammonia will be injected upstream of the SCR catalyst module to act as a reductant.

[1] Available at: https://cfpub.epa.gov/oarweb/MCHISRS/index.cfm?fuseaction=main.resultdetails&recnum=91-II%20%20-01.

Figure 2-1 Aerial Image of the Irvington Generating Station

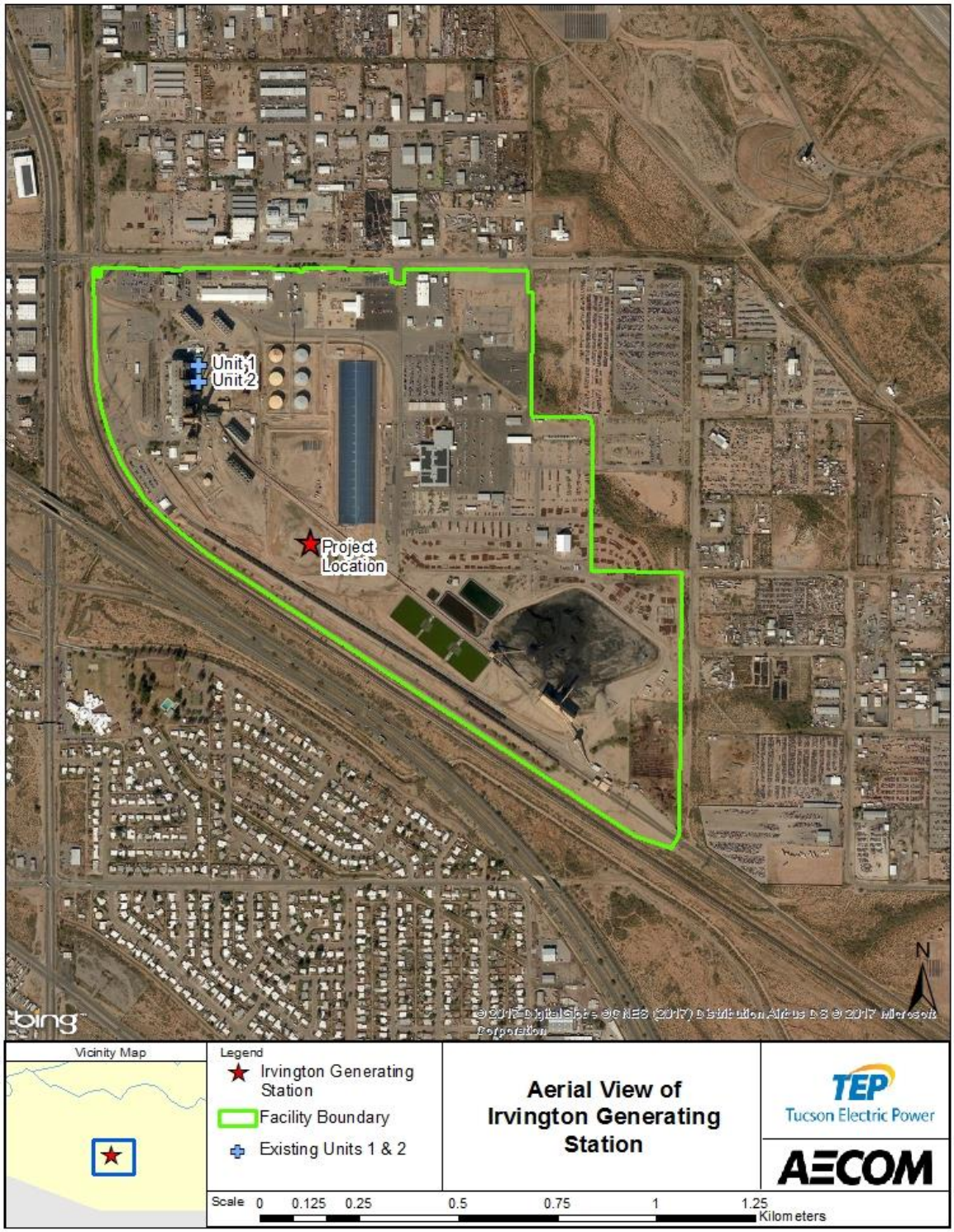


Figure 2-2 Topographic Map Showing Terrain Features Surrounding the Irvington Generating Station

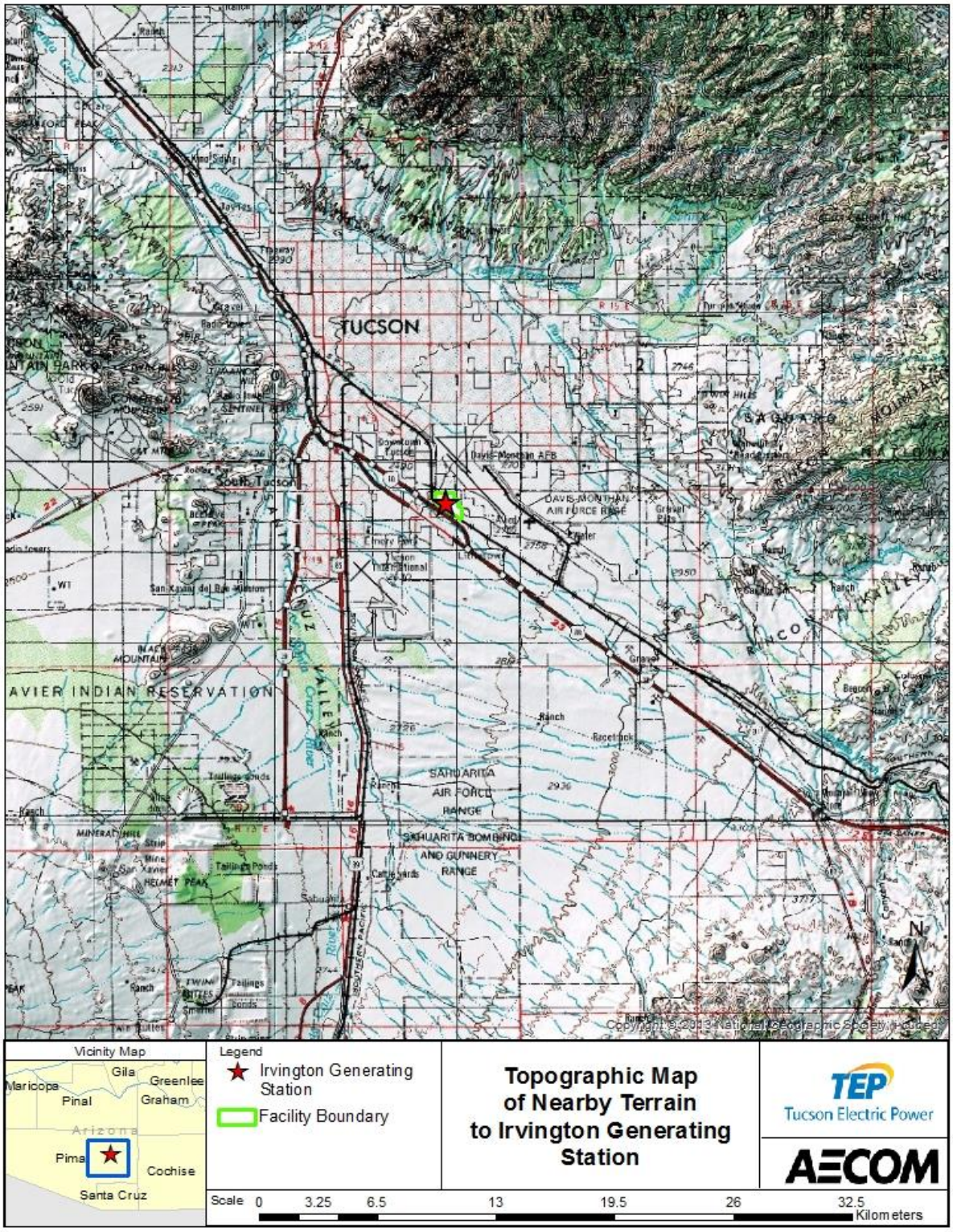


Figure 2-3 Proposed Project Layout in the Vicinity of the RICEs

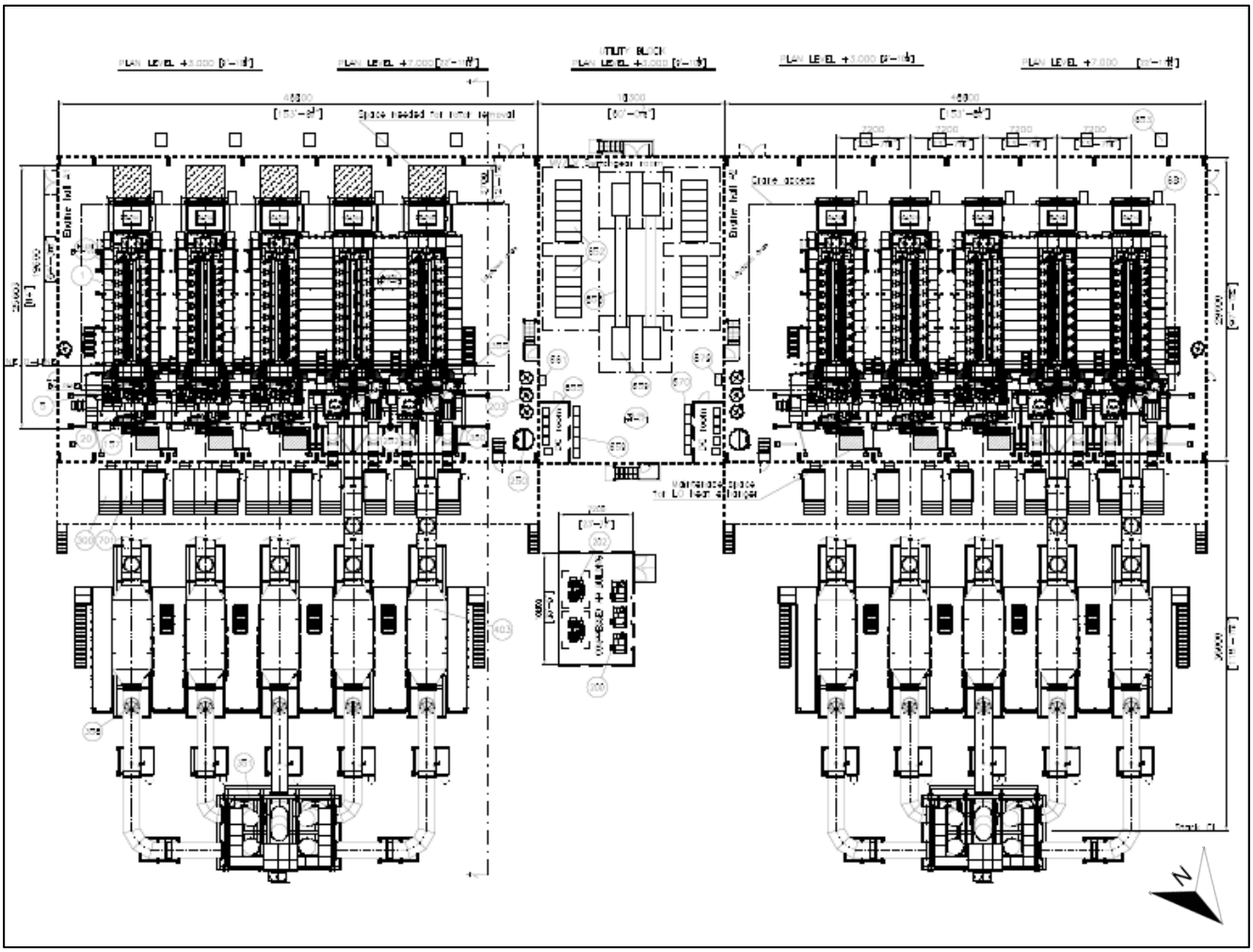
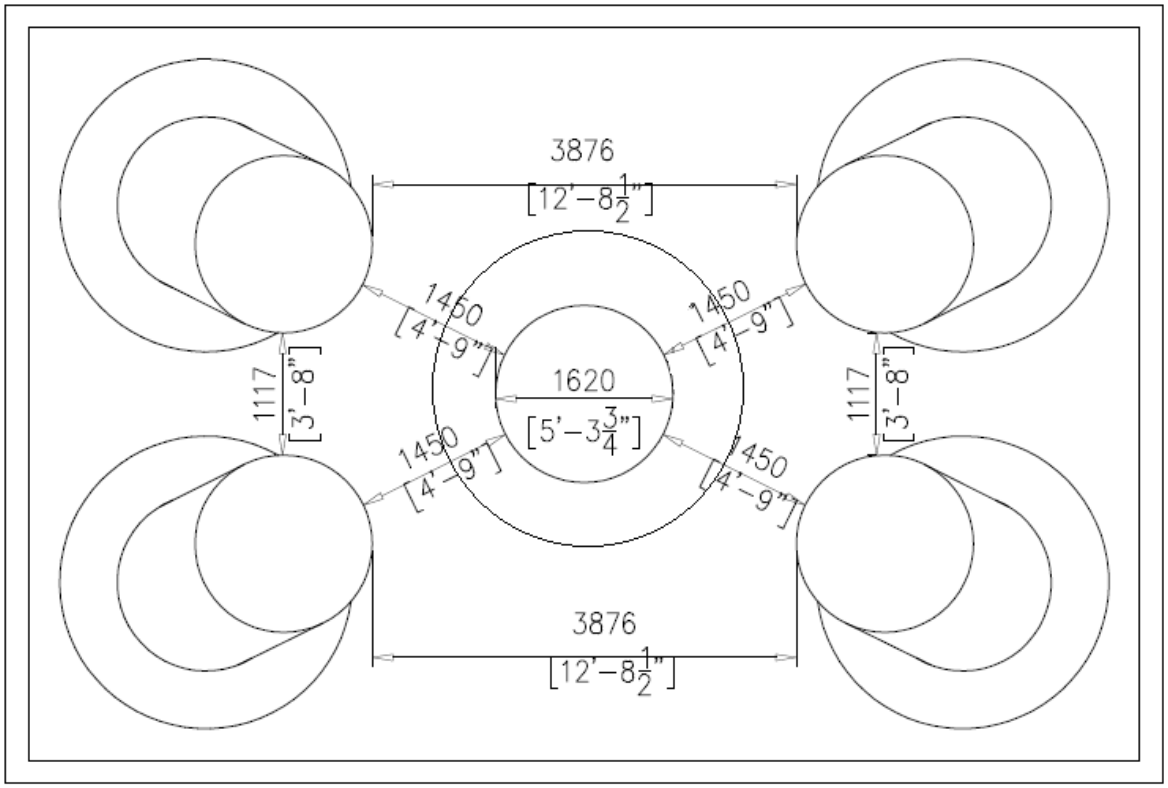


Figure 2-4 Drawing of RICE Stack Configuration with Dimensions



Note: Exterior stack diameter value provided in drawing. The interior flue diameter is 5.25'.

2.3 PSD Applicability

2.3.1 Criteria Pollutant Emissions

IGS is considered a fossil fuel-fired steam electric plant (one of the "major emitting facility" identified in section 169 of the Clean Air Act), and is therefore subject to the Prevention of Significant Deterioration (PSD) permitting requirements. The area around IGS is currently designated as attainment or unclassifiable for all criteria pollutants[2]. The expected annual emissions increases from the proposed engines will be compared to the PSD significant levels in **Table 2-1** to determine the PSD applicability. The RICE project at IGS will constitute a major modification at IGS and has the potential to increase emissions by more than 100 tons per year of carbon monoxide (CO), 15 tons PM_{10}, 10 tons of $PM_{2.5}$, and 40 tons of volatile organic compounds (VOC). In addition, the project will exceed the PSD threshold for Greenhouse Gas (GHG). The Project will not exceed PSD thresholds for NO_2, SO_2, or Lead. Based on this review, CO, VOC, PM_{10} and $PM_{2.5}$ will trigger modeling requirements.

Table 2-1 PSD Significant Emission Rates for RICE Project

Pollutant	PSD Threshold Emission Rates (tons/year)
Carbon monoxide (CO)	100
Nitrogen oxides (NO_x)	40
Sulfur dioxide (SO_2)	40
Particulate matter (PM)	25
Particulate matter (PM_{10})	15
Particulate matter ($PM_{2.5}$)	10
Volatile Organic Compounds (VOC)	40

[2] 40 CFR § 81.303.

3. Background Air Quality and Pre-Construction Monitoring

3.1 Pre-construction Monitoring Requirements

In accordance with pre-construction monitoring requirements (40 CFR 52.21(m)), an application for a PSD permit must contain an analysis of ambient air quality in the vicinity of the proposed Project for each pollutant subject to PSD review. The definition of existing air quality can be satisfied by air measurements from either a state-operated or private network, or by a pre-construction monitoring program that is specifically designed to collect data in the vicinity of the proposed source. A source can fulfill the pre-construction monitoring requirement for PSD without conducting on-site monitoring if data collected from existing monitoring sites are conservatively representative of the air quality in the vicinity of the proposed Project site.

The existing monitoring data must be determined by the reviewing authority to be representative of air quality for the area in which the proposed project would be constructed and operated. In determining whether ambient monitoring data can be considered representative for satisfying the PSD pre-construction monitoring requirement for a project, the EPA guidance in "*Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)*" (EPA-450/4-87-007, May 1987) was reviewed. The PSD ambient monitoring guidelines note three major items which need to be considered in determining the representativeness of existing data: 1) ambient monitor location, 2) quality of the data, and 3) temporal representativeness (how current the data is). These three criteria are discussed below.

Figure 3-1 shows the locations of these monitors relative to the Project site. The CO/ozone monitor at 22nd and Craycroft is approximately 5 kilometers northeast of IGS. The South Tucson PM10 monitor is located approximately 6 kilometers northwest of IGS and the Children's Park PM2.5 monitor is located approximately 15 kilometers north-northwest of IGS. These monitors are well situated such that emissions from IGS and other sources in the downtown Tucson area would impact these monitors based on the wind rose in **Figure 4-1**.

EPA maintains data capture statistics for all monitors in their design value tables[3]. Data capture for CO is 99%, O3 is 100%, PM10 is 96% and PM2.5 is 90%. These monitors meet the 75% data capture requirements set by EPA for the most recent three-year period available (2014-2016).

For temporal representativeness, it is desirable that the data generally have been collected for the most recent one-year period preceding a PSD permit application. However, in some cases, older ambient monitoring data could be considered conservative for representative background purposes if there have not been substantial changes in the operations of existing sources in the area and no new sources have been permitted in the interim. In fact, it is more likely that emissions have been retired, and the older monitoring data overstates the pollutant concentration levels. This is likely to be the case since various new air pollution control programs, such as the reduction in particulate emissions from diesel vehicles, have been implemented in the interim period between data collection and submittal of the permit application.

[3] https://www.epa.gov/air-trends/air-quality-design-values#report

Table 3-1 provides a summary of the most recent 3-year period (2014-2016) ambient background design values.

Table 3-1 Background Design Values for TEP Project Site

Pollutant	Monitor Location	Avg. Period	Design Value[1]	SIL	NAAQS	Units
CO	22nd & Craycroft	1-hr	1.2	1.75[2]	35	ppm
CO	22nd & Craycroft	8-hr	0.7	0.44[2]	9	ppm
O_3	22nd & Craycroft	8-hr	0.062	0.001[4]	0.070	ppm
PM_{10}	South Tucson	24-hr	101	5.0[2]	150	µg/m³
$PM_{2.5}$	Children's Park NCORE	24-hr	11	1.2[3]	35	µg/m³
		Annual	5.1	0.3[3]	12	

[1] *Design Values based on 2014-2016 period.*
[2] *40 CFR 51.165(b)(2).https://www.gpo.gov/fdsys/pkg/CFR-2011-title40-vol2/pdf/CFR-2011-title40-vol2-sec51-165.pdf.*
[3] *Guidance for $PM_{2.5}$ Permit Modeling.* https://www3.epa.gov/scram001/guidance/guide/Guidance_for_PM25_Permit_Modeling.pdf.
[4] *Draft Guidance on Significant Impact Level for Ozone and Fine Particles.* https://www.epa.gov/sites/production/files/2016-08/documents/pm2_5_sils_and_ozone_draft_guidance.pdf

3.2 Background Concentrations for Cumulative Modeling

If cumulative modeling is required[4], representative background concentrations will be developed in addition to modeled impacts in the NAAQS compliance analysis. Ambient air quality data are used to represent the contribution to total ambient air pollutant concentrations from non-modeled sources. Initially, the design concentration values from local monitors approved by PDEQ will be added to the modeled design concentration to estimate the total impact, for applicable pollutants. Use of seasonal and hour-of-day varying background concentrations consistent with EPA guidance in their March 1, 2011 clarification memo[5] will be used.

Depending on the nearby source inventory that the PDEQ deems necessary to include in any cumulative modeling analysis, some double-counting may result with the ambient monitors listed, adding some conservatism to the modeling results.

[4] Cumulative modeling for a pollutant is required if the modeled project impacts exceed the Significant Impact Level (SIL) for that pollutant.
[5] http://www.epa.gov/ttn/scram/guidance/clarification/Additional_Clarifications_AppendixW_Hourly-NO2-NAAQS_FINAL_03-01-2011.pdf

4. Air Quality Impact Assessment Methodology

The dispersion modeling analyses conducted for the RICE project will adhere to the EPA "Revisions to the Guideline on Air Quality Models" (GAQM, which is contained in 40 CFR Part 51, Appendix W)[6], according to direction received from the PDEQ and local Pima County air quality guidance[7]. The following sections present the source data to be modeled, the proposed procedure for assessing ambient air impacts from the future IGS's emission sources and the standards to which the predicted impacts will be compared.

4.1 Background Discussion

The proposed Project will be a major modification for VOCs, CO, $PM_{2.5}$, and PM_{10}; therefore, PSD review and associated dispersion modeling analysis will be required for these pollutants. Modeling analyses to be performed will evaluate compliance with applicable thresholds for these pollutants. In addition, compliance with the National Ambient Air Quality Standards (NAAQS) and PSD increments will be evaluated if the Significant Impact Levels (SILs) are exceeded. The evaluation for VOC is discussed in Section 4.11. There are no modeling requirements for GHGs.

As will be discussed in the following sections of this protocol, the dispersion modeling for the RICE project has been conducted in a manner that tests a range of the engines' operating conditions, as advised by the reviewing agencies, in an effort to predict the highest impact for each pollutant and averaging period. Maximum predicted impacts each of the operating scenarios will be compared to the SILs. For those pollutants which have predicted impacts below the applicable SIL, no additional analysis will be necessary since such a low impact is not expected to change the NAAQS or PSD increment compliance status. If modeling indicates that SILs for some pollutants and averaging periods are exceeded, then a cumulative impact assessment will be undertaken. In that case, the results of the cumulative modeling will be analyzed for comparison to Federal and local ambient air quality standards and PSD increments, if applicable.

