3.0 NEAR-FIELD MODELING ANALYSES

3.1 MODELING METHODOLOGY

A near-field ambient air quality impact assessment was performed to quantify maximum pollutant impacts within and nearby the CD-C Project area resulting from Project-related development and production emissions. Air quality impacts due to criteria pollutant emissions of PM_{10}, $PM_{2.5}$, NO_x, SO_2, and CO, and emissions of hazardous air pollutants (HAPs) (benzene, toluene, ethyl benzene, xylene, n-hexane, and formaldehyde) were evaluated as part of the near-field study. These impacts would result from emissions associated with Project construction and production activities, and are compared to applicable ambient air quality standards and significance thresholds. All modeling analyses were performed in general accordance with the CD-C Air Quality Impact Assessment Modeling Protocol (Carter Lake and ENVIRON, 2010) with input from the WDEQ-AQD, BLM and members of the Air Quality Stakeholders Group, including the EPA, USDA-FS, USDOI-FWS, and USDOI-NPS.

Ozone is also a criteria pollutant and may form from NO_x, VOC, and CO emissions in the presence of sunlight. Analyses of potential ozone formation from Project alternative sources and regional sources were performed using the CAMx photochemical grid model as part of the far-field analysis. Ozone impacts within and outside the CD-C Project area were evaluated. Detailed information regarding the modeling methodologies used in the CAMx ozone analyses is provided in Section 4.

The EPA's Guideline (EPA, 2005a) model, AERMOD (version 11353), was used to assess near-field impacts of criteria pollutants PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO, and to estimate short-term and long-term HAP impacts. Regulatory model settings were used with the exception of the non-regulatory Ozone Limiting Method (OLM) model option, which was used for modeling NO_2 concentration estimates. Three years of meteorology data (2008-2010) collected near Wamsutter, Wyoming that is located within the CD-C Project area were used with the AERMOD dispersion model to estimate these pollutant impacts. Modeling analyses for NO_2 concentration estimates also utilized hourly ozone concentration data collected at the Wamsutter monitoring site from 2008 through 2010. Various construction and production activities were modeled to provide analyses for a complete range of alternatives and activities

Modeling analyses were performed to quantify near-field pollutant concentrations within and nearby the CD-C Project area from Project-related emissions sources for a range of scenarios to assure that the maximum near-field impacts were estimated. Impacts from scenarios including the construction of well pads, well drilling activities, well production facilities, proposed compression, and a proposed gas plant were modeled. Drill rigs with emissions at EPA Tier 0, Tier 2, and Tier 4 levels were evaluated. For sources where buildings and structures could potentially influence dispersion (i.e., drill rigs, compressors, and gas plant), the Building Profile Input Program (BPIP) (version 04112) was used to determine appropriate direction-specific building dimension downwash parameters for each affected source. Modeling scenarios were constructed using maximum Project Alternative proposed development (i.e., down-hole well spacing) in one-section land areas (1 square mile) and locating sources throughout the areas. Various scenarios were evaluated for well pad/access road construction activities based on operator provided well density and well pad construction assumptions to provide a range of impacts from typical field construction activities. Representative modeling scenarios of one-section land areas that include well development activities combined with well production operations were also modeled.

Two sets of modeling receptor sets were used for each modeling scenario. The first set consists of discrete modeling receptors placed at 25-meter intervals along a property fence line defined at 100 meters from the source, with receptors placed at 100-meter intervals out to 1.5 kilometers from the property line. The second receptor set is similar to the first set, however the property line begins 250 meters from the source. Flat terrain receptors were used for all near-field modeling analyses, given that the proposed source locations cannot be adequately defined.

A discussion of the meteorological data used for the near-field analysis, the ambient background data used for combining with modeled concentrations impacts, and the Project emissions data is provided in the following sections. The criteria pollutant impact assessment is provided in Section 3.5 and the HAPs analysis is presented in Section 3.6.

3.2 METEOROLOGY DATA

Three years (2008-2010) of hourly surface meteorological data collected near Wamsutter, Wyoming, along with twice daily sounding data from the Riverton, Wyoming National Weather Service (NWS) site were used in the analysis. The Wamsutter data include 10 meter level measurements of wind speed, wind direction, standard deviation of wind direction [sigma theta], solar radiation, temperature (10 meter and 2 meter), and temperature difference. A wind rose for the Wamsutter site is presented in Figure 3-1.