4.2 Source Data

The air dispersion modeling analysis will be conducted with emission rates and flue gas exhaust characteristics (flow rate and temperature) for a range of operating conditions for the proposed RICE project. The stacks from each of the 10 engines will be bundled or clustered together in two groups of five and will be modeled as four merged stacks. Modeling will assume that the exhaust from three RICE units in each of the two groups of five engines are tied into two of the four merged stacks, while exhaust from two RICEs in the two groups of five engines are tied into the remaining two merged stacks.

A summary of the engine exhaust data for the PSD-regulated pollutants that will be modeled is provided in **Table 4-1**. An equivalent diameter and gas exit velocity calculation for the merged stack configuration noted above, is also shown in the table. The formulas used to calculate the equivalent diameter and gas exit velocity of the merged stacks are provided in equations 1 and 2, respectfully.

[6] 82 FR 5182. https://www.federalregister.gov/documents/2017/01/17/2016-31747/revisions-to-the-guideline-on-air-quality-models-enhancements-to-the-aermod-dispersion-modeling .
[7] PCC § 17.16.590(A)(6). https://library.municode.com/az/pima_county/codes/code_of_ordinances.

$$\text{Equivalent Diameter} = 2 * \sqrt{\frac{(\pi * \left(\frac{d}{2}\right)^2) * n}{\pi}} \quad (1)$$

$$\text{Velocity} = \frac{ACFM * n}{60 * \pi * \left(\frac{equivalent\ d}{2}\right)^2} \quad (2)$$

Where;

ACFM = Gas flow from single stack in units of actual cubic feet per minute,

n is the number of individual engine stacks being merged,

d is the diameter of each individual stack in units of feet,

equivalent diameter is in units of feet, and

velocity is in units of feet per second.

Criteria pollutant emissions for the engines are presented in the following sub-sections.

4.2.1 Normal and Startup Emissions

Each engine will be modeled assuming 8,760 hours of operation per year. For CO (a pollutant with a 1-hour average NAAQS), all ten engines will be conservatively assumed to start simultaneously for each hour modeled over the course of the 5-year period. Startup conditions apply to engine loads less than 25% of full load; when the 25% load is attained, the pollution control equipment is fully operational. The time needed for a startup is, at most, about 30 minutes for a "cold start" (with several hours in between engine operations), while it is even shorter for starts in which the engine is still warmer than ambient temperature. The modeling for startup for CO emissions will be conservatively done assuming a cold start each hour, which is physically impossible.

The vendor for the RICEs have provided TEP with estimated emission rates and exhaust parameters for varying load conditions (25%, 50%, and 100%), as shown in **Table 4-1**. Since these emission specifications are not guaranteed, TEP has added a buffer to the emission rates to ensure they will be able to comply with the proposed PSD conditions, which include 5 startups per day per engine for PM_{10}/$PM_{2.5}$. Startup emission rates are shown in **Table 4-2**. The buffer was calculated by scaling the vendor-supplied emission rates such that the modeled full load emission rate would match the proposed permit value. For example, PM_{10} and $PM_{2.5}$ the scaling factor is 1.331 (2.37 lb/hr (1-hour non-startup) / 1.78 lb/hr (vendor 1-hour non-startup)). This scaling factor was subsequently applied to the vendor-supplied non-startup emission rates for min and mid-loads.

Modeling of PM_{10} and $PM_{2.5}$ (with daily average NAAQS) will assume a maximum of 5 startup events per day. For example, for the full load case, the daily average emission rates assume 5 startup event emissions (1.8 lb/30 minutes during these events) and 21.5 hours of non-startup (normal) emissions (2.37 lb/hr during these periods). The daily average emission rates in this case would be calculated as: ((2.37 lb/hr x 21.5 hours + 1.8 lb/event x 5 startups) / 24 hours in day) = 2.5 lb/hr. This 24-hour average rate of 2.5 lb/hr will be used for the 24-hour and annual averaging periods. For the 8-hour averaging period of CO at full load, the emission rate will assume 8 hours of startup emissions. As

stated above, for the 1-hour averaging period of CO at full load, the modeled emission rate assumes all 10 engines start simultaneously in the same hour, every hour of the year.

Table 4-1 Vendor-Supplied Maximum Emission Rates and Exhaust Parameters During Non-Startup Operations for Various Loads

Engine Load (%)	CO[1] (lb/hr)	PM_{10}[1] (lb/hr)	$PM_{2.5}$[1] (lb/hr)	Gas Exit Temperature (K)	Exhaust Gas Flow (lb/s)
100	2.64	1.78	1.78	628.706	64.8
50	1.85	1.47	1.47	700.372	33.8
25	1.14	0.96	0.96	703.706	21

(1) Emission rates are per engine under ambient conditions of 90°F, 9% relative humidity, and altitude of 2,630 ft.

Table 4-2 Vendor-Supplied Cold Startup Emission Rates

Startup	CO[1] (lb/30 min)	PM_{10}[1] (lb/30 min)	$PM_{2.5}$[1] (lb/30 min)
Cold	9.1	1.8	1.8

(1) A cold catalyst start is when the temperature of the catalyst material inside the reactor is close to ambient temperature. Cold catalyst starts are expected after overhaul periods or when the engine has not been operated during the last 2-3 days.

The scaled emission rates for each engine at 25%, 50%, and 100% operating loads are summarized in **Table 4-3**. The emission rates during startup conditions are either equal to or greater than the normal operations; therefore the worst-case scenario to be modeled includes the startup emission rates.

The exhaust flow (lb/s) is converted to standard cubic feet per second based on the molecular weight of the flue gas and the ideal gas law for standard conditions (385.55 scf/lb mole at 1 atm and 68 F). The molecular weight of the RICE unit flue gas was approximated using the assumptions provided below. Air has an O_2 concentration of 20.9% and a molecular weight of 28.97 lb/lb mole. The molecular weight of the flue gas from natural gas-fired combustion sources is lower than the molecular weight of air due to the relatively high moisture content resulting from hydrogen in the fuel. The molecular weight of flue gas for large lean burn natural gas-fired gas turbines operating with flue gas oxygen concentrations at approximately 13% O_2 on a dry basis is approximately equal to 28.3 lb/lb mole based onavailable vendor data. According to AP-42 Section 3.2.2, lean burn reciprocating engines such as the Wartsila 50SG operate with fuel gas O_2 concentrations in the 4% to 17% range[8]. Based on a worst-case assumption, an oxygen concentration of 17% yielding the flue gas molecular weight for the Wartsila natural gas-fired reciprocation engines is assumed to be approximately 28.6 lb/lb/mole. Lower fuel gas oxygen concentrations would result in lower molecular weights and higher flue gas velocities and be less conservative. Therefore, the selection of a higher O_2 concentration (17%) is conservative as it results in a conservative (lower) velocity for modeling of the Wartsila engines.

[8] EPA AP-42 Air Emission Factors. https://www3.epa.gov/ttn/chief/ap42/ch03/final/c03s02.pdf

The exhaust flow in standard cubic feet per second is converted to actual cubic feet per second based on the actual temperature from the RICE units (provided by vendor) and the atmospheric pressure at the site. At the site elevation of 800 m, the atmospheric pressure is 0.91 atm. The actual flow rate is converted to velocity based on the stack cross sectional area.

Table 4-3 Emissions Summary and Stack Parameters for Modeling (pounds per hour per engine)

Scenario[1]	Stack Height (ft)	Stack Diameter (ft)	Exit Temp. (K)	Exit Velocity (m/s)	Maximum Short-Term Emissions (lb/hr per RICE)[2], [3]		
					CO[3]	PM_{10}[4]	$PM_{2.5}$[4]
100% Load; 2 Merged Stacks	160	7.4	**628.706**	28.985	**18.220**	**2.500**	**2.500**
50% Load; 2 Merged Stacks	160	7.4	700.372	16.842	**18.220**	2.128	2.128
25% Load; 2 Merged Stacks	160	7.4	703.706	**10.513**	**18.220**	1.520	1.520
100% Load; 3 Merged Stacks	160	9.1	**628.706**	28.985	**18.220**	2.500	2.500
50% Load; 3 Merged Stacks	160	9.1	700.372	16.842	**18.220**	2.128	2.128
25% Load; 3 Merged Stacks	160	9.1	703.706	**10.513**	**18.220**	1.520	1.520

(1) Data presented are for multiple operating loads/conditions for 2 types of merged stack configurations.
(2) Bold italicized numbers indicate highest emissions, lowest temperature, and lowest exhaust velocity.
(3) Emission rates based on cold start for every hour.
(4) Emission rates include five 30-minute cold startup events per day.

4.3 Model Selection

The suitability of an air quality dispersion model for a particular application is dependent upon several factors. The following selection criteria were evaluated:

- stack height relative to nearby structures;
- dispersion environment;
- local terrain; and
- representative meteorological data.

Pima County's air quality model guidance refers to EPA's 2004 version of Appendix W and does not yet reflect the recent EPA rule promulgation of Appendix W in May 2017. Per Section 6 part B of Pima County's guidance, if the "guideline" model is inappropriate, it may be substituted with another model. We assume that given the recent EPA rule that Pima County would accept the most recent version of AERMOD as the most appropriate model and the recently promulgated Appendix W guidance as the

most appropriate for this analysis. Based on a review of the factors discussed below, the latest version of AERMOD (16216r) will be used in this modeling of IGS.

In rulemaking released in the December 20, 2016 Pre-Federal Register Version of the Final Rule, the EPA provided a revised version of AERMOD (16216), which replaces the previous version of AERMOD (15181). On January 17, 2017, EPA re-released AERMOD (version 16216r) that addressed several "bugs" discovered in the December 2016 version. The rulemaking included refinements to EPA's preferred short-range model, AERMOD, involving low wind conditions. These refinements included an adjustment to the computation of the friction velocity ("ADJ_U*") in the AERMET (16216) meteorological pre-processor. The promulgated Final Rule also changed the status of the ADJ_U* refinement from a beta option to an approved regulatory option. The modeling conducted for the proposed project at IGS will utilize the newly approved regulatory low wind model option.

4.4 Rural versus Urban

One of the factors affecting input parameters to dispersion models is the presence of either rural or urban conditions near the project site. According to Section 7.2.1.1. of Appendix W, the applicant should follow one of the following procedures; land use or population density. EPA Region 9 in consultation with EPA's Office of Air Quality Planning and Standards (OAQPS) has recommended that TEP to use the population density procedure in determining the rural or urban selection for the modeling of the RICE project. The population density procedure states that if the average population density is greater than 750 people per square kilometer, use urban, otherwise rural would be appropriate. EPA Region 9 provided TEP with an average population density for the Tucson metro area as 860 people per square kilometer. Therefore, for the TEP RICE project, the urban dispersion option in AERMOD will be used.

For urban areas, AERMOD requires the user to provide a representative population value. In 2015, the U.S. Department of Commerce Bureau of Economic Analysis (BEA) reported the Metropolitan Statistical Area (MSA) for Tucson, AZ was 1,010,025 people[9]. This MSA population for Tucson will be used to fulfill the population requirement in AERMOD.

4.5 Meteorological Data for AERMOD

Meteorological data required for AERMOD include hourly values of wind speed, wind direction, and ambient temperature. Since the AERMOD dispersion algorithms are based on atmospheric boundary layer dispersion theory, additional boundary layer variables are derived by parameterization formulas, which are computed by the AERMOD meteorological preprocessor, AERMET[10]. These parameters include sensible heat flux, surface friction velocity, convective velocity scale, vertical potential temperature gradient, convective and mechanical mixing heights, Monin-Obukhov length, surface roughness length, Bowen ratio, and albedo.

4.5.1 Available Meteorological Data for AERMOD

Arizona Department of Environmental Quality (ADEQ) has pre-processed meteorological data[11] for 2012-2016 for the Tucson International Airport (surface and upper air), using AERMET version 16216 along with AERMINUTE version 15272 and AERSURFACE version 13016. The recently-approved low wind ADJ_U* guideline option will be utilized for this data set. The airport is located approximately 5 kilometers to the southwest of IGS and is the only ASOS station in the Tucson area. This data set will

[9] BEA. Published on November 17,2016. https://bea.gov/regional/bearfacts/action.cfm?geoType=5&fips=46060&areatype=MSA.

[10] EPA 2016. User's Guide for the AERMOD Meteorological Preprocessor (AERMET). EPA-454/B-16-010 (December 2016). Office of Air Quality Planning and Standards, Research Triangle Park, NC.

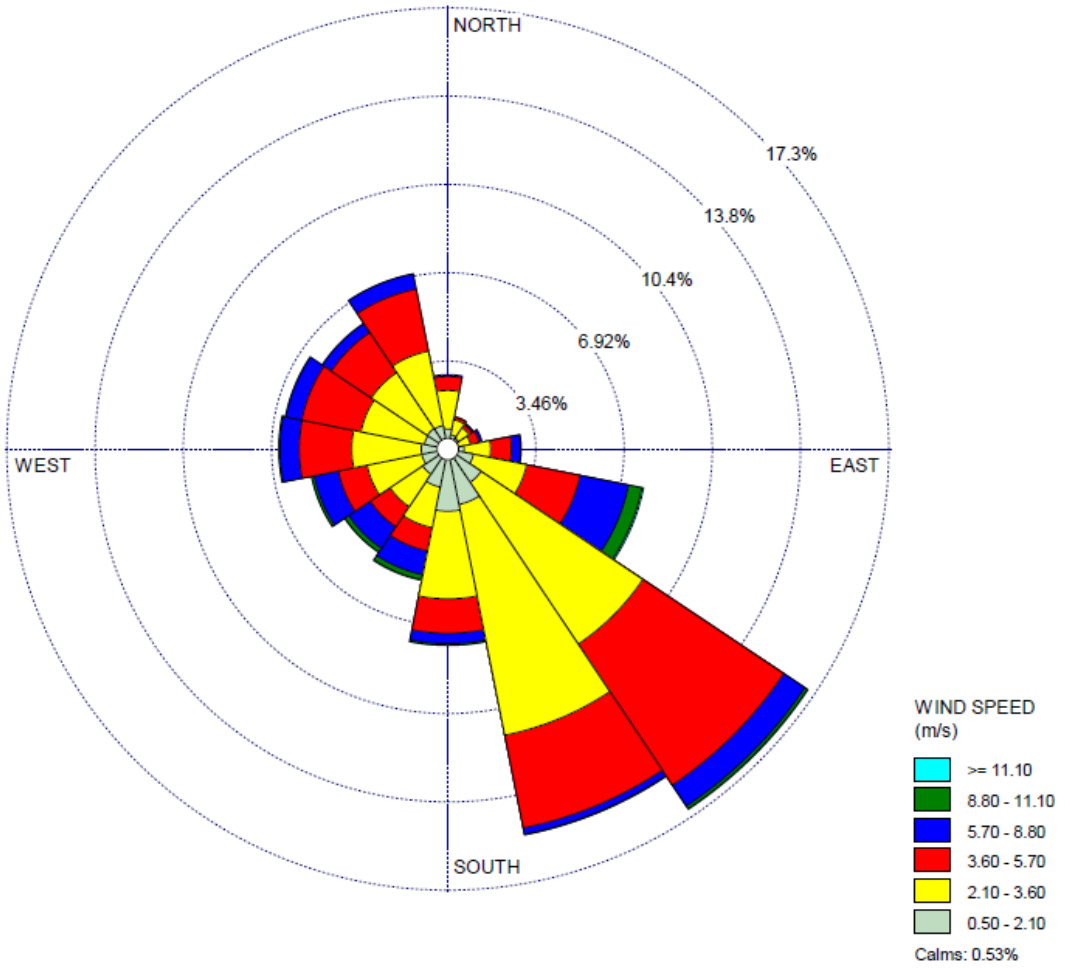
[11] Arizona Department of Environmental Quality (ADEQ) AERMOD-ready meteorological data files are available at http://www.azdeq.gov/node/2127.

be used for the air quality impact analysis. A wind rose using the five-year period from 2012 to 2016 is provided as **Figure 4-1**.

Figure 4-1 Wind Rose from Tucson International Airport 2012-2016

WIND ROSE PLOT:
Tucson International Airport
2012-2016

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	Start Date: 1/1/2012 - 00:00 **End Date: 12/31/2016 - 23:59**	**AECOM**	
	CALM WINDS: **0.53%**	TOTAL COUNT: **43696 hrs.**	AECOM
	AVG. WIND SPEED: **3.53 m/s**	DATE: **6/8/2017**	PROJECT NO.:

4.6 Good Engineering Practice Stack Height Analysis

A Good Engineering Practice (GEP) stack height analysis will be performed to determine the potential for building-induced aerodynamic downwash. The analysis procedures described in EPA's Guidelines for Determination of Good Engineering Practice Stack Height[12], Stack Height Regulations (40 CFR 51), and current Model Clearinghouse guidance will be used.

The GEP formula height is based on the observed phenomena of disturbed atmospheric flow in the immediate vicinity of a structure resulting in higher ground level concentrations at a closer proximity to the building than would otherwise occur. It identifies the minimum stack height at which significant aerodynamics (downwash) are avoided. The GEP formula stack height, as defined in the 1985 final regulations, is calculated from:

$$H_{GEP} = H_{BLDG} + 1.5L$$

where:

H_{GEP} is the maximum GEP stack height;

H_{BLDG} is the height of the nearby structure; and

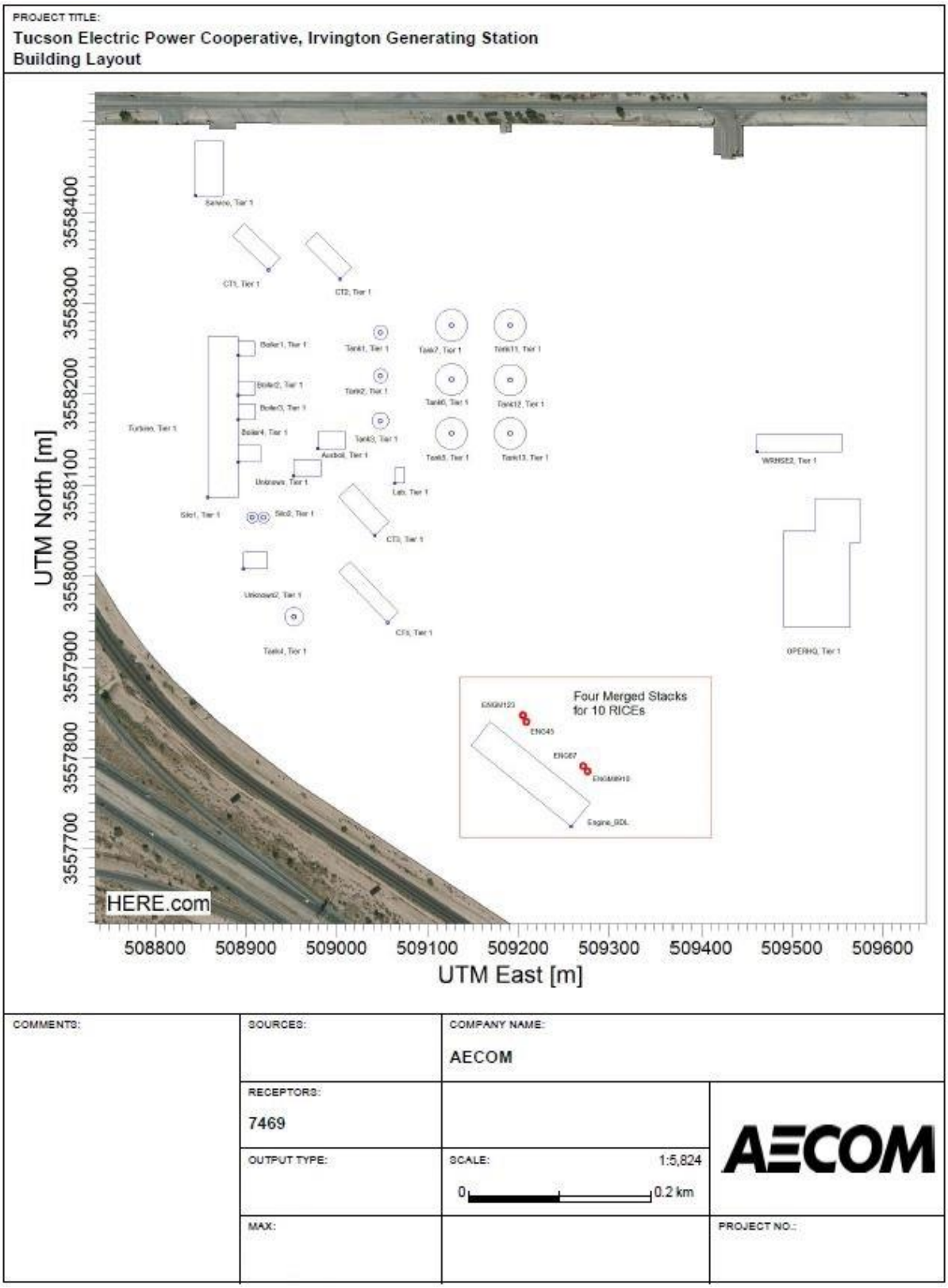
L is the lesser dimension (height or projected width) of the nearby structure.

Both the height and width of the structure are determined from the frontal area of the structure projected onto a plane perpendicular to the direction of the wind. In all instances, the GEP stack height is based on the plane projections of any nearby building that results in the greatest justifiable height. For purposes of the GEP analysis, “nearby” refers to the “sphere of influence,” defined as five times the height or width of the building, whichever is less, downwind from the trailing edge of the structure. In the case where a stack is not influenced by nearby structures, the maximum GEP stack height is defined as 65 meters.

Figure 4-2 is a plot plan showing the locations of the power plant equipment, and structures that could potentially produce aerodynamic downwash of the plumes for the reciprocating RICEs. The direction-specific building dimensions will be determined using the latest version of EPA’s Building Profile Input Program software (BPIP PRIME Dated 04274) using the design values of the stack and building heights.

[12] EPA 1985. Guideline for the Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) - Revised. EPA-450/4-80-023R, US EPA, Research Triangle Park, NC 27711.

Figure 4-2 Plot Plan Used in the GEP Analysis



4.7 Receptor Grid and AERMAP Processing

The modeling analysis will be conducted using the following Cartesian receptor grid design for Class II areas.

- 25-m receptor spacing along the IGS boundary;
- 100-m receptor spacing extending out 2 kilometers from the grid center (located near the center of the facility at 509448.00 meters Easting, 3557910.00 meters Northing);
- 250-m receptor spacing between 2 and 6 kilometers from the grid center;
- 500-m receptor spacing between 6 and 10 kilometers from the grid center;
- 1,000-m receptor spacing between 10 and 20 kilometers from the grid center; and
- 2,000-m receptor spacing beyond 20 kilometers (out to 50 km).

The receptor grid used in the modeling analysis will be based on Universal Transverse Mercator (UTM) coordinates referenced to NAD 83 datum and in zone 12 and is shown in **Figure 4-3** and **Figure 4-4**.

4.7.1 Terrain Processing (AERMAP)

The latest version of AERMAP (version 11103), the AERMOD terrain preprocessor program, will be used to calculate terrain elevations and critical hill heights for the modeled receptors at each of the project facilities using National Elevation Data (NED). The dataset will be downloaded from the USGS website (http://viewer.nationalmap.gov/viewer/) and consists of 1/3 arc second (~10 m resolution) NED. As per the AERMAP User's Guide[13], the domain was sufficient to ensure all significant nodes were included such that all terrain features exceeding a 10% elevation slope from any given receptor, are considered.

[13] EPA 2004. User's Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-03-003 (October 2004 – Addendum March 2011). Office of Air Quality Planning and Standards, Research Triangle Park, NC.

Figure 4-3 Near-Field Receptor Grid

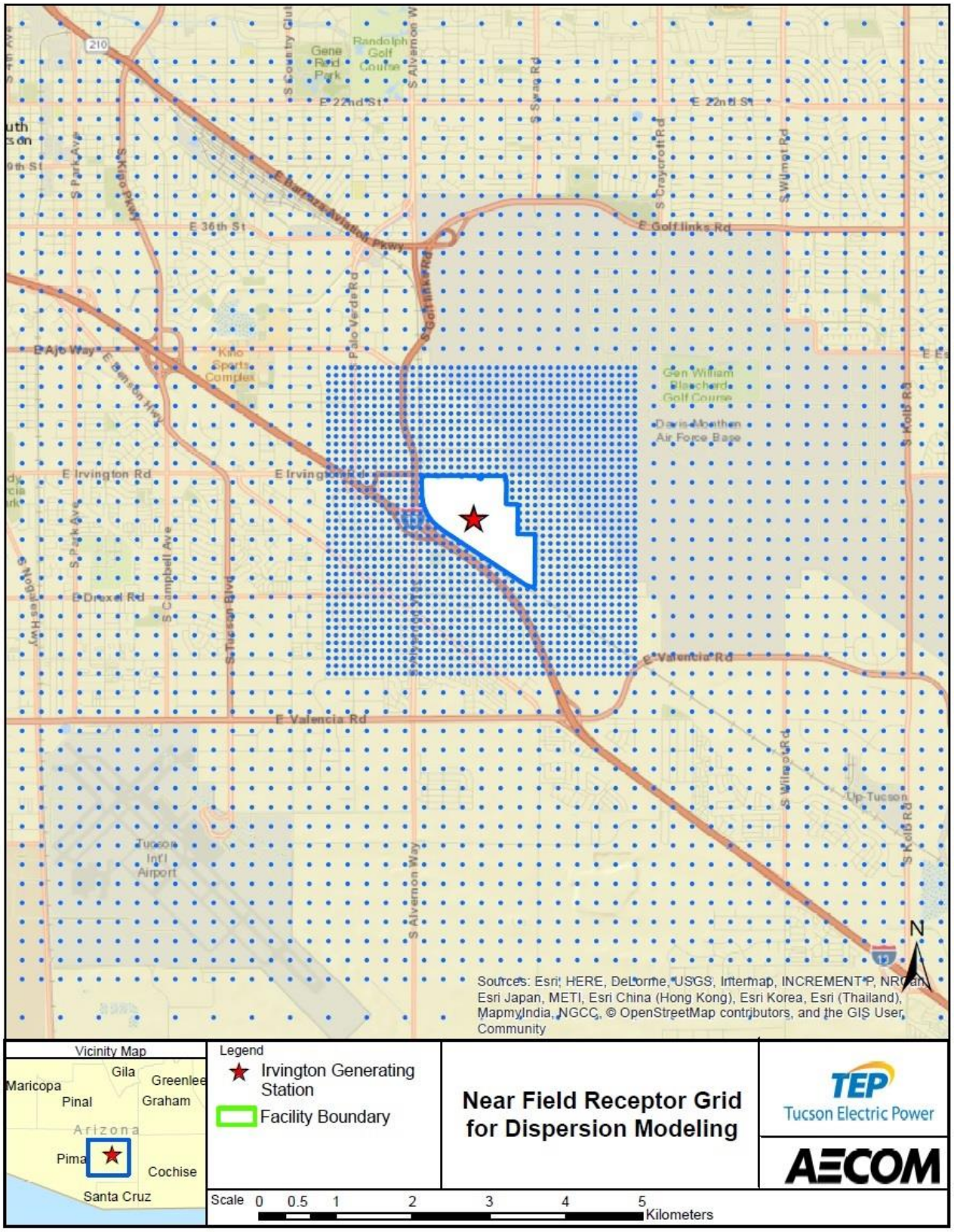
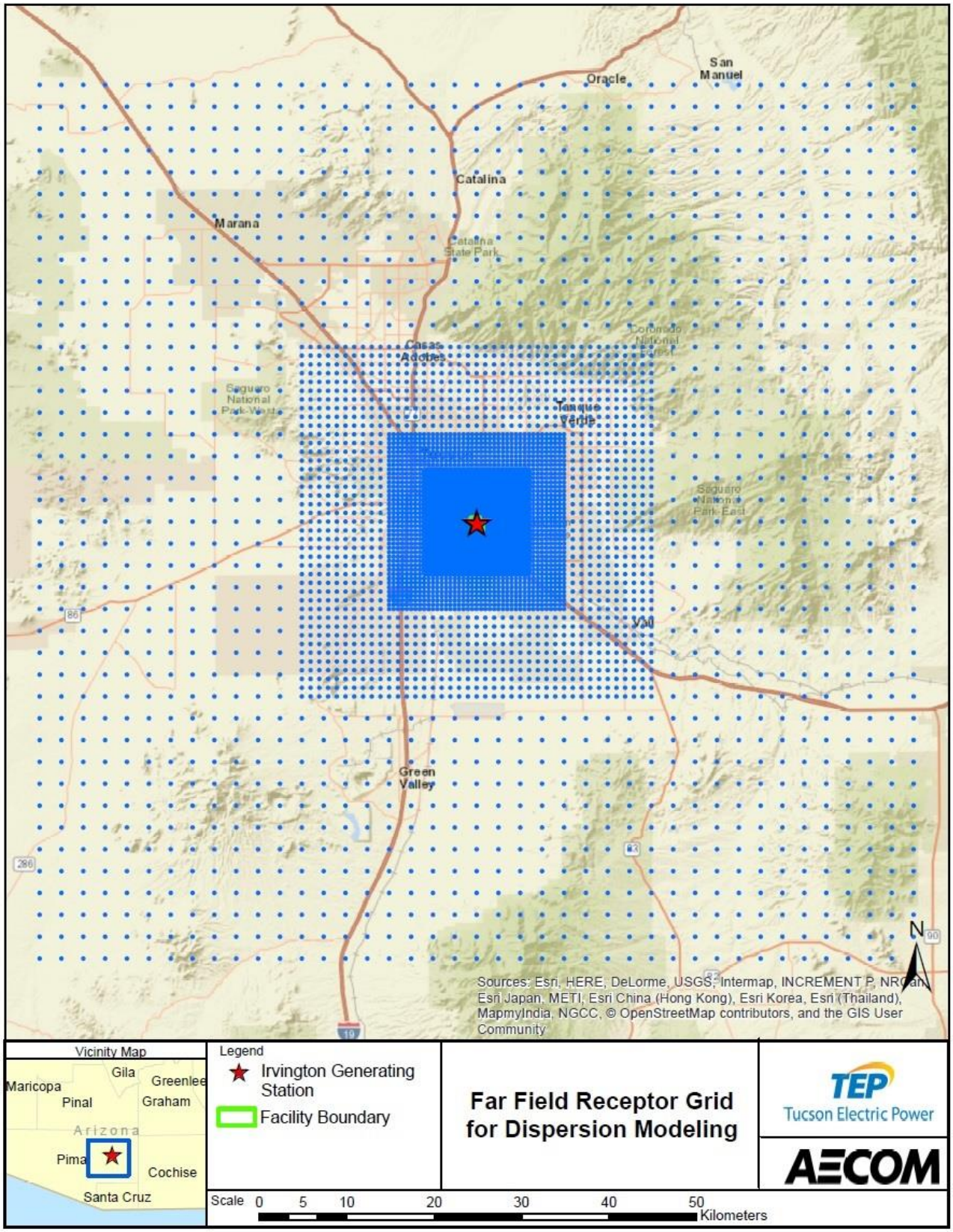


Figure 4-4 Far Field Receptor Grid



4.8 Modeling of Secondary $PM_{2.5}$ Emissions

Based on May 2014 guidance from EPA[14], a tiered approach is recommended for determining which sources would be important to consider when assessing secondary $PM_{2.5}$ concentrations, but the guidance lacks specifics as to how the evaluations should be conducted. The draft guidance suggests four different cases that define what air quality modeling analysis would be needed to consider $PM_{2.5}$ emissions, and any further modeling needed if the consideration of secondary $PM_{2.5}$ would be required. The MERP guidance and Errata Memo can be used as reference should secondary $PM_{2.5}$ consideration be required.

The four cases presented by EPA in the May 2014 guidance include:

- Case 1: If the $PM_{2.5}$ emissions < 10 tons per year (TPY) and NOx and SO2 emissions < 40 TPY; then a $PM_{2.5}$ compliance modeling demonstration IS NOT required.
- Case 2: If the $PM_{2.5}$ emissions > 10 TPY and NO_x and SO_2 emissions < 40 TPY; then a $PM_{2.5}$ compliance modeling demonstration IS required for primary $PM_{2.5}$, but consideration of secondary $PM_{2.5}$ is NOT necessary.
- Case 3: If the $PM_{2.5}$ emissions > 10 TPY and NO_x and/or SO_2 emissions > 40 TPY; then a $PM_{2.5}$ compliance modeling demonstration IS required for primary $PM_{2.5}$ and secondary $PM_{2.5}$ MUST BE accounted for from the project source.
  - EPA suggests the assessment of the effect of precursor emissions on secondary PM2.5 could be completely qualitative in nature, could be a hybrid qualitative/quantitative approach, or may require full photochemical modeling. However, EPA believes that not many cases will require full photochemical modeling.
- Case 4: If the $PM_{2.5}$ emissions < 10 TPY and NO_x and/or SO_2 remissions > 40 TPY; then a $PM_{2.5}$ compliance demonstration is NOT required for primary $PM_{2.5}$ but an assessment of secondary $PM_{2.5}$ is required. Much like Case 3, the assessment could be completely qualitative in nature, could be a hybrid qualitative/ quantitative approach, or may require full photochemical modeling (unlikely).
  - EPA noted that this case is still under review.

$PM_{2.5}$ modeling for IGS falls into Case 2 as described above and thus a qualitative / quantitative analysis to address secondary $PM_{2.5}$ is not required. The modeling of particulate emission impacts are restricted to direct emissions without regard to precursor emissions.

4.9 Class II Area Modeling Analysis

A refined modeling analysis will be conducted using AERMOD (version 16216r). The analysis will be conducted to demonstrate compliance with both federal and local applicable ambient air quality standards. For those pollutants and averaging periods that predict impacts above their applicable SIL, as shown in **Table 4-4**, a refined cumulative modeling analysis that will consider additional NAAQS and PSD increment consuming sources would be conducted to determine compliance with the NAAQS and PSD increments.

[14] Available at https://www3.epa.gov/scram001/guidance/guide/Guidance_for_PM25_Permit_Modeling.pdf.

4.9.1 PSD Class II Significant Impact Level Analysis

Impacts will be assessed using AERMOD at the Class II receptor locations described previously, and compared to the Class II SILs provided in **Table 4-4**. Five years (2012-2016) of representative meteorological data will be used as input to AERMOD, as discussed in **Section 4.5**.

When modeled concentrations for a specific pollutant and averaging period are less than the SILs, the proposed source's contribution to ambient air quality is deemed to be insignificant, such that the source impact has no bearing on compliance with ambient standards and increments for that pollutant and averaging period. Significance for 24-hour $PM_{2.5}$ is determined by averaging the maximum concentrations for each year modeled at each receptor over the 5 years and comparing to the SIL (AERMOD performs this calculation internally). All other pollutants/averaging periods are determined by comparing the maximum concentration for any year modeled to the SIL. When a specific pollutant and averaging period is modeled to be less than the SIL, then no additional modeling is required for that pollutant and averaging period. Since the exhaust parameters and emission rates vary by operating load, minimum (25%), mid-range (50%), and full load (100%) will be modeled and compared against the SILs.

Table 4-4 Criteria Pollutant Class II Significant Impact Levels

Pollutant	Averaging Time (1)				
	Annual *µg/m³*	**24-hour** *µg/m³*	**8-hour** *µg/m³*	**3-hour** *µg/m³*	**1-hour** *µg/m³*
CO	-	-	500	-	2000
PM_{10}	1	5	-	-	-
$PM_{2.5}$	1.2	0.2		25	7.9

(1) Maximum modeled concentration.

4.9.2 Class II Area Cumulative Air Quality Analysis

As stated previously, for those pollutants and averaging periods determined to have modeled concentrations less than the SILs, no further analysis will be performed. The discussion below applies only to those pollutants and averaging periods for which a significant impact is predicted with AERMOD.

Compliance with the PSD increments and NAAQS would be based on the sum of the following:

- Modeled concentrations attributable to the Project;
- Modeled concentrations from “nearby” and existing facility sources; and
- Representative ambient background concentration (NAAQS only).

Modeled concentrations attributable to Project along with “nearby” and existing facility sources will be estimated using AERMOD along with the meteorological data and receptors grids described in Sections 4.5 and 4.7.

An inventory of sources will be obtained from PDEQ for each pollutant which exceeds the SIL, covering facilities that could contribute significantly to ambient concentrations within the SIL radius. Two classes of facilities will be included. For the evaluation of PSD increments, only sources that

received PSD permits or have been designated by PDEQ as PSD increment-consuming sources will be included, as well as any sources that expand PSD increment, which could also be included in the analysis. For the evaluation of NAAQS, all sources of the applicable pollutant will be evaluated for potential inclusion into the modeled NAAQS inventory. Some facilities with a low ratio of total emissions divided by their distance from the proposed Project may not be included into the NAAQS analysis as the contribution from these sources would likely be minimal and would be accounted for in the ambient background concentration added to the modeled concentrations.

For the cumulative analysis, if required, the modeled design short-term and annual concentration from the proposed Project, as well as influencing nearby emission sources, will be compared with the NAAQS and PSD increments. The standards to which the modeling results will be compared to are presented in **Table 4-5** and **Table 4-6**. For the NAAQS analysis, a background concentration will be added to modeled design short-term and annual impacts to determine compliance.

Table 4-5 Ambient Air Quality Standards

Pollutant	Averaging Period	Class II NAAQS	Units	Form (Design)
CO	1-hour	40,000	µg/m^3	Not to be exceeded more than once per year.
	8-hour	10,000	µg/m^3	
PM_{10}	24-hour	150	µg/m^3	Not to be exceeded more than once per year.
$PM_{2.5}$	24-hour	35	µg/m^3	98th percentile, not to be exceeded as averaged over 3 years.
	Annual	12	µg/m^3	Annual mean never to be exceeded.as averaged over 3 years.
Source: 40 CFR 50 and PCC § 17.08				

Table 4-6 PSD Increments

Pollutant	Averaging Period	Class II PSD Increments	Units	Form (Design)
PM_{10}	24-hour	30	µg/m^3	Not to be exceeded more than once per year.
	Annual	17	µg/m^3	Annual mean never to be exceeded.
$PM_{2.5}$	24-hour	9	µg/m^3	Not to be exceeded more than once per year.
	Annual	4	µg/m^3	Annual mean never to be exceeded.
Source: Federal Register – Vol 75, No. 202, PCC § 17.08.150, PCC § 17.16.590(A)(5)(a).				

4.10 Class I Area

PSD regulations[15] recommend that facilities within 100 km of a PSD Class I area perform a modeling evaluation of the ambient air quality in terms of Class I PSD Increments and Air Quality Related Values. In addition, large projects beyond 100 km (but less than 300 km) from the nearest Class I area may be requested to conduct an evaluation of air quality impacts by the Federal Land Managers (FLMs). There are ten Class I areas within 300 km of IGS as shown in **Figure 4-5**:

1. Chiricahua NM
2. Chiricahua Wilderness
3. Galiuro Wilderness
4. Gila Wilderness
5. Mazatzal Wilderness
6. Mount Baldy Wilderness
7. Pine Mountain Wilderness
8. Saguaro National Park (East and West)
9. Sierra Ancha Wilderness
10. Superstition Wilderness

There are no other Class I areas within 300 km of IGS. Project impacts for PM_{10} and $PM_{2.5}$ pollutants subject to PSD review will be assessed for the Class I areas (and portions thereof) within 300 km of the facility. The Class I SILs that the project impacts will be compared to are summarized in **Table 4-7**. In 1996, EPA proposed rulemaking[16] for Class I specific SILs for PM10 24-hour (0.3 µg/m^3) and annual (0.2 µg/m^3); however, this rule was never finalized.

Table 4-7 Criteria Pollutant Class I Significant Impact Levels

Pollutant	Averaging Time (1)	
	Annual *µg/m^3*	**24-hour** *µg/m^3*
PM_{10}	0.2	0.3
$PM_{2.5}$	0.05	0.27
(1) Highest 1st high concentration		

4.10.1 Class I Significant Impact Level Analysis (within 100 kilometers)

This PSD Class I analysis will consider the closest Class I areas, Saguaro National Park (East and West) and Galiuro Wilderness, which are within 100 kilometers of IGS. The Significant Impact Analysis for compliance with PSD Class I increments will be conducted with AERMOD using the same meteorological data as the Class II modeling. It is anticipated that the Class I area modeling will result in modeled impacts that are less than the SILs for all pollutants and averaging periods.

[15] 1992 EPA Memorandum. Clarification of Prevention of Significant Deterioration (PSD) Guideance for Modeling Class I Area Impacts. https://www.epa.gov/sites/production/files/2015-07/documents/class1.pdf.
[16] 61 FR 38249.

Class I receptor grids were obtained from EPA Region 9's Class I database[17] and will be used for the PSD Class I modeling. The Galiuro Wilderness Class I area resides approximately 60 km from IGS, yet AERMOD has a maximum domain of 50 km. Therefore, for Galiuro receptors, it is proposed that these receptors be shifted to a closer distance of 50 km from IGS in the model such that the set of receptors became contained within the model's domain. In doing so, all of the Galiuro receptor elevations and hill heights will be preserved from what they are at their actual locations. **Figure 4-6** shows the proposed model receptor locations for Class I areas.

4.10.2 Class I Cumulative Impact Analysis

As stated previously, for those pollutants and averaging periods determined to have modeled concentrations less than the SILs, no further analysis will be performed. The discussion below applies only to those pollutants and averaging periods for which a significant impact is predicted with AERMOD.

Compliance with the PSD increments would be based on the sum of the modeled concentrations attributable to the Project and modeled concentrations from "nearby" and existing facility sources that affect increment consumption. Modeled concentrations attributable to Project along with "nearby" and existing facility sources will be estimated using AERMOD along with the meteorological data and receptors grids described in Sections 4.5 and 4.7.

An inventory of sources will be obtained from PDEQ and ADEQ for each pollutant which exceeds the SIL, covering facilities within 300 kilometers of the Class I Area. These areas are likely to be associated with the peak impacts. For the evaluation of PSD increments, only sources that received PSD permits or have been designated by PDEQ or ADEQ as PSD increment-consuming sources will be included, as well as any sources that expand PSD increment, which could also be included in the analysis.

For the cumulative analysis, if required, the modeled design short-term and annual concentration from the proposed Project, as well as influencing nearby emission sources, will be compared with the PSD increments. The standards to which the modeling results will be compared to are presented in **Table 4-8**.

Table 4-8 Criteria Pollutant Class I PSD Increment Levels

Pollutant	Averaging Period	Class I PSD Increments	Units	Form (Design)
PM_{10}	24-hour	8	$\mu g/m^3$	Not to be exceeded more than once per year.
	Annual	4	$\mu g/m^3$	Annual mean never to be exceeded.
$PM_{2.5}$	24-hour	2	$\mu g/m^3$	Not to be exceeded more than once per year.
	Annual	1	$\mu g/m^3$	Annual mean never to be exceeded.
Source: Federal Register – Vol 75, No. 202, PCC § 17.08.150, PCC § 17.16.590(A)(5)(a).				

[17] EPA, Region 9 Federal Class I Areas. https://www3.epa.gov/region9/air/maps/r9_clss1.html .