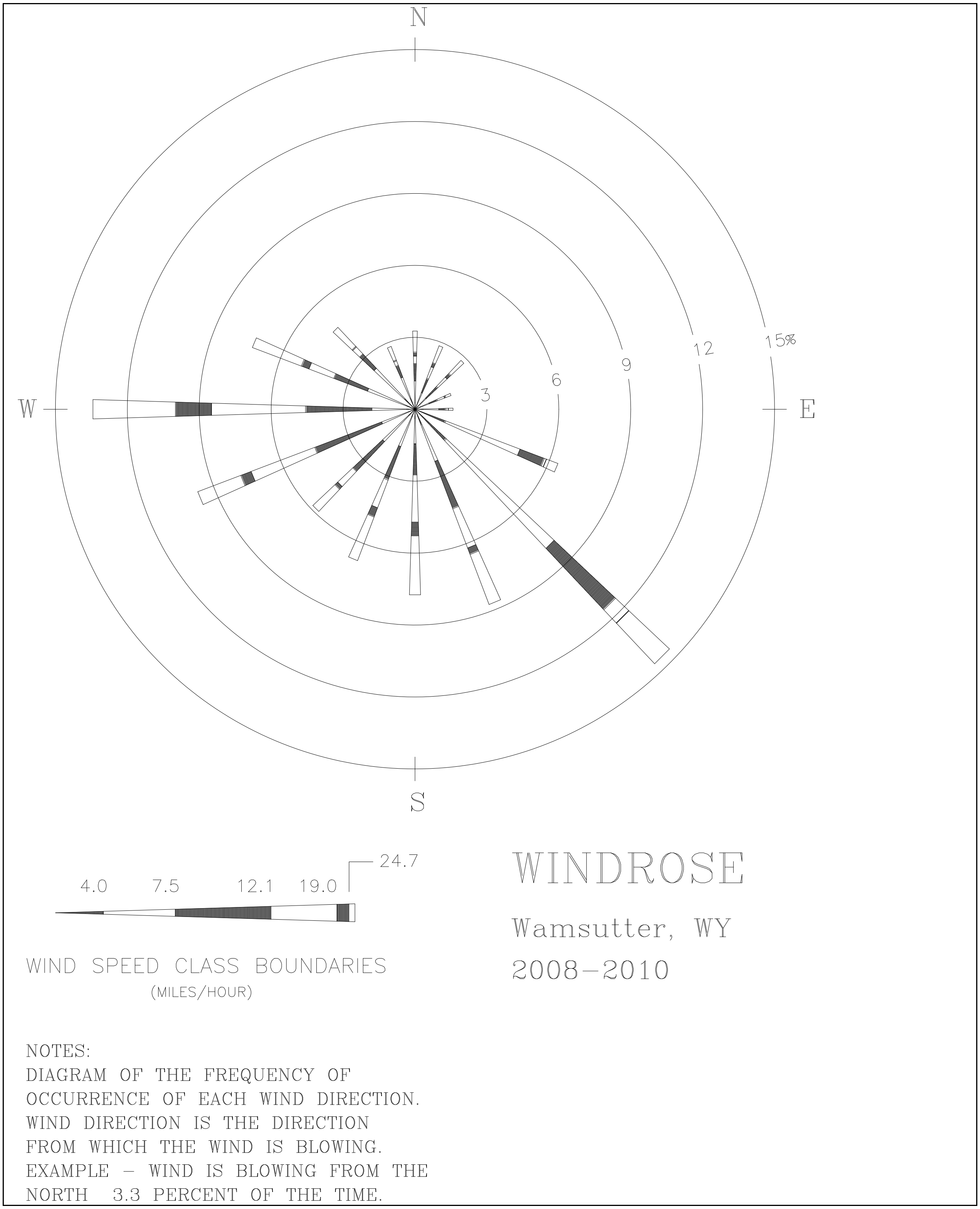

Figure 3-1 Wamsutter, WY Meteorological Data Wind Rose.

The AERMOD preprocessor AERMET (version 11059) was used to process the meteorological data into datasets (surface data and profile data) compatible with the AERMOD dispersion model. AERMET was applied following Bulk Richardson method switch settings to combine the hourly Wamsutter tower data with twice daily Riverton sounding data. AERSURFACE (Version 08009) was used to develop twelve sector seasonal surface characteristics for the Wamsutter station location, and these surface characteristics were used in the AERMET processing.

3.3 BACKGROUND POLLUTANT CONCENTRATIONS

Background pollutant concentrations are used as an indicator of existing conditions in the region, and are assumed to include emissions from industrial emission sources in operation and from mobile, urban, biogenic, other non-industrial emission sources, and transport into the region. These background concentrations are added to modeled near-field Project impacts to calculate total ambient air quality impacts. The most representative monitored regional background concentrations available for criteria pollutants as identified by WDEQ-AQD are shown in Table 3-1.

Table 3-1. Near-Field Analysis Background Ambient Air Quality Concentrations (Micrograms per Cubic Meter [μg/m^3]).

Pollutant	Averaging Period	Measured Background Concentration
CO[1]	1-hour	1,026
	8-hour	798
NO_2[2]	1-hour	75
	Annual	9.1
PM_{10}[3]	24-hour	56
	Annual	13.5
$PM_{2.5}$[4]	24-hour	9.2
	Annual	4.2
SO_2[5]	1-hour	19.7
	3-hour	11.5
	24-hour	4.2
	Annual	3.8

[1]Data collected during 2008 at Murphy Ridge, Wyoming, concentrations are maximum values.
[2]Data collected at Wamsutter, Wyoming: 1-hour concentration is the three year average (2008-2010) of daily maximum 98th percentile 1-hour concentrations, annual value is for 2010.
[3]Data collected at Wamsutter, Wyoming during 2010, 24-hour value is maximum concentration.
[4]Data collected at Cheyenne, Wyoming: 24-hour value is the three year average (2008-2010) of daily maximum 98th percentile 24-hour concentrations, annual value is three year average of annual means (2008-2010).
[5]Data collected at Wamsutter, Wyoming: 1-hour value is the three year average (2007-2009) of daily maximum 98th percentile 1-hour concentrations, 3-hour, 24-hour and annual concentrations were collected during 2009, 3-hour and 24-hour data are maximum values.

3.4 PROJECT EMISSIONS

Methods used to develop the Project emissions inventory are described in Section 2 and details of the emissions calculations are presented in Appendix H. The Project emissions inventory was reviewed in order to select the emissions activities that could result in the maximum criteria pollutant and HAP impacts. The activities that would generate that largest pollutant impacts include well development activities such the construction of well pads, well drilling activities and well completions, and field production activities such as well production facilities, proposed compression, and a proposed gas plant. The maximum criteria pollutant (CO, NO_x, SO_2, PM_{10}, and $PM_{2.5}$) impacts would occur from both project development and production activities, and from combinations of these activities. The maximum HAP impacts would occur from production activities. Table 3-2 presents the project field development activities that were considered as part of the near-field analysis. Table 3-3 presents the production activities that were analyzed for criteria pollutant impacts and for HAP impacts.

Table 3-2 presents drill rigs emissions for Tier 0, Tier 2, and Tier 4 emissions levels. As part of the Project Alternatives operators have proposed the use of drill rigs with Tier 0 and Tier 2 emissions. For informational purposes, near-field analyses were performed using the emissions for Tier 0, Tier 2, and Tier 4 levels. In addition, the hourly drill rig emissions for NO_x, CO, and SO_2 were computed using a maximum operating load factor of 0.6, versus a normal operating load factor of 0.3. Both operating load conditions were developed from data provided by the operators. Maximum operating load conditions were used for modeling pollutants that have short duration (less than 24-hour) ambient air quality standards.

The well construction and well production emissions presented in the Tables 3-2 and 3-3 are for developing and operating a single well in the CD-C field. The emissions shown in Table 3-3 for proposed compression and a gas plant are field-wide totals. Operators have proposed a new gas processing facility (760 mmscfd) and to add up to 24,936 hp of compression as part of the Project Alternatives. The near-field modeling analysis described in the following sections analyzes combinations of several wells under development and wells in production, assumes one compression facility, and assumes a single gas processing facility. Total emissions that are modeled for each scenario can be easily determined from these tables by simply multiplying the single well values by the number of wells including in the analyzed scenario.

Table 3-2. CD-C Project - Field Development Criteria Pollutant Emissions by Activity.