Figure 4-5 Class I Areas within 300 km of IGS

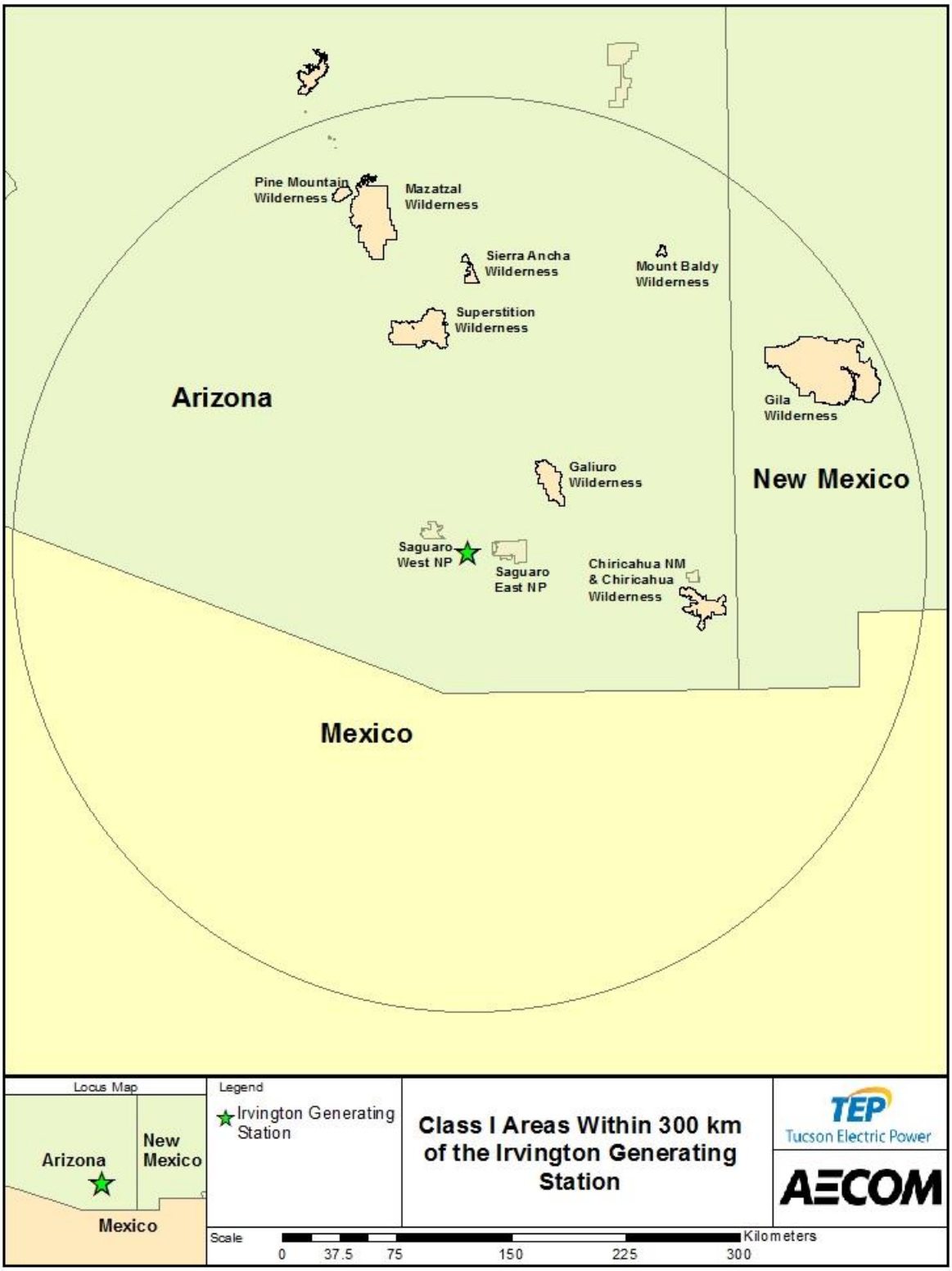
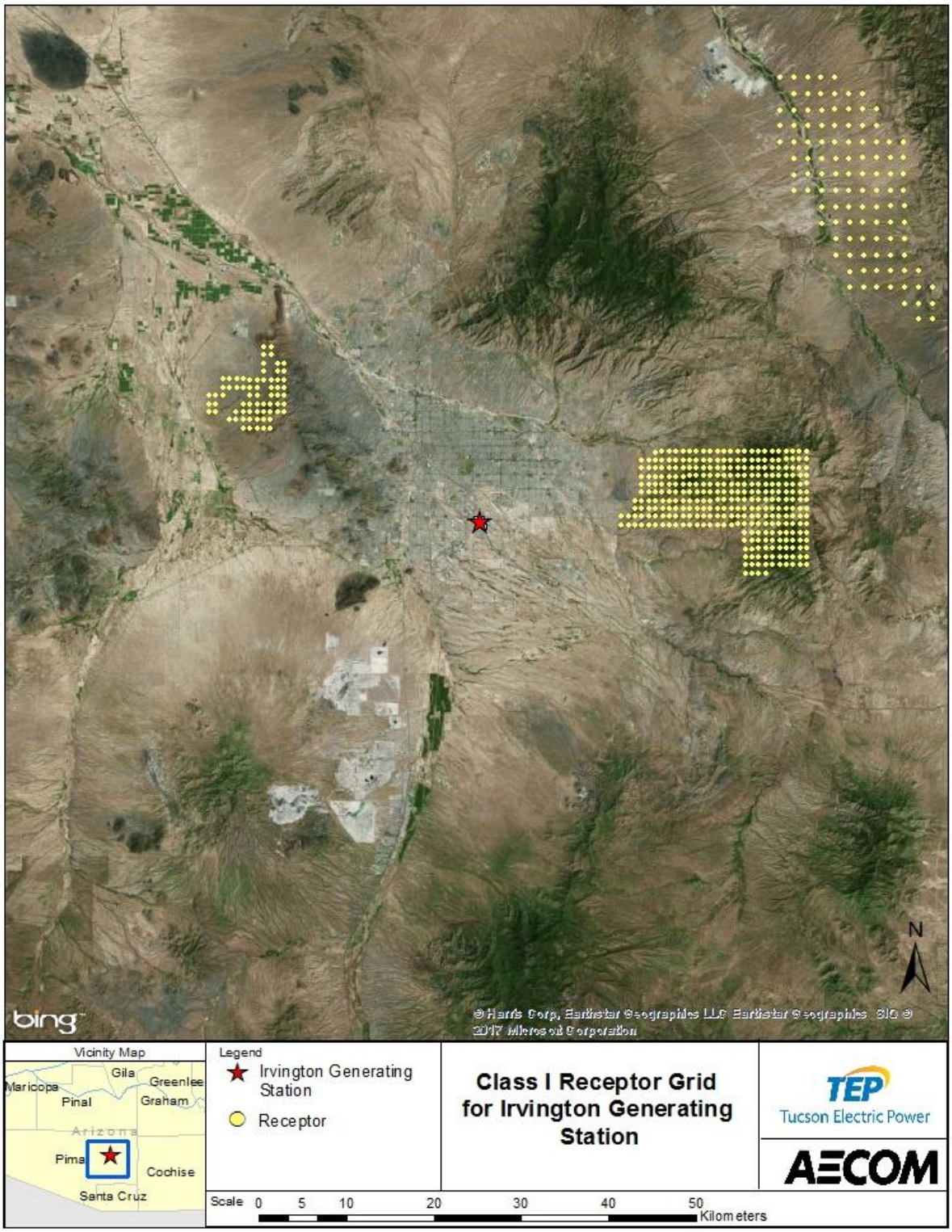


Figure 4-6 Class I Receptor Grid



4.11 Modeling of Ozone Precursors

In rulemaking promulgated in May 2017, EPA's Appendix W, Revisions to the Guideline on Air Quality Models provided a more specific procedure for assessing the impacts of an individual source on ozone. In conjunction with the updated Appendix W rule, the EPA is currently finalizing a two-tiered demonstration approach for addressing individual source impacts on ozone. The first tier involves use of technically credible existing relationships between precursor emissions and a source's impacts while the second tier involves application of more sophisticated case-specific chemical transport models. The EPA has recently issued draft guidance providing recommendations on air quality modeling and related technical analyses to satisfy compliance demonstration requirements for ozone for permit-related assessments under the PSD program; Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and $PM_{2.5}$ under the PSD Permitting Program (December 02, 2016)[18] and Errata Memo (February 23, 2017)[19]. The draft guidance provides a Tier 1 demonstration tool for ozone (and $PM_{2.5}$). The MERPs are screening thresholds for precursor emissions, where VOC and NO_x screening values are provided for ozone, that are expected to result in an insignificant increase in ambient ozone relative to the NAAQS; i.e., an impact less than the 8-hour ozone SIL of 1 ppb. The MERP values were derived based on modeling conducted by EPA for locations across the U.S. For this project, since PSD review requirements are not triggered with respect to NO_X, only a comparison against VOC MERPS is required.

Table 7.1 of the guidance, as updated in the Errata Memo, provides the "Most Conservative (Lowest) Illustrative MERP Values (tons per year) by Precursor, Pollutant and Region". MERP values are provided for VOC for the central, eastern and western U.S. To determine if an individual source will exceed the critical air quality threshold, the emissions increase is calculated as a percent of the lowest MERP for each precursor requiring analysis and summed. The equation prescribed for this determination of additive secondary impacts on 8-hour daily maximum ozone will be used and its anticipated results will show the critical air quality threshold will not be exceeded and the Project will be presumed to have an insignificant impact on ozone concentrations.

Per Pima County Code § 17.16.590(A)(5)(b)), a new major source of volatile organic compounds or oxides of nitrogen, or a major modification to a major source of volatile organic compounds or oxides of nitrogen shall be presumed to contribute to violations of the Arizona ambient air quality standards for ozone if it will be located within fifty kilometers of a nonattainment area for ozone. The only ozone nonattainment area in Arizona is located in Maricopa County, which is more than 100 kilometers from IGS; therefore, a demonstration that the project will not cause or contribute to a violation is not required. However, if the project emissions are expected to have an impact below the ozone SIL, then its emissions are not expected to cause or contribute to an ozone NAAQS violation.

[18] Available at https://www3.epa.gov/ttn/scram/guidance/guide/EPA454_R_16_006.pdf.
[19] Available at https://www3.epa.gov/ttn/scram/guidance/guide/MERPs_Data_Distribution_and_Errata_Memo-02232017.pdf.

5. Additional Impact Analysis

EPA's guidance on new source review states that all PSD permit applicants must prepare an additional impact analysis for each pollutant subject to regulation. This analysis assesses the impacts of air, ground and water pollutions on soils, vegetation, and visibility caused by any increase in emissions of any regulated pollutant from the source or modification under review, and from associated grow. This section presents how these additional impact analyses would be conducted.

5.1 Visibility Analysis (within 50 kilometers)

5.1.1 Class I Areas

For any new major source or major modification, Pima County requires (PCC § 17.16.630) an analysis of the anticipated impacts of the proposed source on visibility in any Class I areas which may be affected by the emissions from that source. Furthermore, *Federal Land Managers'Air Quality Related Values Work Group Phase 1 Report – Revised (2010)*[20] recommends that the applicant perform an analysis of visibility impairment (i.e., plume blight) at Class I areas within 50 kilometers of the proposed Project site, in this case Saguaro National Park (eastern and western units).

Preliminary visible plume analysis was conducted with EPA's screening model, VISCREEN, to determine if project emission during both normal and startup operations have the potential to cause visibility impairment at the Saguaro National Park units. Upon further review, the National Park Service has recommended that a refined visibility analysis using the PLUVUE-II model should be conducted. Given the complex nature of the refined visibility assessment using PLUVUE-II, a separate modeling protocol was developed and submitted to the NPS for approval (see Appendix C).

5.1.2 Class II Areas

In addition to the Class I area analysis, there is a requirement, as part of the PSD additional impacts analysis, for a visibility analysis to be considered within 50 km of the facility in Class II areas, especially if there are no Class I areas within 50 km (§ 52.21(o)(1)). In that regard, PDEQ will be consulted to identify a nearby state park or other sensitive area in the Project vicinity for which a visible plume analysis will be conducted, if closer than the aforementioned Class I areas. Due to the presence of the east and west units of the Saguaro National Park within 50 km of the project site, the consideration of plume visibility impacts in the national park will likely be determined to fulfill the Class II review as well.

[20] National Park Service, 2010. Phase I Report of the Federal Land Managers' Air Quality Related Values Workgroup (FLAG) Revised 2010. National Park Service, Air Resources Division; U.S. Forest Service, Air Quality Program; U.S. Fish and Wildlife Service, Air Quality Branch. http://www.nature.nps.gov/air/Pubs/pdf/flag/FLAG_2010.pdf.

5.2 Class I Analysis (beyond 50 kilometers)

In accordance with the revised FLAG 2010 guidance that is recommended by the Federal Land Managers, we will exclude from modeling consideration Class I areas that are beyond the FLAG-specified screening distance from IGS. The screening distance is determined by adding the permitted short-term emissions from proposed routine (non-emergency) point sources for SO_2 + NO_x + PM_{10} + H_2SO_4. A FLAG-prescribed screening distance has been calculated for the RICE project to determine what Class I areas will be considered for the Air Quality Related Values (AQRVs) analysis.

The sum of these emissions is not expected to exceed 277.59 tons per year (12.6 tons SO_2 + 153.3 tons NO_x + 109.5 tons PM_{10} and 2.19 tons H_2SO_4) for the RICE project not including the reductions in emissions from Unit 1 and 2. With a FLAG-prescribed screening distance of 278/10 = 27.8 km, this results in the determination that only impacts within the Saguaro National Park were considered for Air Quality Related Values (AQRVs), since all other Class I areas are beyond this distance and beyond 50 km from the project location.

5.3 Growth Analysis

A growth analysis examines the potential emissions from secondary sources associated with the proposed Project. While these activities are not directly involved in Project operation, the emissions involve those that can reasonably be expected to occur; for instance, industrial, commercial, and residential growth that will occur in the Project area due to the Project itself. Secondary emissions do not include any emissions which come directly from a mobile source, such as emissions from the tailpipe of any on-road motor vehicle or the propulsion of a train. They also do not include sources that do not impact the same general area as the source under review.

The Project is not expected to employ additional employees at this time. Therefore, population growth from this project is not expected, and thus an analysis of such growth is not proposed.

5.4 Soils and Vegetation Analysis

An analysis of the Project's potential impact on soils and vegetation in the vicinity of the facility will be performed in accordance with the procedures recommended in EPA's "A Screening Procedure for Impacts of Air Pollution Sources on Plants, Soils and Animals"[21]. The highest predicted impacts from the project used in the SIL analysis, plus a conservative background concentration, will be compared to the NAAQS and screening concentrations listed in the above referenced document, which are summarized in **Table 5-1**, to demonstrate compliance.

[21] EPA 1980. A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals. EPA-450/2-81-078. EPA, Research Triangle Park, NC 27711.

Table 5-1 Injury Threshold for Vegetation

Pollutants	**NAAQS** (µg/m^3)	**EPA's 1980 Screening Concentration**[1] (µg/ m^3)
PM (as PM_{10})	150 (24 hour)	None
O3	140 (8-hour)	392 (1-hour) 196 (4-hours) 118 (8-hours)
CO	None	1,800,000 (weekly)

1. "A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals". EPA 450/2-81-078, December 1980.

6. Submittal of Analysis Results

The findings of the air quality impact analyses will be submitted to PDEQ as part of the permit application for review and approval. The permit application will address the following:

- Source Data: Source data required for evaluation of Project impacts will be provided. This will include criteria pollutant emission rates and stack exhaust parameters.
- Choice of Models: The chosen models including version numbers and selected options will be discussed.
- Receptor Data: A plot of the receptor grid used in the AERMOD analysis will be provided with the final application document.
- Meteorology: The meteorological data used in the analysis will be documented.
- Modeling Summary: Results of the modeling analyses will be documented and summarized.
- Compliance with NAAQS and PSD Increments: A demonstration of compliance with these standards will be presented and supported in the report in text, tabular and/or graphical format.
- Additional impacts: The additional impacts analysis will consist of an analysis of visible plume impacts, a growth analysis, and an analysis on impacts of soils and vegetation.
- Model Output and Databases: The model input and output files, including BPIP-Prime input and output files will be provided to PDEQ. The final modeling report will also include graphics (e.g., contour maps) that show the extent of the air quality impacts for the worst case year for each pollutant and averaging period. The figures will utilize a base map that is readily understandable by the general public. Each map will clearly identify the IGS location relative to these air quality impacts.

Kaplan, Mary

From: Rupesh Patel <Rupesh.Patel@pima.gov>
Sent: Thursday, October 19, 2017 6:12 PM
To: 'Suzanne Kennedy'; 'Kate Graf'; 'Scott McCann'; Brian McNamara; Richard Grimaldi; Mellanie Fuller
Cc: 'CSpencer@tep.com'; Charles W. Komadina; ZFang@tep.com; 'Colin Campbell'; Kaplan, Mary; Paine, Bob; Holladay, Cleveland
Subject: FW: Tucson Electric Power's IGS RICE Project: Urban vs Rural Determination Land Use Classification; Approval of Merge Plumes

Hi Cleve,

Thank you for your comments on the modeling procedures for the Tucson Electric Power's IGS RICE Project.

Rupesh Patel
Air Permit Engineering Manager
Pima County Department of Environmental Quality
33 N. Stone Ave, 7th Floor
Tucson, Arizona 85701
Tel: (520) 724-7341

From: Holladay, Cleveland [mailto:Holladay.Cleveland@epa.gov]
Sent: Thursday, October 19, 2017 3:03 PM
To: Rupesh Patel <Rupesh.Patel@pima.gov>
Cc: Chen, Eugene <Chen.Eugene@epa.gov>; TSAI, YA-TING <Tsai.Ya-Ting@epa.gov>; Rios, Gerardo <Rios.Gerardo@epa.gov>; Brode, Roger <Brode.Roger@epa.gov>; john_notar@nps.gov; 'don_shephard@nps.gov'; 'kirsten_king@nps.gov'
Subject: Tucson Electric Power's IGS RICE Project: Urban vs Rural Determination Land Use Classification; Approval of Merge Plumes

Hi Rupesh,

Here are my comments and approvals of the following modeling procedures. Tucson Electric Power may proceed to the use the "urban" land use option based on the procedure in Section 5 of the AERMOD Implementation Guide (Last Revised December, 2016). The use of this option is also based on population density data indicating urban (867/km2 vs 750 km2) and the Tucson International Airport wind rose showing predominant winds blowing from the southeast over the proposed project to the urban area to the northwest.

Tucson Electric may also proceed to use plume merging provided that the stack arrangement is the following as described in the applicant's "Technical and Policy Justification for Plume Merging: Tucson Electric Power's IGS RICE Project". For each group of the IGS RICE project's five stacks shown in Figure 2, two sets of stacks indicated by red boxes are proposed to be modeled as separate merged stacks (see orange stars in the figure) due to their separation in each group by slightly less than one stack diameter from every other stack in that group. One group of 3 stacks would be modeled as a single merged stack and the remaining 2 stacks would be modeled as a second (smaller) merged stack (a "3 + 2" configuration). This merging approach follows the

policy decisions from past EPA Model Clearinghouse memos that the merged stacks should be within one diameter of each other in the merging approach.

-Cleve Holladay
US EPA Air Division, Air 07
75 Hawthorne Street, San Francisco, CA 94105
415-947-4140

AECOM Imagine it. Delivered.

Technical and Policy Justification for Plume Merging: Tucson Electric Power's IGS RICE Project

Project number	Client	Date	Prepared by
60530048	Tucson Electic Power Company	October 10, 2017	AECOM

Introduction

The calculation of plume rise from a point source is a key component in determining the downwind impacts associated with that source. Regulatory models such as AERMOD do not account for merging of plumes from nearby stacks, which can result in enhancements in the plume buoyancy. However, for stacks that are closely spaced, this consideration results in a more accurate characterization of the source.

For flues combined in a single stack, the assumption of enhancement of the plume buoyancy is intuitively obvious. For stacks with some finite separation, the determination of the enhancement is more complicated. In previous policy decisions[1,2], EPA has determined that full enhancement can effectively be assumed for stacks within 1 diameter of each other, citing the similarity of this situation to combining building tiers in EPA's Building Input Profile Program[3]. Studies cited below in this document refer to analyses of actual field data of plume merging as well as wind tunnel studies that indicate that plumes from adjacent, aligned stacks tend to combine, resulting in a buoyant plume rise greater than that from any one of the individual sources. The arrangement of the stacks as well as the stack exhaust parameters are factors involved in calculating the enhanced buoyancy flux.

AECOM has developed a procedure called AERLIFT, as documented in a peer-reviewed paper[4], to determine whether and to what extent the buoyancy of adjacent stacks will be enhanced. This procedure is based upon the Briggs algorithm involving plume rise from a row of stacks[5] that EPA has not yet incorporated into its guideline models.

In the following sections, a review of the Tucson Electric Power Company (TEP) proposed quick-start engine project and components of the AERLIFT formulation provide further support that specific stack groups associated with the TEP project should be modeled as merged.

Project Overview and Stack Merging Issue

TEP is proposing to modify the existing Irvington (Sundt) Generating Station (IGS) located in Tucson, Arizona, approximately 2 miles northeast of Tucson International Airport. The reciprocating internal combustion engine (RICE) project involves adding ten quick-start RICEs for the purpose of load stabilization to accommodate intermittent renewable energy sources (solar and wind) that feed into the system.

Figure 1 shows the proposed project layout for the RICE engines and the updated stack configuration. There are two sets of five RICE engine stacks shown in the Figure. A closer view of one of the two identical stack arrangements is shown in Figure 2.

---

[1] Model Clearinghouse memo 91-II-01, available at https://cfpub.epa.gov/oarweb/mchisrs/.
[2] Model Clearinghouse memo 6-V-10, available at https://cfpub.epa.gov/oarweb/mchisrs/.
[3] BPIP user manual is available at https://www3.epa.gov/scram001/userg/relat/bpipdup.pdf.
[4] Paine, R., Warren, L.L., Moore, G.E.,2016. Source Characterization Refinements for Routine Modeling Applications, *Atm. Env.* 129 (2016), 55-67. doi: 10.1016/j.atmosenv.2016.01.003. http://www.sciencedirect.com/science/article/pii/S1352231016300036
[5] Briggs, G.A., 1984. Plume rise and buoyancy effects. In *Atmospheric Science and Power Production*, edited by D. Randerson. U.S. Department of Energy Document DOE/TIC-27601 (DE84005177).