Source	Activity Duration	Pollutant	Emissions (lbs/hour)	Emissions (tons/event)
Drill Rigs – Tier 0 emissions[1]	7-10 days	NO_x	51.4	3.2
		CO	19.2	1.2
		SO_2	0.6	0.04
		PM_{10}	1.6	0.2
		$PM_{2.5}$	1.5	0.2
Drill Rigs – Tier 2 emissions[1]	7-10 days	NO_x	27.2	1.7
		CO	15.8	1.0
		SO_2	0.6	0.04
		PM_{10}	0.5	0.06
		$PM_{2.5}$	0.5	0.05
Drill Rigs – Tier 4 emissions[1]	7-10 days	NO_x	15.3	1.0
		CO	15.8	1.0
		SO_2	0.6	0.04
		PM_{10}	0.2	0.03
		$PM_{2.5}$	0.2	0.03
Completion Engines	1 day	NO_x	52.6	0.6
		CO	19.7	0.2
		SO_2	0.02	0.0003
		PM_{10}	3.2	0.04
		$PM_{2.5}$	3.1	0.04
Drilling and Completion	3 days	NO_x	1.4	0.1
Fugitives (Traffic, Flaring)		CO	3.1	0.2
(Traffic emissions for 20 mile		SO_2	0.005	0.0005
round trip distance)		PM_{10}	16.6	1.0
		$PM_{2.5}$	1.7	0.1
Single Well Pad Construction (Pad/Road Construction, Traffic, Wind Erosion) (Traffic emissions for 20 mile round trip distance)	5-days	NO_x	21.5	0.7
		CO	26.6	0.8
		SO_2	0.4	0.01
		PM_{10}	8.5	0.3
		$PM_{2.5}$	3.7	0.1
Multi-well P ad Construction	7-days	NO_x	21.5	0.9
(Pad/Road Construction,		CO	26.6	1.1
Traffic, Wind Erosion)		SO_2	0.4	0.02
(Traffic emissions for 20 mile		PM_{10}	8.6	0.4
round trip distance)		$PM_{2.5}$	3.7	0.2

[1] Maximum operational load of 0.6 used for estimating drill rig NO_x, CO, SO_2 hourly emissions. For other pollutants and for total event emissions an average load factor of 0.3 is used.

Table 3-3. CD-C Project - Field Production Criteria Pollutant and HAP Emissions (tons/year).

	Compression	Gas Plant	Production Well
NO_x	54.6	383.0	0.3
CO	62.4	503.7	0.9
SO_2	0.0	0.7	0.00004
PM_{10}	6.1	35.5	0.1
$PM_{2.5}$	6.1	35.5	0.03
VOC	2.7	72.2	1.7
HAPs			
Benzene	0.01	0.8	0.01
Toluene	0.0	0.4	0.01
Ethyl Benzene	0.0	0.01	0.0003
Xylene	0.0	0.04	0.01
n-Hexane	0.0	0.2	0.05
Formaldehyde	2.2	24.9	0.07

3.5 CRITERIA POLLUTANT IMPACT ASSESSMENT

The near-field criteria pollutant impact assessment was performed to estimate maximum potential impacts of PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO from Project emissions sources including emissions resulting from proposed well site construction and production activities, proposed compression, and a proposed gas plant. Maximum predicted concentrations in the vicinity of project emissions sources were compared with the Wyoming Ambient Air Quality Standards (WAAQS), National Ambient Air Quality Standards (NAAQS), and applicable Prevention of Significant Deterioration (PSD) Class II increments shown in Table 3-4. This NEPA analysis compared potential air quality impacts from Project alternatives to applicable ambient air quality standards and PSD increments. The comparisons to the PSD Class II increments are intended to evaluate a threshold of concern for potential impacts, and do not represent a regulatory PSD increment comparison. Such a regulatory analysis is the responsibility of the state air quality agency (under EPA oversight).

Table 3-4. Ambient Air Quality Standards and Class II PSD Increments for Comparison to Near-Field Analysis Results (µg/m³).

Pollutant/Averaging Time	NAAQS	WAAQS	PSD Class II Increment[1]
CO			
1-hour[2]	40,000	40,000	--[3]
8-hour[2]	10,000	10,000	--
NO_2			
1-hour[4]	188		
Annual[5]	100	100	25
PM_{10}			
24-hour[2]	150	150	30
Annual[5]	--[6]	50	17
$PM_{2.5}$			
24-hour[7]	35		9
Annual[5]	15		4
SO_2			
1-hour[8]	196		
3-hour[2]	1,300	1,300	512
24-hour[2]	--[6]	260	91
Annual[5]	--[6]	60	20

[1]The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
[2]No more than one exceedance per year.
[3]No PSD increments have been established for this pollutant.
[4]An area is in compliance with the standard if the 98th percentile of daily maximum 1-hour NO_2 concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.
[5]Annual arithmetic mean.
[6]The NAAQS for this averaging time for this pollutant has been revoked by EPA.
[7]An area is in compliance with the standard if the maximum 24-hour $PM_{2.5}$ concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.
[8]An area is in compliance with the standard if the 99th percentile of daily maximum 1-hour SO_2 concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.