Figure 1: Proposed project layout in the vicinity of the RICE engines (top of figure faces SW)

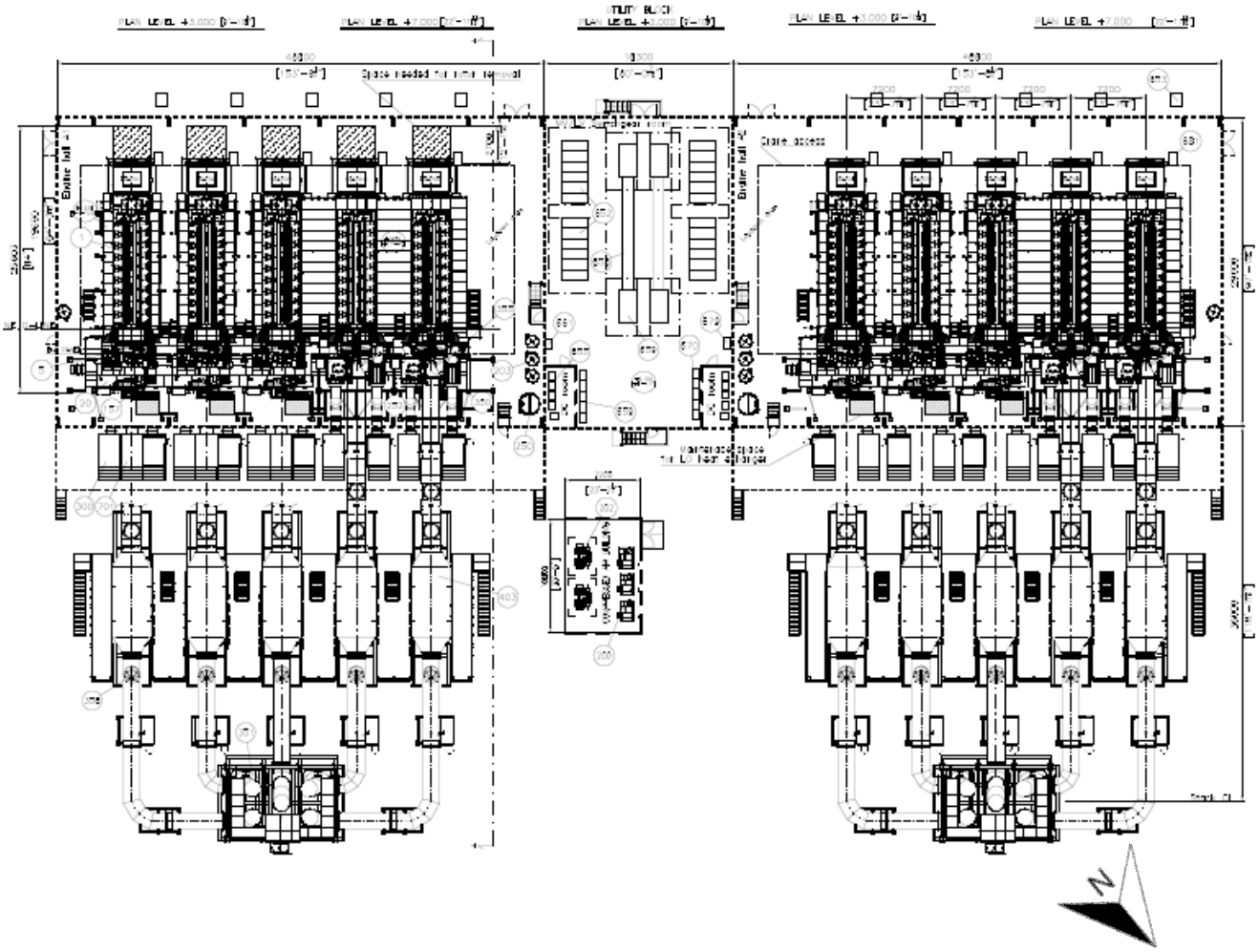
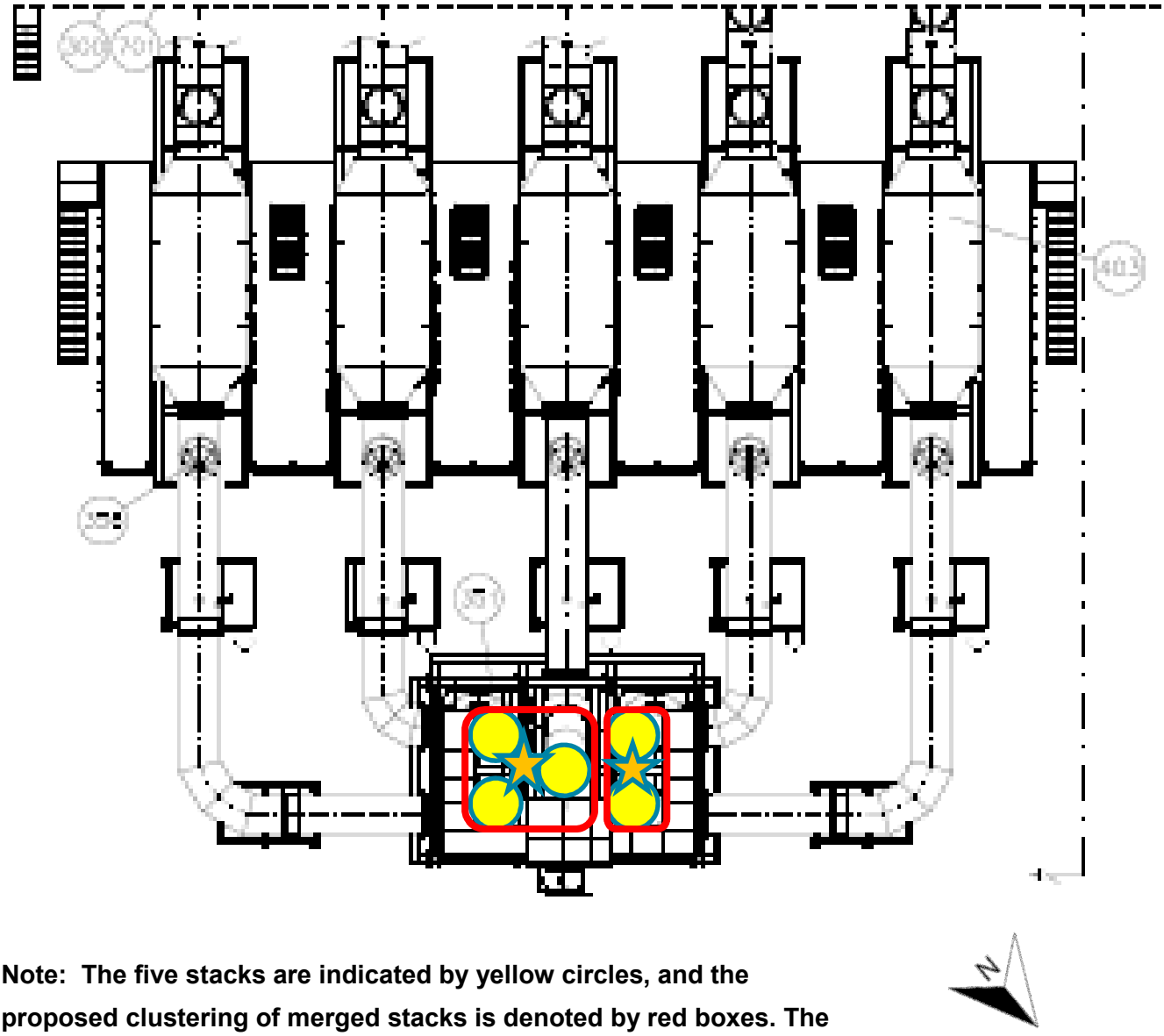


Figure 2: Close-up view of the 3+2 arrangement for one cluster of RICE engine stacks



Note: The five stacks are indicated by yellow circles, and the proposed clustering of merged stacks is denoted by red boxes. The orange stars indicate the locations of the merged stacks for modeling.

The stack configuration for the group of five stacks shown as yellow circles in Figure 2 for the proposed TEP RICE project is nearly identical to a similar project conducted in Oregon. The Port Westward Generating Plant (PWGP), owned and operated by Portland General Electric (located in Portland, Oregon), received approval from the Oregon Department of Environmental Quality to construct and operate 12 RICE generators (in groups of 6) in February of 2013 (see Appendix A, page 36). For the modeling demonstration, the stacks for each group of 6 RICE generators were located adjacent to each other in two rows of three stacks, as shown in Figure 3. Each six-stack group for the PWGP was represented in the modeling as a single point source with an effective stack diameter that equals the area of the six individual stacks. The stack diameters for the PWGP RICEs are 1.6 meters, which is identical to the RICEs that TEP are planning to install. With each of the PGWP stacks being within one diameter of each of the *nearest* stacks, it was realized that the cluster of stacks would result in air flow going around the cluster of plumes, which would effectively merge.

For each group of the IGS RICE project's five stacks shown in Figure 2, two sets of stacks indicated by red boxes are proposed to be modeled as separate merged stacks (see orange stars in the figure) due to their separation in each group by slightly less than one stack diameter from every other stack in that group. One group of 3 stacks would be modeled as a single merged stack and the remaining 2 stacks would be modeled as a second (smaller) merged stack (a "3 + 2" configuration). This merging approach is more conservative (less merging) than that approved for the Port Westward Generating Project, and it strictly follows the policy decisions from past EPA Model Clearinghouse memos that the merged stacks should be within one diameter of each other in the merging approach.

Preliminary modeling of the individual stacks shown in Figure 1 indicates that high SW wind conditions (with ~10 m/s winds blowing in a direction with the stacks lined up), result in peak daily concentrations for $PM_{2.5}$. Accordingly, we examined AERLIFT treatment of adjacent stacks for these conditions in the following section.

Figure 3: Photo of the operational Port Westward Power Plant RICE stacks

Photo Credit: Portland General Electric Company, http://www.pennenergy.com/articles/pennenergy/2015/01/pge-begins-operations-at-new-220-mw-natural-gas-fired-power-plant.html.

AERLIFT Calculations

In his "Plume Rise and Buoyancy Effects" Chapter 8[5], Briggs refers to the results of wind tunnel studies that indicate the usefulness of a merge parameter, S', to determine the effect of the angle of the wind relative to the stack alignment:

$S' = [\Delta s \sin\Theta] / [L_B^{1/3} (\Delta s \cos\Theta)^{2/3}]$ (Eq. 1)

Where,

Δs is the average spacing between the aligned stacks

Θ is the wind angle relative to the alignment angle of the adjacent, inline stacks

L_B is the buoyancy length scale = F_B / U^3 (Eq. 2)

F_B is the buoyancy flux = $g\, v_S^{\,2} D_S^2 / 4\, (T_S - T_A)/T_S$ (Eq. 3)

U is the wind speed at plume height

V_S is the stack gas exit velocity

T_S is the stack gas temperature

T_A is the ambient temperature

D_S is the stack diameter

Due to the stack alignment for winds blowing across the proposed engine building structures (and no downwash for winds blowing perpendicular to the sets of stacks considered for merging), we considered alignment angles up to 75 degrees from a line associated with winds from the SW for this technical review.

Briggs indicated that wind tunnel studies using neutral conditions showed that if S' is less than 2.3, then buoyancy enhancement would take place, while values above 3.3 indicate very little enhancement (intermediate values would indicate partial enhancement).

The value of S' was calculated for the TEP RICE project to determine if buoyancy enhancement would occur for 2 stacks with up to 1 diameter in stack separation (from the outside of the stacks). The stack diameter is 1.6 meters, gas exit temperature is 633.16 K, and gas exit velocity is 29.45 m/s. An ambient temperature of 295 K was used, based on a 5-year annual average from Tucson International Airport. A buoyancy flux (F_B) of 2,906 m^4/s^3 was determined for each individual stack by applying TEP's RICE-specific variables to Eq. 3. The final step required before S' was calculated was the determination of the buoyancy length (L_B) (Eq. 2). A review of the top 50 maximum 24-hour PM near-field impacts (Class II receptors) was conducted to see what the wind speed at plume height (U) was for the controlling modeled impacts. Table 1 summarizes the dates and the corresponding 24-hour average wind speed at plume height. The highest controlling wind speed from this dataset is 8.66 m/s. For this worst-case wind speed, the buoyancy length (L_B) is about 4.47 meters.

For all angles considered, the value of S' was below the threshold value of 2.3, indicating that buoyancy enhancement calculations are appropriate.

Table 1: Dates and 24-hour wind speeds from top 10 modeled impacts for 24-hour Class II modeling

Date (mm/dd/yyyy)	24-hour Average Wind Speed at Plume Height (m/s)
01/02/2012	7.77
11/12/2013	8.66
11/13/2013	7.71
11/26/2013	6.96
01/24/2014	6.90
01/09/2015	6.03
01/02/2016	7.97
01/03/2016	7.68
11/09/2016	8.31
11/26/2016	7.29

With the confirmation that plume merging should be accounted for in an arrangement with any stack within a diameter of any other stack, we then applied an AERLIFT formulation for the buoyancy enhancement of at least 2 stacks. We also accounted for other factors noted above due to the merging of adjacent plumes which can be taken from Manins implementation[6] of Briggs formulation:

Buoyancy enhancement factor $E = [n+S]/[1+S]$ (Eq. 4)

where,

n is the number of stacks in the row

S is a separation factor $= 6 \{[(n-1)\ \Delta s]/[n^{1/3}\ \Delta h]\}^{3/2}$ (Eq. 5)

and

Δh is the plume rise for one stack.

For Eq. 2, we computed the enhancement factor for 2 stacks to determine if the total is close to 2.0, indicating full enhancement.

Modeling for a single RICE engine stack for effective wind speeds of about 8.66 m/s yields a plume rise of at least 42 m.

The appropriate value for Δs in this case is 2 stack diameters (where Δs is the separation of the stacks between stack *centers*) for the case of 1 stack diameter between the stack outer walls.

For a separation between stacks as proposed (Δs = 3.2 meters for 2 stack diameters between stack centers, although the actual separation will be slightly less), the buoyancy enhancement as calculated by Eq. 4 is 1.996, which is very close to a full merging of buoyancy fluxes. The buoyancy enhancement for a cluster of 3 stacks as shown in Figure 2 (e.g., 3 stacks arranged in a triangular formation), would also be expected to be very close to a full merging because the cluster of 3 stacks will be more likely to force air flow around the plume cluster from all directions.

[6] Manins P, Carras J and Williams D, (1992), Plume Rise from Multiple Stacks. Clean Air (Australia). Volume 26, Part 2. pp 65-68.; see http://www.planning.nsw.gov.au/asp/pdf/08_0021_bamarang_ps_stage2_ea_app_c_pt3.pdf

Summary and Conclusions

A technical analysis was conducted to determine the likelihood that enhancement of the plume buoyancy occurs from stacks that are very close in proximity to each other. We have demonstrated, through a quantitative and peer-reviewed approach, that for the proposed RICE stacks with a separation distance slightly less than their diameter, plume buoyancy would effectively be fully enhanced by the interaction of the adjacent stack plumes. The result of this analysis, in addition to precedent policy decisions cited above, supports merging of 3 adjacent stacks arranged in a triangular formation with each stack having a separation from the outside of the stack within 1 diameter of the other 2 stacks, as well as the other 2 adjacent stacks in a line, as shown in Figure 2.

Tucson Electric Power Company Irvington (Sundt) Generating Station: Protocol to Assess Visible Plumes at Saguaro National Park using PLUVUE II

Tucson Electric Power Company

Project Number: 60530048

December 22, 2017

Quality information

Prepared by	Checked by	Approved by
David Heinold Sr. Air Quality Meteorologist	Robert J. Paine Associate Vice President	Mary Kaplan Project Manager

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Appendix A VISCREEN OUTPUT

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1. Introduction

1.1 Project Overview

Tucson Electric Power Company (TEP) is proposing to modify the existing Irvington (Sundt) Generating Station (IGS) located in Tucson, Arizona, approximately 5 km northeast of Tucson International Airport. The reciprocating internal combustion engine (RICE) project involves adding ten quick-start RICEs for the purpose of load stabilization to accommodate intermittent renewable energy sources (solar and wind) that feed into the system. This project will also allow the retirement of two less efficient, older units (Units 1 & 2) at IGS.

1.2 Purpose of Protocol

The purpose of this document is to present the proposed methodology using the Level-3 PLUVUE II model ("PLUVUE") to assess visible plumes from the project sources at Saguaro National Park in support of the air permit application for the RICE project. In addition, the Level-2 VISCREEN model has been applied to reduce the number of simulated hours for the Level-3 analysis. The modeling is conservative in that it does not credit the removal of plume emissions from the sources to be retired. Modeling methods and assumptions, including model selection and options, meteorological data and source parameters to be used in the modeling analyses, are presented in this document for review and approval by the National Park Service (NPS) and Pima County Department of Environmental Quality (PDEQ).

1.3 Contents of the Modeling Protocol

Section 2 of this protocol document contains a project description, including information regarding the equipment, location and the expected air pollutant emissions. Sections 3 through 5 present a detailed description of the modeling approach proposed to be used in evaluating the potential for visible plumes at Saguaro National Park. Section 6 presents the description of the results analysis that will be submitted to NPS and PDEQ in support of the PSD permit application.

2. Project Description

2.1 Project Location and Layout

The proposed RICE project will be sited approximately 500 m to the southeast of existing units at IGS, which is located about 2 miles northeast of Tucson International Airport. An aerial map of the site region is provided in **Figure 2-1**.

The terrain surrounding IGS is generally flat within 10 kilometers before the landscape changes with the addition of rolling hills, rugged canyons and mountain peaks. **Figure 2-2** shows the varying elevations associated with these features near IGS.

2.2 Description of the Proposed Engines

The proposed modification at IGS includes the installation of ten RICEs, in two groups of five engines. Each group of engines has a cluster of five stacks, which for the modeling of CO and $PM_{2.5}$ pollutant concentrations were modeled as merged groups of 2 and 3 stacks in a procedure that has been separately approved by EPA. These engines will only be fired by natural gas and each will be installed with selective catalytic reduction (SCR) control utilizing ammonia and oxidation catalyst for CO and VOC control. The two clusters of five stacks sources are separated by a distance of nearly 100 m, aligned at an angle of 130° from true north as shown in **Figure 2-3**. For modeling plume visibility, it is conservatively assumed that the exhausts from the ten engines merge into a single plume, such that the effective emission source is placed at the centroid of the units, located at 509,240 UTM East and 3,557,820 UTM North as indicated in the figure.

2.3 Emissions and Source Characterization

For the Level-3 plume visibility assessment, natural gas-fired RICE emissions of three pollutants will be considered: sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (PM). PM emitted from natural gas combustion scatters visible light. Sulfur dioxide, although not optically active, converts during transport to ammonium sulfate, a light scattering particulate. Nitrogen oxides (comprised of NO and NO_2) contribute to plume visibility in two ways:

1) Some of the NO is converted to nitrogen dioxide (NO_2) when it reacts with atmospheric ozone. NO_2 can cause a plume to look yellow or brown because it preferentially absorbs the blue portion of the visible light;

2) During transport, NO_x can transform to ammonium nitrate, a particulate that scatters light.

PLUVUE II simulates both of these transformations and their associated optical effects.

Figure 2-1 Aerial Image of the Irvington Generating Station

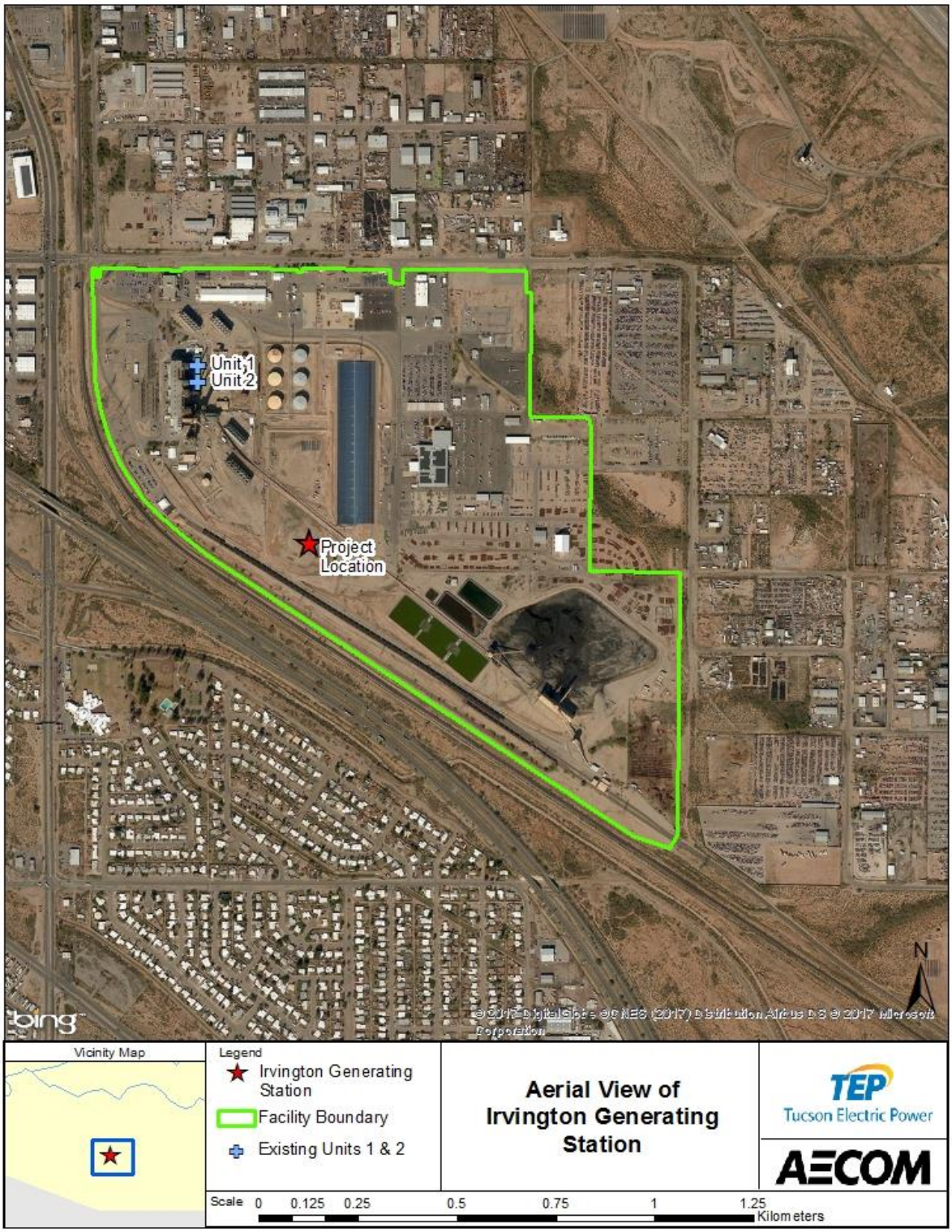


Figure 2-2 Topographic Map Showing Terrain Features Surrounding the Irvington Generating Station

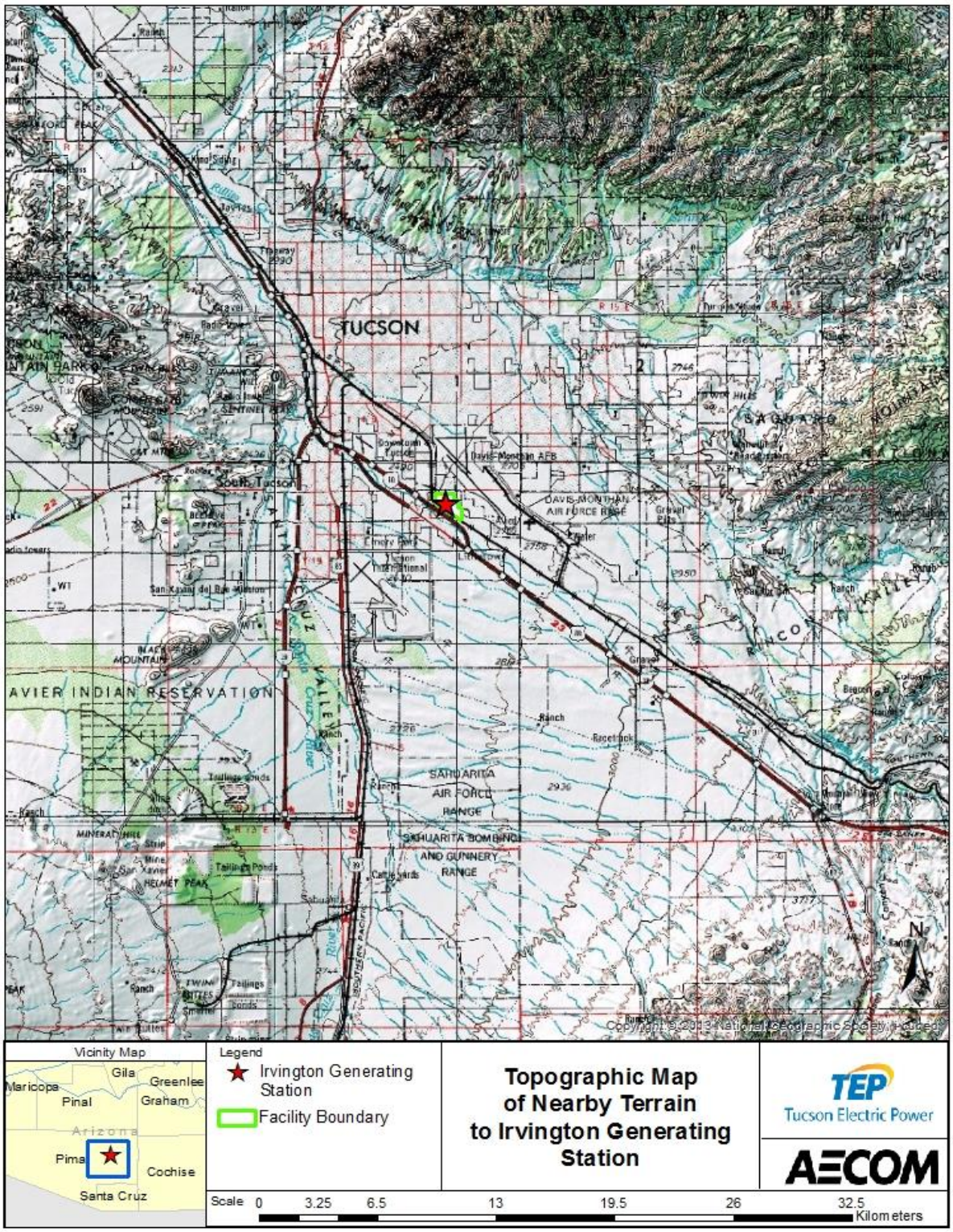
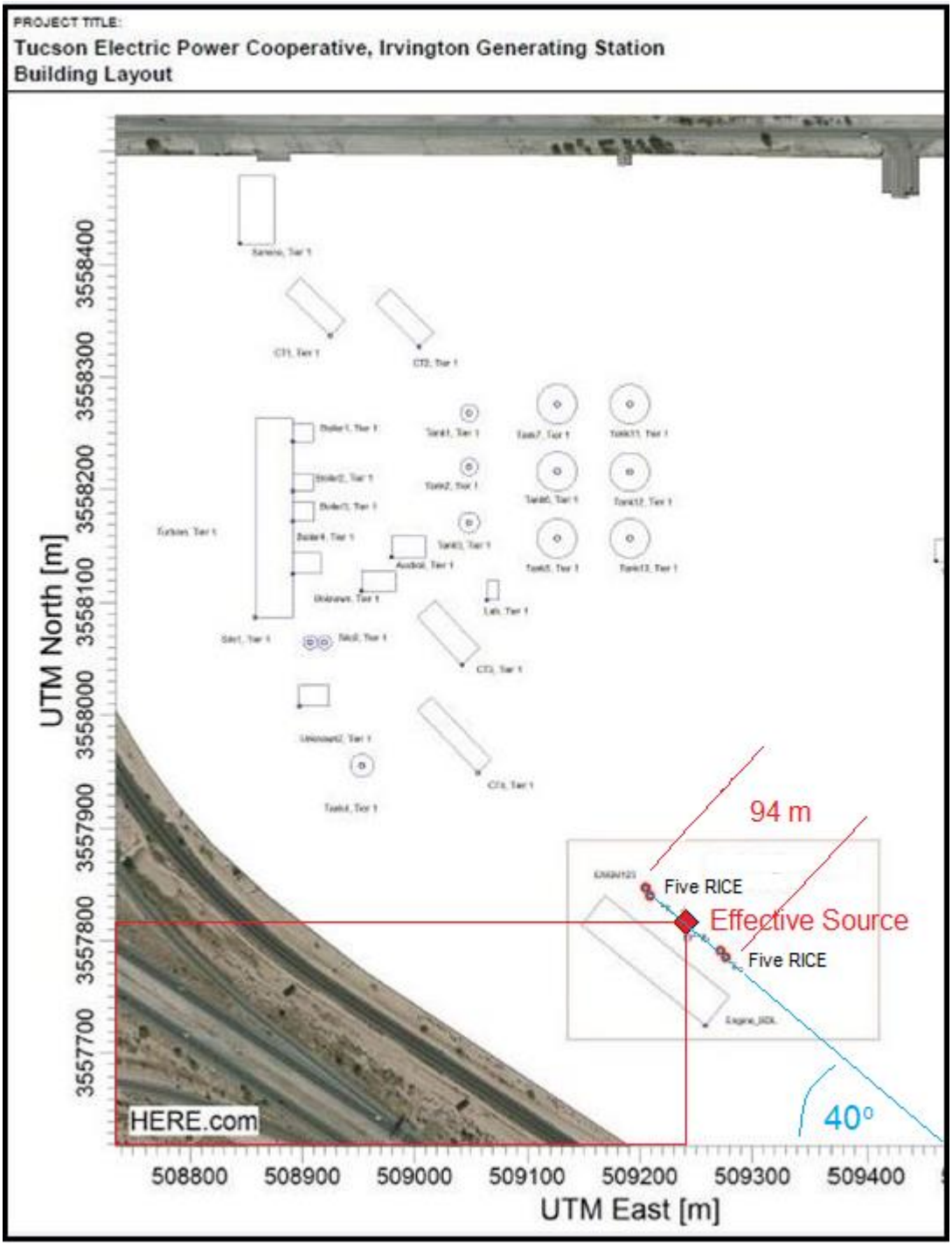


Figure 2-3 Location of RICE Units and Effective Source for the Plume Visibility Assessment



Two sets of emissions will be considered for the plume visibility assessment:

- Case 1: maximum 1-hour average emissions that account for the simultaneous start-up of all 10 RICE units within 30 minutes, plus 30 minutes running at 100% load in the same hour (this is a conservative case since one RICE unit is typically operating at a minimum of 50% load and the simultaneous start of all other engines in the same hour is not typical); and
- Case 2: emissions from all 10 RICE units at 100% load.

The combined emission rates for these two cases, which will be simulated in the PLUVUE plume visibility assessment, are provided in **Table 2-1.**

Table 2-1 Emissions Summary for All Ten RICE Units (pounds per hour)

Pollutant	Case 1	Case 2
PM	29.85	23.70
NOx	110.50	15.00
SO_2	3.20	3.20

PLUVUE II simulates the release and dispersion for all 10 engines from a single location even though emissions will actually be emitted from two main locations, each with 5 RICE units as shown in **Figure 2-3**. The AERMOD modeling assumed that each group of 5 RICE units consists of a group of 3 as well as 2 merged flues, for a total of 4 merged stacks serving the 10 RICE units. For PLUVUE, the effective stack parameters for the proposed project use the actual release height, exhaust temperature and exit velocity for a typical merged stack. In order to simulate plume rise that approximates the criteria pollutant modeling, one fourth of the total exhaust flow rate for the 10 RICE units was used for the single representative PLUVUE stack. The stack parameters for the effective source used in the visibility assessment are provided in **Table 2-2.**

Table 2-2 Stack Parameters Applied in PLUVUE II

Description	Stack Height (ft)	Temperature (K)	Volumetric Flow Rate (acfm)	Exit Velocity (m/s)
Engines 1-10	160	629	308,800	28.985

Note that because PLUVUE II simulates dispersion from a single stack, the source characterization necessarily differs from the approach used and approved by EPA for criteria pollutant modeling, in which four effective stacks were modeled, two stacks for each RICE cluster of 5 units[1,2].

To simulate the 94-m separation and orientation of the two RICE clusters, an initial plume width is specified in PLUVUE II by an initial cross-wind dispersion coefficient (sigma-y_0), which varies with wind direction. As such, the value of the initial sigma-y applied in the PLUVUE II simulations will be based on the wind direction for the selected hour of meteorology at the time of emission. When the wind direction is either 130° or 310°, the plumes from the two clusters align such that sigma-y_0 is equal to zero and when the wind blows in the perpendicular direction (40° or 220°) sigma-y_0 is maximized. Following EPA guidance for volume sources, the maximum sigma-y_0 is set to 21.9 m (94/4.3). For other wind directions, sigma-y_0 is between zero and 21.9 m.

[1] E-mail from Cleveland Holladay, EPA Region 9, to Rupesh Patel, Pima County, Arizona, dated October 19, 2017.
[2] EPA approved the merging of groups of stacks that are within one diameter of each other. This has resulted in a division of the cluster of 5 stacks at each RICE group into sets of 2 and 3 stacks being modeled as if the stacks were in a single merged stack.

3. PLUME Visibility Assessment Methodology

The plume visibility assessment will follow guidance provided by the National Park Service in consultation with staff at Saguaro National Park and applying AECOM's experience in conducting refined plume visibility assessments.

3.1 Model Selection

PLUVUE II is the model recommended by the NPS for Level-3 assessments[3]. It is appropriate because it incorporates specified observer points and lines of sight for various hours of the day, times of year and corresponding weather conditions, all of which are important in modeling plume perceptibility. As discussed in Section 3.4, VISCREEN was applied in a preprocessing step to remove from consideration hours with meteorological conditions for which perceptible plume visibility effects are not expected due to the high degree of plume dispersion.

3.1.1 Meteorological Data for PLUVUE II

The Arizona Department of Environmental Quality (ADEQ) has pre-processed meteorological data[4] for 2012-2016 for the Tucson International Airport (surface and upper air), using AERMET[5] version 16216 along with AERMINUTE version 15272 and AERSURFACE version 13016. The airport is located approximately 5 kilometers to the southwest of IGS. This data set will be used for the air quality impact analysis. A wind rose using the five-year period from 2012 to 2016 is provided as **Figure 3-1**.

AERMET output is used to provide to PLUVUE II the values of the wind direction, wind speed, and ambient temperature. PLUVUE II requires the following additional meteorological parameters not addressed by AERMET:

- atmospheric stability class (A-highly unstable to F-stable);
- temperature lapse rate near the surface; and
- urban mixing height.

Stability class and the urban mixing height will be determined by applying PCRAMMET[6], EPA's program that pre-processes hourly meteorology for Industrial Source Complex Model[7] (ISC3, the predecessor to AERMOD). PCRAMMET generates hourly values of stability and corresponding rural and urban mixing heights based on hourly surface observations and twice-daily mixing heights. Hourly meteorological data for the period 2012-2016, provided in SAMSON (Solar and Meteorological Surface Observation Network) format will be used as input

[3] Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report—Revised (2010)

[4] Arizona Department of Environmental Quality (ADEQ) AERMOD-ready meteorological data files are available at http://www.azdeq.gov/node/2127.

[5] EPA 2016. User's Guide for the AERMOD Meteorological Preprocessor (AERMET). EPA-454/B-16-010 (December 2016). Office of Air Quality Planning and Standards, Research Triangle Park, NC.

[6] Meteorological Processors and Accessory Programs https://www3.epa.gov/scram001/metobsdata_procaccprogs.htm

[7] https://www.epa.gov/scram/air-quality-dispersion-modeling-alternative-models

to PCRAMMET along with seasonal twice-daily urban mixing heights for precipitation-free days computed by EPA for Tucson, Arizona[8]. To be consistent with ISC3 model which like PLUVUE II simulates plume dispersion according to stability class, the mixing height for stable hours (E and F) will be unlimited (10,000 m).

The temperature lapse rate required in PLUVUE II (entered in units of ^{o}F per 1000 feet of elevation) is defined as adiabatic temperature lapse rate minus 10 K per km. The temperature lapse rate for each hour will be specified based on stability category using the potential temperature lapse rates from ISC: for Stability F: 35 K per km, for Stability E: 20 K per km and for stabilities A, B, C and D: 0 K per km.

3.2 Class I Area

FLAG Guidance indicates that for Class I areas within 50 km of a PSD Class I area, the applicant should perform a modeling evaluation of visible plumes as an Air Quality Related Value. As shown in **Figure 3-2**, Saguaro National Park East and West Units are the only Class I areas within 50 km of the project site.

3.3 Background Data for PLUVUE Modeling

PLUVUE requires the input of background concentrations of ozone, NO_x and NO_2 as well as background visual range. Hourly background pollutant concentrations will be taken from a representative ADEQ monitor located in Tucson (yellow star in **Figure 3-3**).

Plume perceptibility increases with the increase in background visual range, a measure of the amount of light extinction in the background atmosphere through which the plume is viewed. The monthly natural background visual range specified by the NPS[9] varies from 248 km to 252 km. The maximum monthly natural background visual range will be applied in PLUVUE II, because the modeled plume visibility parameters are not expected to be sensitive to this minor variation.

Although the PLUVUE II analysis will apply the maximum natural background visual range recommended by the NPS, this value far exceeds the actual visual range that has recently been experienced at Saguaro National Park. **Figure 3-4** from the VIEWS[10] website provides the plot of the total daily measured light extinction ($B_{ext,}$ Mm^{-1}) at Saguaro National Park West. For a uniform atmosphere extinction coefficient can be used to compute visual range according to the Koschmieder equation[11]:

$$VR\ (km) = 3912 / B_{ext.}$$

To place the natural background visual range to the experience of visitors to Saguaro NP, the average and the 99th percentile visual ranges, corresponding to extinction values of 30 Mm^{-1} and 20 Mm^{-1}, respectively, have been computed. The average visual range is 131 km and the 99th percentile visual range is 196 km, indicating a high degree of conservatism in the PLUVUE II analysis.

[8] Holzworth, 1972, Mixing Heights, "Wind Speed and Potential for Urban Air Pollution Throughout the Contiguous United States", AP-101, Appendix B, page 110

[9] Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report—Revised (2010), Table 10.

[10] http://views.cira.colostate.edu/web/

[11] https://www.stanford.edu/group/efmh/jacobson/FAMbook/Chap10.pdf Chapter 10 of Fundamentals of Atmospheric Modeling by Mark Z. Jacobson Department of Civil & Environmental Engineering Stanford University Stanford, CA 94305-4020

Figure 3-1 Wind Rose from Tucson International Airport 2012-2016

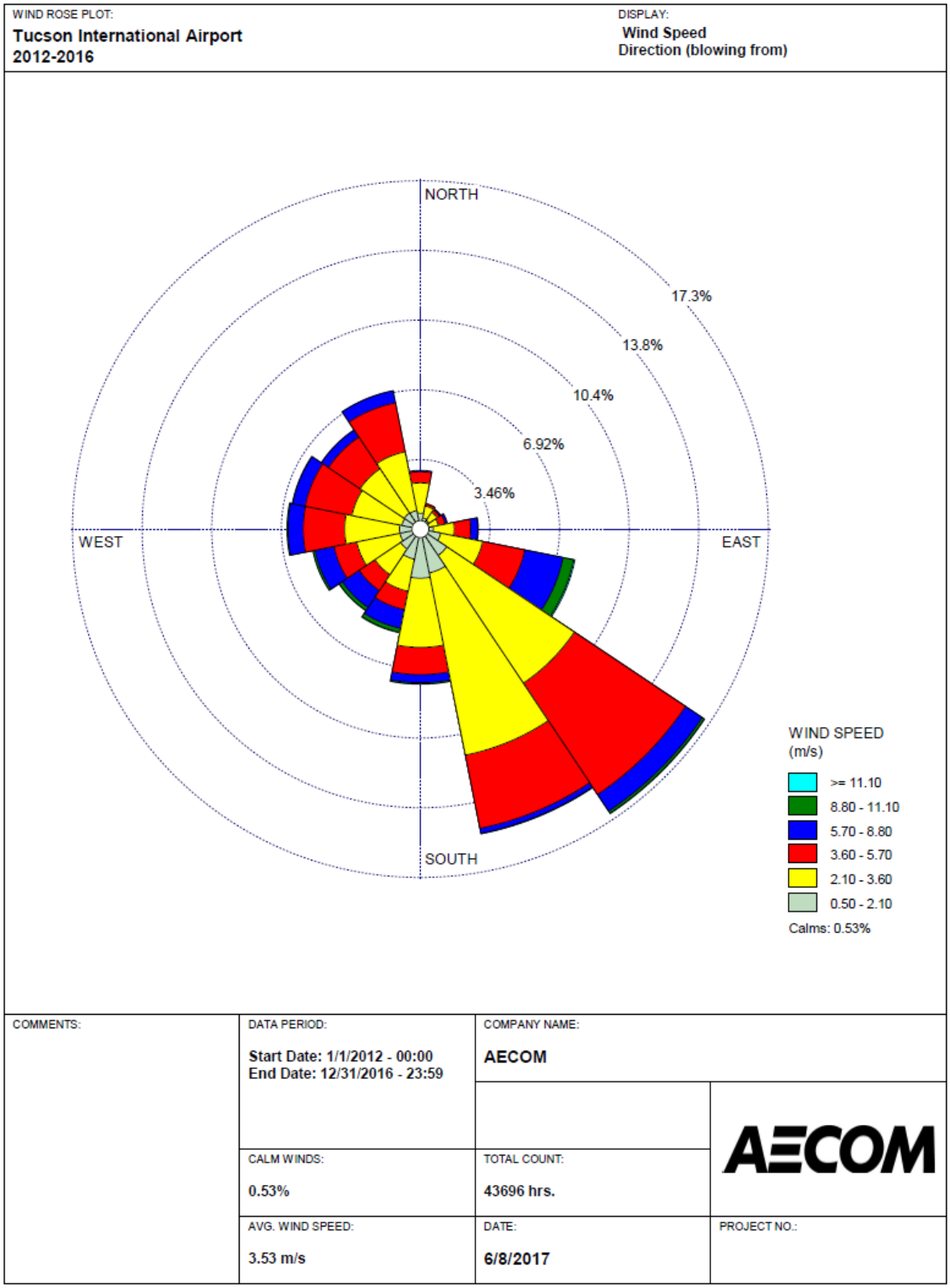


Figure 3-2 Class I Areas within 50 km of IGS

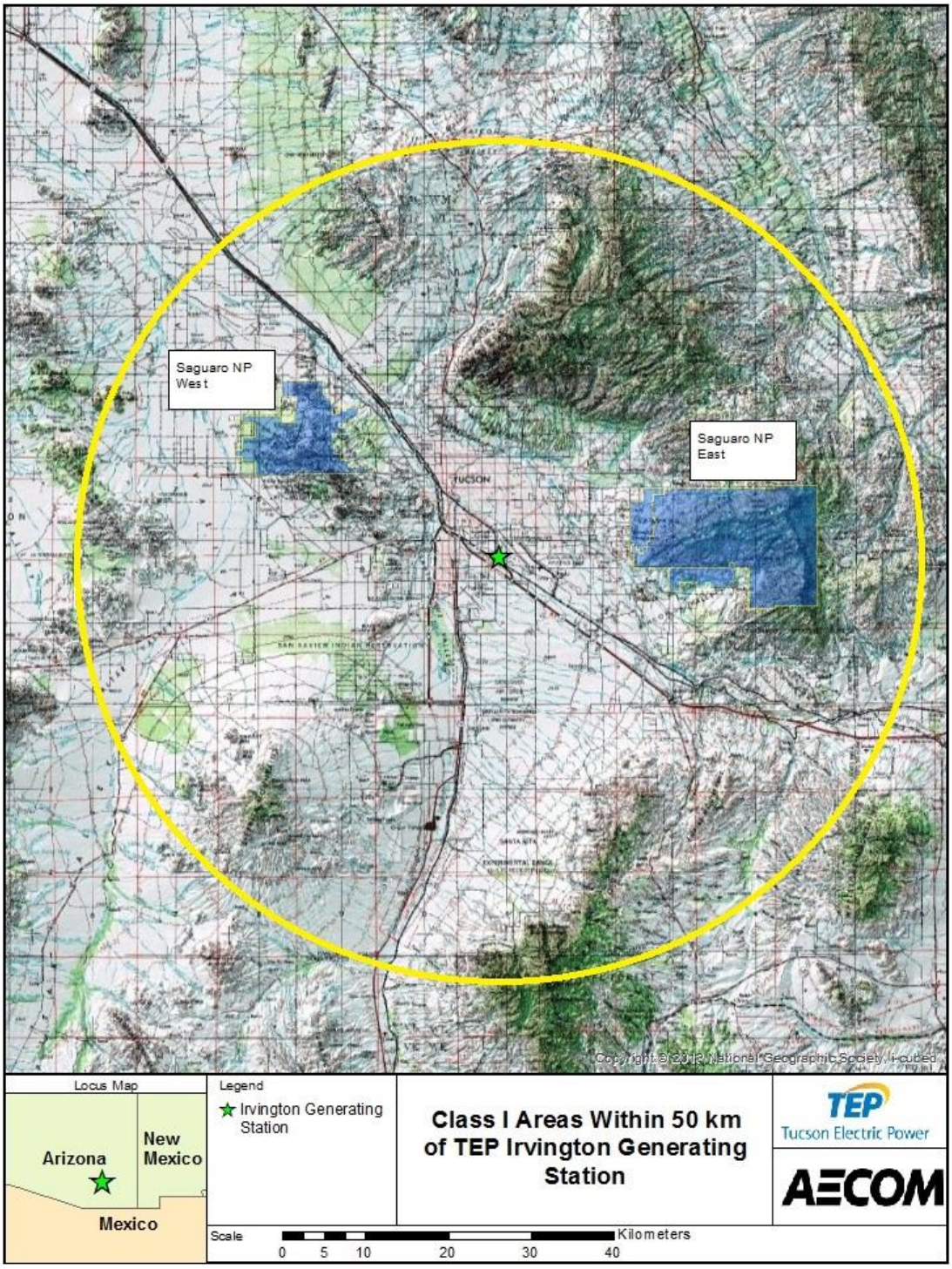


Figure 3-3 Location of Nearby Ambient Monitor for Ozone and NO_2

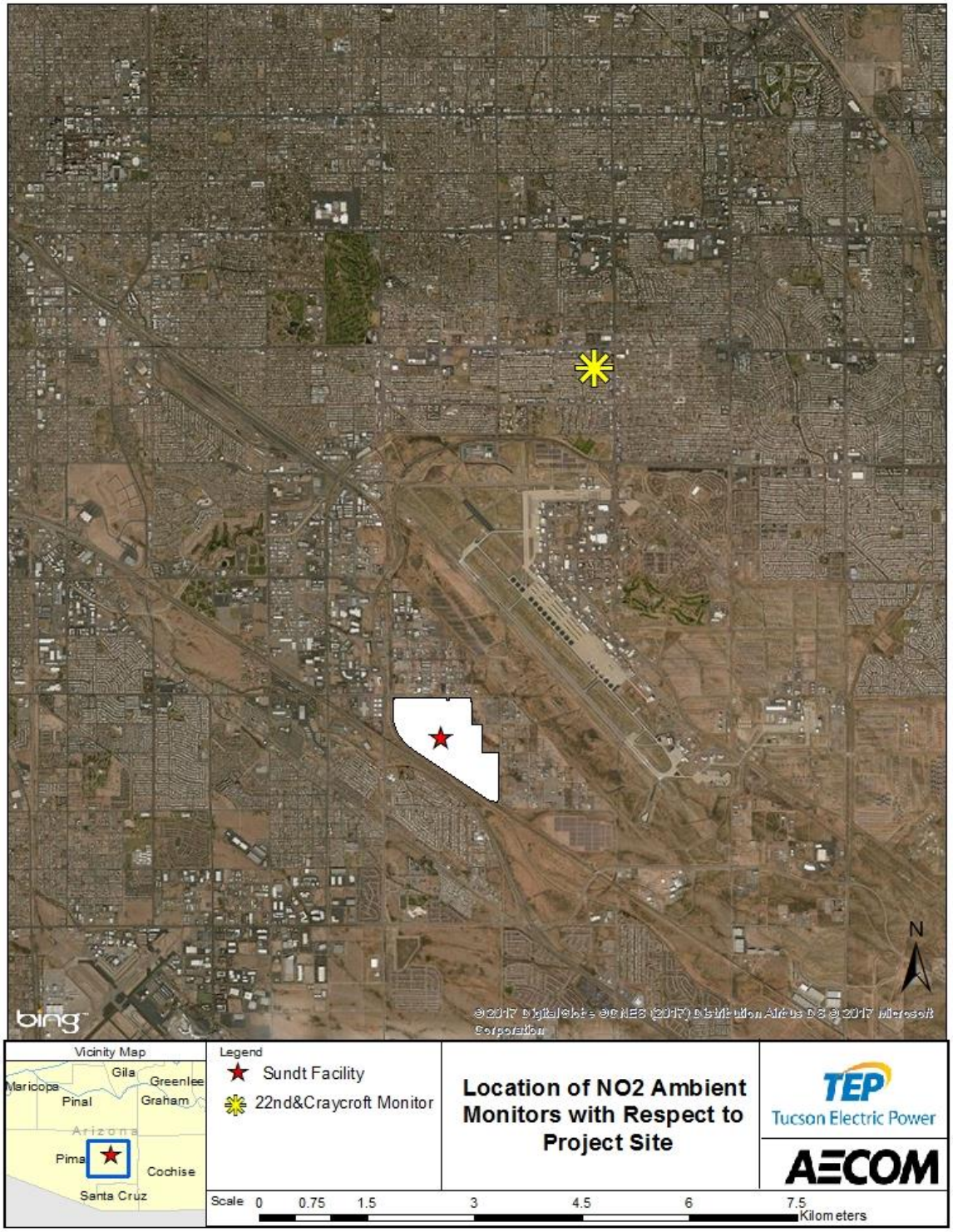
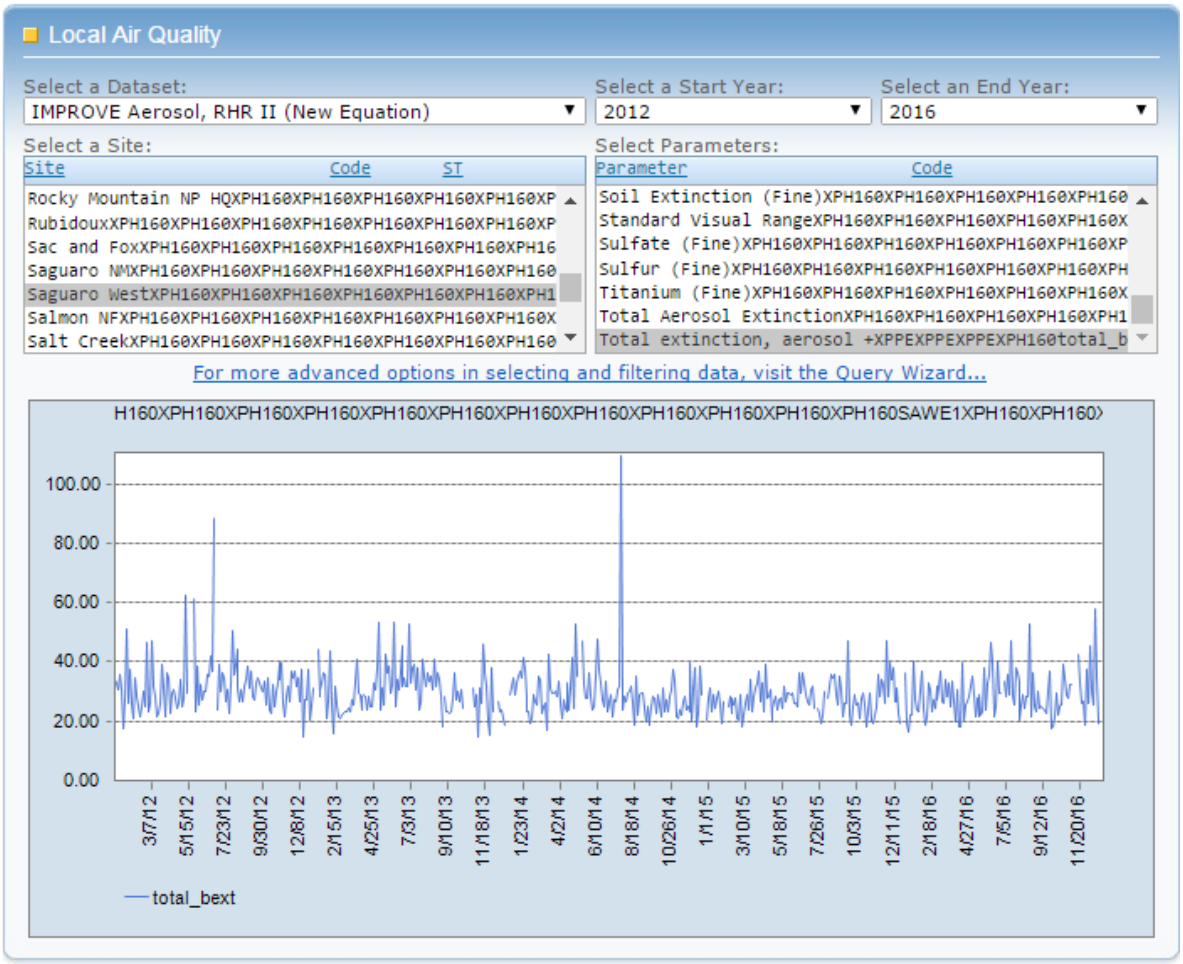


Figure 3-4 Measured Optical Extinction at Saguaro West National Park



3.4 Selection of Hours Simulated with PLUVUE II

3.4.1 Apply VISCREEN to Determine Stability Categories to Be Excluded

VISCREEN provides a means to screen out meteorological conditions prior to running PLUVUE II because it incorporates an observer's line-of-site through a plume and sun angle that maximizes the absolute value of the modeled plume perceptibility parameters. VISCREEN has been applied with Case 1 emission rates for an observer at Saguaro NP East and West with the specifications provided in **Table 3-1**. The wind speed of 1 m/sec was applied to maximize plume visibility for each stability category. All of the other parameters were taken from the VISCREEN assessment that was previously applied for the TEP permit application[12]. The corresponding VISCREEN output files are provided in Appendix A. The maximum values of C_p and ΔE for each stability class provided in **Table 3-2** indicate modeled visibility parameters are less than the screening-level thresholds of 2.0 for ΔE and +/- 0.05 for C_p for the stability classes A, B and C for Saguaro West and stability classes A and B for Saguaro East, respectively. Thus, these stability categories will be excluded in the five years of hourly meteorological data

[12] Air Quality Dispersion Modeling Report in Support of the Application for a Prevention of Significant Deterioration (PSD) Authorization and Significant Revision to Class I Air Quality Permit for Irvington Generating Station, Tucson Electric Power Company, AECOM Project Number: 60530048 July 27, 2017

for PLUVUE II. The procedures used in the Level-2 VISCREEN model were described in a previously-submitted modeling report.

Table 3-1 VISCREEN Modeling Parameters

Parameter	SNPW	SNPE
Background Ozone (ppm)	0.03	0.03
Background Visual Range (km)	252	252
Source-Observer Distance (km)	19.10	15.49
Min. Source-Class I Distance (km)	19.10	15.49
Max. Source-Class I Distance (km)	35.96	39.06
Wind Speed (m/s)	1.00	1.00

Table 3-2 VISCREEN Level 1 Results by Stability Category for Case 1 Emissions

Stability	SNPW		SNPE	
	Cp	ΔE	Cp	ΔE
A	0	0	0	0
B	0.004	0.515	0.005	0.747
C	0.011	1.519	0.019	2.197
D	-0.067	6.424	0.102	11.06
E	10.732	0.131	0.188	18.564
F	16.849	0.235	0.333	27.083

Note: Shaded values indicate insignificance

3.4.2 Criteria for Selecting Hours to be Simulated with PLUVUE II

The hourly meteorological data will be parsed according to the following criteria:

1. Hours will be considered between the hour prior to sunrise through hour prior to sunset;

2. For SNPW, hours with stability classes of D, E, or F and for SNPE, hours with stability classes of C, D, E, or F;

3. Hours free of precipitation or relative humidity less than 90%, to eliminate natural obscuration;

4. The full range of wind directions corresponding to each portion of the Class I area is illustrated in **Figure 3-5**:

   - For SNPE: 243° to 281° (west-southwest to west) and
   - For SNPW: 109° to 136° (east-southeast to southeast).

   The selected simulated hours have wind directions within these windows that represent plume transport directions that cross between the observer and the target terrain listed below in **Table 3-3**. For instance, for observer W7 the wind direction window is 119.17° and 131.80°.

If the wind direction varies during the time it would take for the plume to reach the line-of-sight, then a plume may meander and pass outside of the line-of-sight. Thus, an additional criterion was imposed based on wind persistence. If after one hour of transport the plume would not reach the Class I area, the wind speed and direction for the following hour will be checked to determine if the wind direction is within the line-of-sight window and the wind speed is sufficient to reach the Class I area in two hours. This step will be repeated until there is a sufficient number of hours of a persistent wind direction is achieved for the plume to reach the specified line-of-sight within the Class I area.

PLUVUE requires a solar elevation angle of at least 2° for considering the hour to be simulated. Accounting for travel time in setting the observation hour in PLUVUE allowed for the inclusion of stable pre-dawn emission hours as suggested by the NPS.

The spreadsheet accompanying this protocol (*PLUVUE Hours.xlsx*) carries out this filtering process on the five years of meteorological data.

3.5 Selection of Observer Locations, Lines of Site

The assessment will address 16 lines of sight, combinations of observer locations and terrain features being viewed that have been recommended by the NPS[13]. These are shown in **Figures 3-6 and 3-7**. An observer will be placed on each end of the line-of-sight indicated by the light blue lines, looking toward the terrain on which the corresponding observer is standing. Details of the geometry for each observer-terrain pair are provided in **Table 3-3**. Hours with wind directions which cause the centerline of the plume to cross the line-of-sight and which meet the other criteria specified in Section 3.4.2 will be assessed with PLUVUE II.

[13] 40 CFR 51.304 Identification of integral vistas https://www.law.cornell.edu/cfr/text/40/51.304

Figure 3-5 Wind Direction Sectors for Saguaro National Park East and West

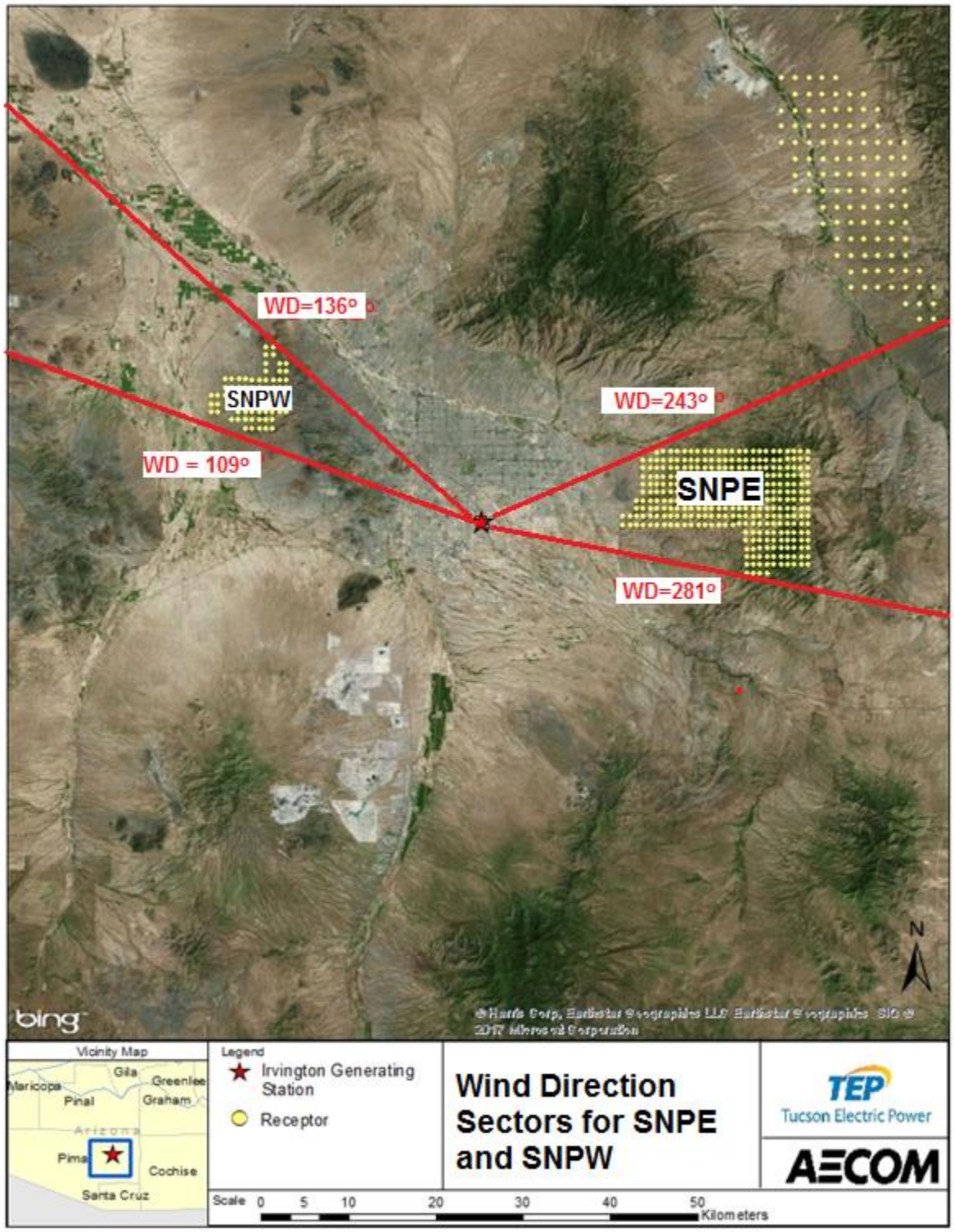


Figure 3-6 Observer-Terrain Target Combinations at SNPW

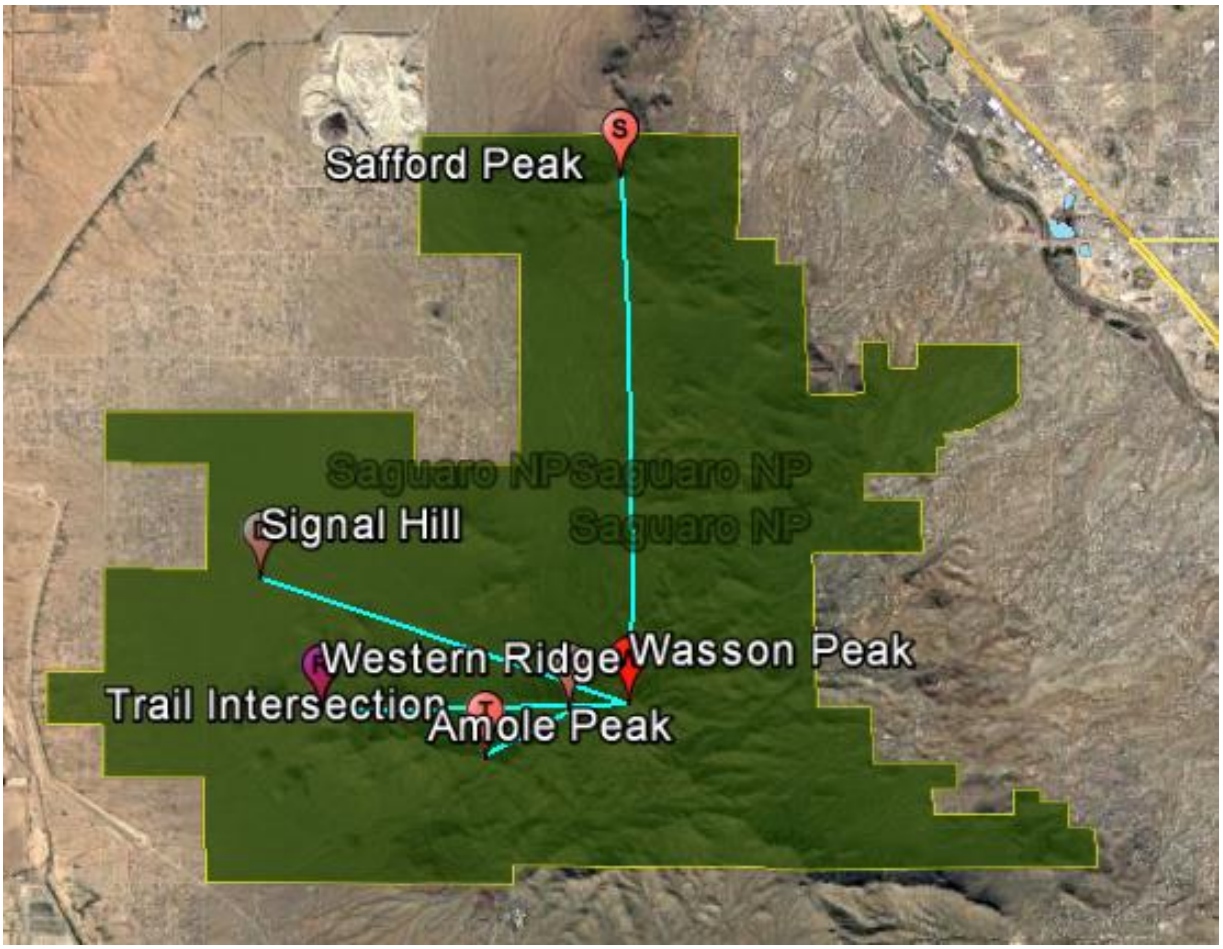
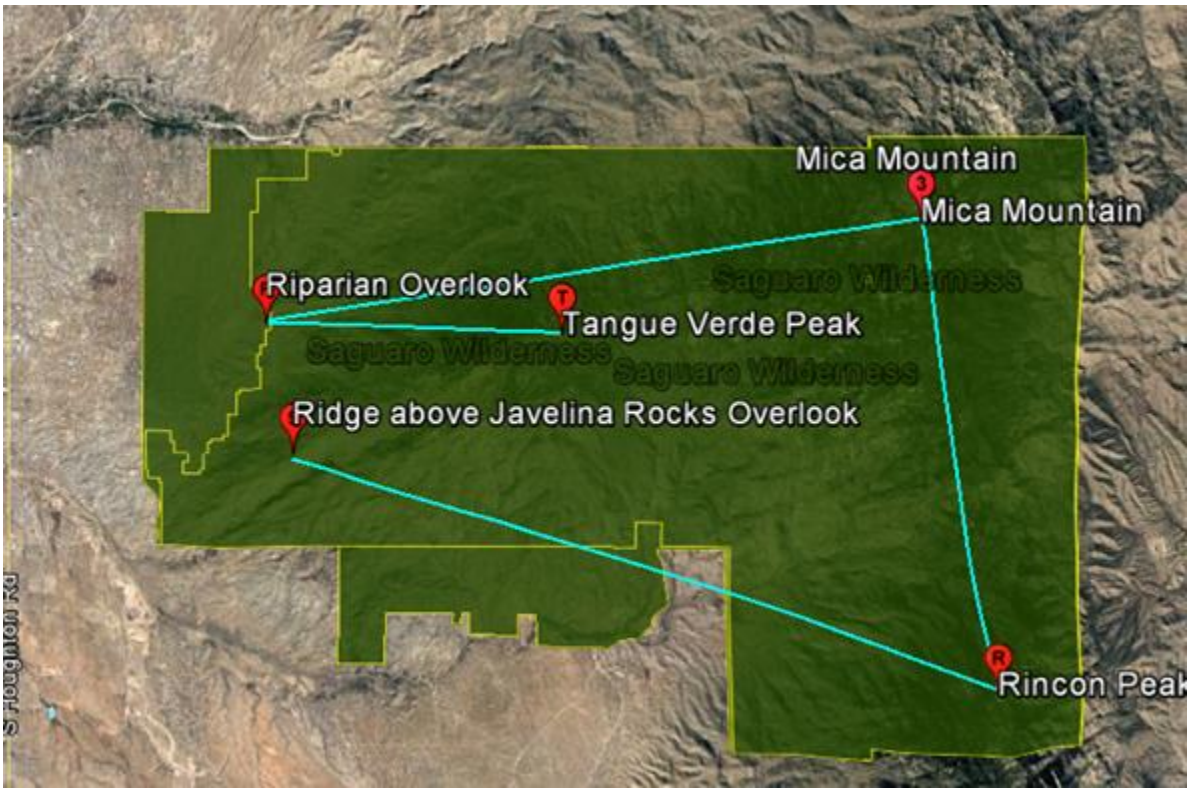


Figure 3-7 Observer-Terrain Target Combinations at SNPE



In addition to the specified line-of-sight, other lines-of-sight through which the plume will be observed within the Class I area will be simulated. This will ensure that the observer-plume-sun geometry that maximizes the modeled plume visibility will be simulated. To accomplish this, PLUVUE will be applied in an observer-based mode with lines of sight passing through the plume at 16 downwind distances (the maximum number allowed in PLUVUE II). These distances will include the four prescribed in the User's Guide (1, 2.5, 5 and 10 km) that are required for the model to run properly. These distances will not be used for the assessment since they are all closer to the RICE units than the nearest point of the Class I areas. The distances to be evaluated for the plume visibility assessment include the NPS-recommended primary line-of-sight plus another eleven distances evenly spaced between the closest point along the mean plume trajectory and the furthest point in each Class I area. The model requires the terrain elevation (feet above mean sea level) to be specified for each of these downwind distances. These elevations will be determined for the mean plume path, corresponding to the wind direction that bisects each of the lines-of-sight pairs recommended by the NPS.

Another parameter to be specified is the straight-line distance (km) from the observer to the terrain of interest. This is specified in 15° intervals around the compass. For the 15° intervals that bracket the primary line-of-sight, the terrain distance will be specified as distance separating the observer and the observed terrain target that has been specified by the NPS. For the other 15° intervals, the terrain distance will be set to the distance to the Class I area boundary.

An illustration of how the various parameters will be specified for a selected observer is provided in **Figure 3-8**, which depicts an observer at Mica Mountain at Saguaro National Park East with a primary line-of-sight toward Rincon Peak at a distance of 11.2 km.

Table 3-3 Details for Recommended Lines-of-Site

Class I Area	Line-of-Sight ID	Observer	Viewing Target	Observer		Viewing Target		Observer-Target Distance (km)	WD to Observer (deg)	WD to Target (deg)	Size of WD Window (deg)	LOS-Plume Angle (deg)
				UTME (m)	UTMN (m)	UTME (m)	UTMN (m)					
SNPW	W1	Trail Intersection	Amole Peak	483884	3569878	485214	3570618	1.5	115.4	118.0	2.6	87.6
SNPW	W2	Amole Peak	Trail Intersection	485214	3570618	483884	3569878	1.5	118.0	115.4	2.6	87.6
SNPW	W3	Wasson Peak	Western Ridge	486161	3570726	481258	3570571	4.9	119.2	114.5	4.7	115.0
SNPW	W4	Western Ridge	Wasson Peak	481258	3570571	486161	3570726	4.9	114.5	119.2	4.7	115.0
SNPW	W5	Wasson Peak	Signal Hill	486161	3570726	480321	3572622	6.1	119.2	117.1	2.1	100.1
SNPW	W6	Signal Hill	Wasson Peak	480321	3572622	486161	3570726	6.1	117.1	119.2	2.1	100.1
SNPW	W7	Wasson Peak	Safford Peak	486161	3570726	485884	3578731	8.0	119.2	131.8	12.6	37.5
SNPW	W8	Safford Peak	Wasson Peak	485884	3578731	486161	3570726	8.0	131.8	119.2	12.6	37.5
SNPE	E1	Rincon Peak	Ridge above Javelina Rocks Overlook	544996	3553814	528384	3559211	17.5	276.4	265.9	10.5	16.8
SNPE	E2	Ridge above Javelina Rocks Overlook	Rincon Peak	528384	3559211	544996	3553814	17.5	265.9	276.4	10.5	16.8
SNPE	E3	Rincon Peak	Mica Mountain	544996	3553814	543063	3564890	11.2	276.4	258.2	18.2	82.8
SNPE	E4	Mica Mountain	Rincon Peak	543063	3564890	544996	3553814	11.2	258.2	276.4	18.2	82.8
SNPE	E5	Mica Mountain	Riparian Overlook	543063	3564890	527712	3562246	15.6	258.2	256.6	1.6	22.4
SNPE	E6	Riparian Overlook	Mica Mountain	527712	3562246	543063	3564890	15.6	256.6	258.2	1.6	22.4
SNPE	E7	Riparian Overlook	Tangue Verde Peak	527712	3562246	534751	3562179	7.0	256.6	260.4	3.8	12.1
SNPE	E8	Tangue Verde Peak	Riparian Overlook	534751	3562179	527712	3562246	7.0	260.4	256.6	3.8	12.1

Figure 3-8 Illustration of Plume Trajectory, Observation Points, Plume Path Elevation and Radial Terrain Distances for an Observer at Mica Mountain and Target at Rincon Peak

X No.	Distance (km)	Height (ft msl)
1	1	2650
2	2.5	2682
3	5	2746
4	10	2808
5	15.6	3046
6	17.84	3930
7	20.08	4320
8	22.32	4970
9	24.56	5264
10	26.8	4418
11	29.04	4621
12	31.28	5775
13	33.52	5894
14	**34.85**	**6839**
15	37.09	6826
16	38	4607

3.6 Other Specifications for PLUVUE II runs

An example PLUVUE II input file for the observer-target combination illustrated in **Figure 3-8** is provided in **Figure 3-9**. For PLUVUE II inputs that are not discussed above nor related to the site-specific application (such as particle distributions and optical properties), PLUVUE II default values will be applied. Each run will apply the meteorological conditions and the measured background concentrations at the time of emission to estimate dispersion, transport and chemical processes. The time of day for the observer to view a plume as it passes over the Class I area will be one to four hours after the emissions hour, depending on the average wind speed starting at the hour of the release to the hour the plume reaches the nearest point of the Class I area. In this case, for a wind speed of 13.3 mph (21.4 km/hr), the plume would reach the Class I area after an hour of transport. As such, the time of the observation is set to 9 AM, or one hour after the time of emission.

In analyzing the output of PLUVUE II, in accordance with NPS guidance, results for lines of sight aimed almost straight up and down the plume will be excluded. This situation occurs if a plume centerline passes very close to an observer so that it is nearly overhead and the observer is looking either toward or directly away from the project location. In VISCREEN, these lines of sight are excluded by setting a minimum value of the angle between the line of sight and the plume centerline (alpha) to 11.25 degrees. For the PLUVUE assessment, the minimum alpha for which the results will be analyzed will be set to 10 degrees.

Figure 3-9 Example PLUVUE II Input File

```
SNPE-Mica to Rincon
 13.3    4 -5.49
 1
     14.91        0.
     500.0
    14.000
    0
 1 1 1 016 1 7 1 0 0 0
 1 0 0 0 0 0
       1.0       2.5       5.0      10.0      15.6      17.8      20.1      22.3
      24.6      26.8      29.0      31.3      33.5      34.9      37.1      38.0
      0.00     1.326    0.3582
  308800.0     629.0       3.0     28.98
  2.0160.0
      57.8
   0.00051   0.00051     0.032     0.000
     0.150     3.000     0.100     1.000
     2.000     2.200     2.000     2.000
     1.500     2.500     1.500     2.500
     0.050     2.000     2.000     0.000     0.000
     1.500     0.000     1.500     0.000
     1.500     0.000     2.000     1.000
     5.000
    2
   252.000
 1.00 1.00 0.10 0.10
    0
 0.0000000
    2    2
  543.0630 3564.890    8612.00
  509.2422 3557.8440   2625.00
   12    3    40900.   7. 2013
    2650.0    2682.0    2746.0    2802.0    3046.0    3930.0    4320.0    4970.0
    5264.0    4418.0    4621.0    5775.0    5894.0    6839.0    6826.0    4607.0
       1.9       2.0       2.8       3.9       4.3       4.1       4.2       5.0
       5.7       7.0      11.2      11.2      13.2       9.0      13.5      16.5
      19.0      16.6       4.2       2.7       2.0       2.0       1.9       1.8
     267.0
```

4. Interpretation of Model Outputs

For each of two emission cases and 16 observer-target combinations, results will be provided in tabular format for the following parameters:

- Plume-terrain contrast (Cp) for sky and white, gray and black terrain background[14]
- Perceptibility (ΔE) for sky and white, gray and black terrain background.
- List of the modeled values (ranked by absolute value for Cp) with corresponding meteorological conditions
- Number of excursions above up to four specified thresholds
  - For Cp: +/-0.02, 0.035, 0.05 and 0.075
  - For ΔE: 1, 1.5, 2 and 3
- Number of expected excursions by
  - Month
  - Hour of the day observed
  - Number of days per year
  - Number of days with multiple hours of excursions.

The most constraining statistics for these metrics among the 16 lines-of-sight within the Class area will be determined.

It is understood that there are no established thresholds for either magnitude or frequency of the modeled plume visibility parameters which would automatically determine the degree of "acceptability", because there are many factors the NPS may take into account. There are many factors that could affect how the model output is interpreted. For example, the coloration and brightness of the background terrain as illustrated in **Figure 4-1** could affect whether white, gray or black background is appropriate and the size of the plume in relation to the field of vision may affect plume perceptibility[15].

The hours selected for the PLUVUE II cases do not impose any restrictions on the periods for which the emissions for the two cases modeled would actually occur during the periods when the plume reaches the Class I area during daylight hours. How often the RICE engines are expected to be operating in the two modeled modes could also be accounted for in evaluating the frequency of the modeled parameters. For example, if worst-case startup conditions are possible for up to 5 hours per day, there are 19 hours per day for which these emission conditions do not occur.

[14] Eye adjusted to background terrain
[15] Richards, W.; J. Prouty,; S. Zell; and P. Catizone, 2007. "Refinements of Plume Visibility Thresholds for Apparent Plume Width", Air and Waste Management Association: Pittsburgh, PA, 2007.

Figure 4-1 Photo of Saguaro National Park

Photo credit: https://www.expedia.com/pictures/arizona/southern-arizona.d6054714/landscape/.

Appendix A VISCREEN OUTPUT

```
              Visual Effects Screening Analysis for
                Source: RICE
                Class I Area: SNPE


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        15.49 km
    Min. Source-Class I Distance:    15.49 km
    Max. Source-Class I Distance:    39.06 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   1
    Wind Speed:   1.00 m/s

                           R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
          Screening Criteria ARE NOT Exceeded
                                    Delta E       Contrast
                                 ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 162.   39.1     7. 21.63  0.000   0.54  0.000
 SKY     140. 162.   39.1     7. 13.93  0.000   0.54  0.000
 TERRAIN  10. 162.   39.1     7. 14.84  0.000   0.54  0.000
 TERRAIN 140. 162.   39.1     7. 10.19  0.000   0.54  0.000


         Maximum Visual Impacts OUTSIDE Class I Area
             Screening Criteria ARE Exceeded
                                    Delta E       Contrast
                                 ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.93  1.608   0.06  0.031
 SKY     140.   1.    1.0   168.  2.00  0.727   0.06 -0.013
 TERRAIN  10.   1.    1.0   168.  2.00  5.343*  0.06  0.038
 TERRAIN 140.   1.    1.0   168.  2.00  0.534   0.06  0.004
```

```
              Visual Effects Screening Analysis for
                Source: RICE
                Class I Area: SNPE


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        15.49 km
    Min. Source-Class I Distance:    15.49 km
    Max. Source-Class I Distance:    39.06 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   2
    Wind Speed:   1.00 m/s

                           R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
          Screening Criteria ARE NOT Exceeded
                                     Delta E       Contrast
                                  ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 162.   39.1     7. 11.77  0.275   0.27  0.005
 SKY     140. 162.   39.1     7.  7.58  0.095   0.27 -0.002
 TERRAIN  10.  84.   15.5    84.  8.27  0.747   0.43  0.003
 TERRAIN 140.  84.   15.5    84.  5.76  0.025   0.43  0.000


         Maximum Visual Impacts OUTSIDE Class I Area
            Screening Criteria ARE Exceeded
                                     Delta E       Contrast
                                  ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.00  8.445*  0.05  0.187*
 SKY     140.   1.    1.0   168.  2.00  2.625*  0.05 -0.063*
 TERRAIN  10.   1.    1.0   168.  2.00 22.134*  0.05  0.185*
 TERRAIN 140.   1.    1.0   168.  2.00  2.201*  0.05  0.023
```

```
              Visual Effects Screening Analysis for
                Source: RICE
                Class I Area: SNPE


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        15.49 km
    Min. Source-Class I Distance:    15.49 km
    Max. Source-Class I Distance:    39.06 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   3
    Wind Speed:   1.00 m/s

                           R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
          Screening Criteria ARE NOT Exceeded
                                     Delta E       Contrast
                                  ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 162.   39.1     7.  4.67  0.904   0.10  0.016
 SKY     140. 162.   39.1     7.  3.01  0.312   0.10 -0.007
 TERRAIN  10. 162.   39.1     7.  3.20  2.197   0.10  0.019
 TERRAIN 140. 162.   39.1     7.  2.20  0.268   0.10  0.003


         Maximum Visual Impacts OUTSIDE Class I Area
            Screening Criteria ARE Exceeded
                                     Delta E       Contrast
                                  ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.00 14.040*  0.05  0.332*
 SKY     140.   1.    1.0   168.  2.00  3.534*  0.05 -0.098*
 TERRAIN  10.   1.    1.0   168.  2.00 31.210*  0.05  0.283*
 TERRAIN 140.   1.    1.0   168.  2.00  3.332*  0.05  0.040
```

Visual Effects Screening Analysis for
Source: RICE
Class I Area: SNPE

*** User-selected Screening Scenario Results ***

Input Emissions for

Particulates	29.85	LB /HR
NOx (as NO2)	110.50	LB /HR
Primary NO2	0.00	LB /HR
Soot	0.00	LB /HR
Primary SO4	0.50	LB /HR

PARTICLE CHARACTERISTICS

	Density	Diameter
Primary Part.	2.5	6
Soot	2.0	1
Sulfate	1.5	4

Transport Scenario Specifications:

Background Ozone:	0.03	ppm
Background Visual Range:	252.00	km
Source-Observer Distance:	15.49	km
Min. Source-Class I Distance:	15.49	km
Max. Source-Class I Distance:	39.06	km
Plume-Source-Observer Angle:	11.25	degrees
Stability:	5	
Wind Speed:	1.00	m/s

R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

Maximum Visual Impacts INSIDE Class I Area
Screening Criteria ARE Exceeded

					Delta E		Contrast	
Backgrnd	Theta	Azi	Distance	Alpha	Crit	Plume	Crit	Plume
SKY	10.	162.	39.1	7.	2.00	10.197*	0.05	0.188*
SKY	140.	162.	39.1	7.	2.00	3.434*	0.05	-0.080*
TERRAIN	10.	162.	39.1	7.	2.00	18.564*	0.05	0.185*
TERRAIN	140.	162.	39.1	7.	2.00	3.099*	0.05	0.038

Maximum Visual Impacts OUTSIDE Class I Area
Screening Criteria ARE Exceeded

					Delta E		Contrast	
Backgrnd	Theta	Azi	Distance	Alpha	Crit	Plume	Crit	Plume
SKY	10.	1.	1.0	168.	2.00	31.732*	0.05	0.855*
SKY	140.	1.	1.0	168.	2.00	7.554*	0.05	-0.228*
TERRAIN	10.	1.	1.0	168.	2.00	48.120*	0.05	0.509*
TERRAIN	140.	1.	1.0	168.	2.00	8.229*	0.05	0.112*

```
              Visual Effects Screening Analysis for
                Source: RICE
                Class I Area: SNPE


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        15.49 km
    Min. Source-Class I Distance:    15.49 km
    Max. Source-Class I Distance:    39.06 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   4
    Wind Speed:   1.00 m/s

                           R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 162.   39.1     7.  2.00  5.289*  0.05  0.096*
 SKY     140. 162.   39.1     7.  2.00  1.807   0.05 -0.041
 TERRAIN  10. 162.   39.1     7.  2.00 11.060*  0.05  0.102*
 TERRAIN 140. 162.   39.1     7.  2.00  1.590   0.05  0.019


         Maximum Visual Impacts OUTSIDE Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.00 24.256*  0.05  0.621*
 SKY     140.   1.    1.0   168.  2.00  5.657*  0.05 -0.170*
 TERRAIN  10.   1.    1.0   168.  2.00 42.386*  0.05  0.426*
 TERRAIN 140.   1.    1.0   168.  2.00  5.918*  0.05  0.077*
```

```
              Visual Effects Screening Analysis for
                Source: RICE
                Class I Area: SNPE


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        15.49 km
    Min. Source-Class I Distance:    15.49 km
    Max. Source-Class I Distance:    39.06 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   6
    Wind Speed:   1.00 m/s

                           R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 162.   39.1     7.  2.00 17.693*  0.05  0.333*
 SKY     140. 162.   39.1     7.  2.00  5.791*  0.05 -0.142*
 TERRAIN  10. 162.   39.1     7.  2.00 27.083*  0.05  0.292*
 TERRAIN 140. 162.   39.1     7.  2.00  5.427*  0.05  0.073*


         Maximum Visual Impacts OUTSIDE Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.00 41.816*  0.05  1.204*
 SKY     140.   1.    1.0   168.  2.00 10.618*  0.05 -0.314*
 TERRAIN  10.   1.    1.0   168.  2.00 53.924*  0.05  0.600*
 TERRAIN 140.   1.    1.0   168.  2.00 12.035*  0.05  0.176*


              Visual Effects Screening Analysis for
```

```
                Source: RICE
                Class I Area: SNPW


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        19.10 km
    Min. Source-Class I Distance:    19.10 km
    Max. Source-Class I Distance:    35.96 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   1
    Wind Speed:   1.00 m/s

                           R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
          Screening Criteria ARE NOT Exceeded
                                    Delta E       Contrast
                                 ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 157.   36.0    12. 21.63  0.000   0.54  0.000
 SKY     140. 157.   36.0    12. 13.93  0.000   0.54  0.000
 TERRAIN  10. 157.   36.0    12. 21.61  0.000   0.54  0.000
 TERRAIN 140. 157.   36.0    12. 13.92  0.000   0.54  0.000


         Maximum Visual Impacts OUTSIDE Class I Area
             Screening Criteria ARE Exceeded
                                    Delta E       Contrast
                                 ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.39  1.578   0.05  0.029
 SKY     140.   1.    1.0   168.  2.00  0.643   0.05 -0.013
 TERRAIN  10.   1.    1.0   168.  2.00  4.515*  0.05  0.035
 TERRAIN 140.   1.    1.0   168.  2.00  0.502   0.05  0.005
```

```
              Visual Effects Screening Analysis for
                Source: RICE
                Class I Area: SNPW


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        19.10 km
    Min. Source-Class I Distance:    19.10 km
    Max. Source-Class I Distance:    35.96 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   3
    Wind Speed:   1.00 m/s

                           R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
          Screening Criteria ARE NOT Exceeded
                                     Delta E       Contrast
                                  ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 157.   36.0    12.  5.76  0.614   0.13  0.011
 SKY     140. 157.   36.0    12.  3.71  0.254   0.13 -0.005
 TERRAIN  10.  84.   19.1    84.  5.89  1.519   0.28  0.007
 TERRAIN 140.  84.   19.1    84.  4.10  0.056   0.28  0.000


         Maximum Visual Impacts OUTSIDE Class I Area
            Screening Criteria ARE Exceeded
                                     Delta E       Contrast
                                  ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.00 13.699*  0.05  0.317*
 SKY     140.   1.    1.0   168.  2.00  3.208*  0.05 -0.094*
 TERRAIN  10.   1.    1.0   168.  2.00 27.911*  0.05  0.263*
 TERRAIN 140.   1.    1.0   168.  2.00  3.118*  0.05  0.043
```

Visual Effects Screening Analysis for
Source: RICE
Class I Area: SNPW

*** User-selected Screening Scenario Results ***

Input Emissions for

Particulates	29.85	LB /HR
NOx (as NO2)	110.50	LB /HR
Primary NO2	0.00	LB /HR
Soot	0.00	LB /HR
Primary SO4	0.50	LB /HR

PARTICLE CHARACTERISTICS

	Density	Diameter
Primary Part.	2.5	6
Soot	2.0	1
Sulfate	1.5	4

Transport Scenario Specifications:

Background Ozone:	0.03	ppm
Background Visual Range:	252.00	km
Source-Observer Distance:	19.10	km
Min. Source-Class I Distance:	19.10	km
Max. Source-Class I Distance:	35.96	km
Plume-Source-Observer Angle:	11.25	degrees

Stability: 2
Wind Speed: 1.00 m/s

R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

Maximum Visual Impacts INSIDE Class I Area
Screening Criteria ARE NOT Exceeded

					Delta E		Contrast	
Backgrnd	Theta	Azi	Distance	Alpha	Crit	Plume	Crit	Plume
SKY	10.	157.	36.0	12.	13.29	0.188	0.31	0.004
SKY	140.	157.	36.0	12.	8.56	0.078	0.31	-0.001
TERRAIN	10.	84.	19.1	84.	8.84	0.515	0.43	0.002
TERRAIN	140.	84.	19.1	84.	6.15	0.019	0.43	0.000

Maximum Visual Impacts OUTSIDE Class I Area
Screening Criteria ARE Exceeded

					Delta E		Contrast	
Backgrnd	Theta	Azi	Distance	Alpha	Crit	Plume	Crit	Plume
SKY	10.	1.	1.0	168.	2.00	8.272*	0.05	0.179*
SKY	140.	1.	1.0	168.	2.00	2.339*	0.05	-0.060*
TERRAIN	10.	1.	1.0	168.	2.00	19.469*	0.05	0.172*
TERRAIN	140.	1.	1.0	168.	2.00	2.056*	0.05	0.025

Visual Effects Screening Analysis for

```
                Source: RICE
                Class I Area: SNPW


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        19.10 km
    Min. Source-Class I Distance:    19.10 km
    Max. Source-Class I Distance:    35.96 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   4
    Wind Speed:   1.00 m/s

                          R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 157.   36.0    12.  2.00  3.536*  0.05  0.067*
 SKY     140. 157.   36.0    12.  2.00  1.458   0.05 -0.028
 TERRAIN  10.  84.   19.1    84.  2.00  6.424*  0.08  0.033
 TERRAIN 140.  84.   19.1    84.  2.00  0.261   0.08  0.002


         Maximum Visual Impacts OUTSIDE Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.00 23.618*  0.05  0.594*
 SKY     140.   1.    1.0   168.  2.00  5.246*  0.05 -0.162*
 TERRAIN  10.   1.    1.0   168.  2.00 38.521*  0.05  0.398*
 TERRAIN 140.   1.    1.0   168.  2.00  5.558*  0.05  0.082*


              Visual Effects Screening Analysis for
```

```
                Source: RICE
                Class I Area: SNPW


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        19.10 km
    Min. Source-Class I Distance:    19.10 km
    Max. Source-Class I Distance:    35.96 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   6
    Wind Speed:   1.00 m/s

                           R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 157.   36.0    12.  2.00 12.124*  0.05  0.235*
 SKY     140. 157.   36.0    12.  2.00  4.927*  0.05 -0.100*
 TERRAIN  10.  84.   19.1    84.  2.00 16.849*  0.05  0.099*
 TERRAIN 140.  84.   19.1    84.  2.00  0.857   0.05  0.006


         Maximum Visual Impacts OUTSIDE Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.00 40.729*  0.05  1.149*
 SKY     140.   1.    1.0   168.  2.00 10.005*  0.05 -0.299*
 TERRAIN  10.   1.    1.0   168.  2.00 49.651*  0.05  0.564*
 TERRAIN 140.   1.    1.0   168.  2.00 11.356*  0.05  0.183*
```

```
              Visual Effects Screening Analysis for
                Source: RICE
                Class I Area: SNPW


              *** User-selected Screening Scenario Results ***
Input Emissions for

   Particulates    29.85  LB /HR
   NOx (as NO2)   110.50  LB /HR
   Primary NO2      0.00  LB /HR
   Soot             0.00  LB /HR
   Primary SO4      0.50  LB /HR


              PARTICLE CHARACTERISTICS
              Density       Diameter
              =======       ========
Primary Part.     2.5            6
Soot              2.0            1
Sulfate           1.5            4

              Transport Scenario Specifications:

    Background Ozone:                 0.03 ppm
    Background Visual Range:        252.00 km
    Source-Observer Distance:        19.10 km
    Min. Source-Class I Distance:    19.10 km
    Max. Source-Class I Distance:    35.96 km
    Plume-Source-Observer Angle:     11.25 degrees
    Stability:   5
    Wind Speed:   1.00 m/s

                           R E S U L T S

Asterisks (*) indicate plume impacts that exceed screening criteria

         Maximum Visual Impacts INSIDE  Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10. 157.   36.0    12.  2.00  6.844*  0.05  0.131*
 SKY     140. 157.   36.0    12.  2.00  2.811*  0.05 -0.056*
 TERRAIN  10.  84.   19.1    84.  2.00 10.732*  0.05  0.058*
 TERRAIN 140.  84.   19.1    84.  2.00  0.477   0.05  0.003


         Maximum Visual Impacts OUTSIDE Class I Area
            Screening Criteria ARE Exceeded
                                   Delta E       Contrast
                                ===========   ============
Backgrnd Theta Azi Distance Alpha Crit  Plume   Crit  Plume
======== ===== === ======== ===== ====  =====   ====  =====
 SKY      10.   1.    1.0   168.  2.00 30.894*  0.05  0.817*
 SKY     140.   1.    1.0   168.  2.00  7.068*  0.05 -0.218*
 TERRAIN  10.   1.    1.0   168.  2.00 44.033*  0.05  0.477*
 TERRAIN 140.   1.    1.0   168.  2.00  7.746*  0.05  0.118*
```

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