The AERMOD model was used to estimate near-field concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO from Project Alternative emission sources. AERMOD was run using three years of AERMET- processed Wamsutter meteorology data. Regulatory model settings were used with the exception of the non-regulatory OLM model option, which was used for modeling NO_2 concentration estimates. Modeling analyses for NO_2 concentration estimates utilized hourly ozone concentration data concurrent with the meteorological data from the Wamsutter monitoring site. The NO_2 analyses with OLM also utilized in-stack NO/NO_2 concentration ratios for source emissions that were determined from data provided by the operators. For modeling of drill rig NO_2 emissions an in-stack ratio of 10 percent NO_2 was used, for all other sources an in-stack ratio of 20 percent NO_2 was used.

3. NEAR-FIELD MODELING ANALYSES

For each criteria pollutant, the magnitude and duration of emissions from project development and production emissions activities shown in Tables 3-2 and 3-3 were examined to determine the maximum emissions scenario for modeling. Multiple years of project emissions activities were evaluated for purposes of demonstrating compliance with the NAAQS for 1-hour NO_2, and 1-hour SO_2 and 24-hour $PM_{2.5}$ concentrations.

The production activities modeled for criteria pollutant comparisons with the NAAQS and WAAQS and PSD Class II increments, along with the pollutants analyzed include the following:

- Compressor station (NO_2, CO, PM_{10}, $PM_{2.5}$)
- Gas processing facility (NO_2, SO_2, CO, PM_{10}, $PM_{2.5}$)
- 16 single wells in production (40 acre/section spacing) (NO_2, CO)
- 1 multi-well pad with 16 wells in production (40 acre/section spacing) (NO_2, CO)
- 1 multi-well pad with 32 wells in production (20 acre/section spacing) (NO_2, CO)

Combinations of field development activities and production activities were also modeled for criteria pollutant comparisons with the NAAQS and WAAQS. Note that the emissions from field development activities are temporary and do not consume PSD increment, and as a result are excluded from increment comparisons. The selected scenarios along with the pollutants analyzed include:

- Drill rig operating, surrounded by 4 single wells (i.e. one well per pad) in production (NO_2)
- Drill rig operating, surrounded by 4 multi-well pads with varied number of wells in production (40 acre/section spacing) (NO_2)
- Drill rig operating on 1 multi-well pad with varied number of wells (up to 16) in production (40 acre/section spacing) (NO_2)
- Drill rig operating on 1 multi-well pad with varied number of wells (up to 32) in production (20 acre/section spacing) (NO_2)
- 4 drill rigs operating in a section on single well pads (NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$)
- 4 drill rigs operating in a section on multi-well pads (NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$)
- 4 single well pads and access roads under construction (PM_{10})
- 4 multi-well pads and access roads under construction (PM_{10})
- 4 single well pads and access roads under construction, 4 drill rigs operating, 4 wells in production ($PM_{2.5}$)
- 4 multi-well pads and access roads under construction, 4 drill rigs operating, 16 wells in production ($PM_{2.5}$)

Each of the above modeling scenarios is described in the following sections.

For 1-hour NO_2 NAAQS compliance demonstrations, all modeled impacts represent the 3-year average of the eighth-highest daily maximum 1-hour concentrations. For scenarios where drilling operations were modeled, drilling operations were assumed to occur for a maximum of 2 years during the 3-year averaging period. Since drill rigs move to different locations during field development, it is not likely that a drilling operation would occur over 3 consecutive years in the same location. The yearly maximum eighth-highest daily maximum 1-hour NO_2 concentrations for all modeled scenarios are provided in Appendix L. Appendix L provides both the maximum modeled 1-hour NO_2 concentrations for each scenario or year that were used for computing the 3-year averaged concentrations (paired in location), and the maximum (unpaired) values for each scenario or year.

For 24-hour $PM_{2.5}$ NAAQS compliance demonstrations from well pad and access road construction, all modeled impacts represent the 3-year average of the maximum 24-hour concentrations from three separate activities, assuming well pad and access road construction occurs over 1 year, drilling operations occur for 1 year and well production activities occur for 1 year. Since well pad and access road construction would be temporary (occurring over a 5 –7 day period) and in isolation, this scenario represents a conservative estimate of $PM_{2.5}$ concentrations in the vicinity of a well pad. The yearly maximum 24-hour $PM_{2.5}$ concentrations for all modeled scenarios are provided in Appendix L. Appendix L provides both the maximum modeled 24-hour $PM_{2.5}$ concentrations for each scenario that were used for computing the 3-year averaged concentrations (paired in location), and the maximum (unpaired) values for each scenario.

3.5.1 Compression

Operators have proposed to add up to 24,936 hp of compression as part of the Project Alternatives. The added compression would be combination of reciprocating and turbine engines. The estimated criteria pollutant emissions for the proposed compression are shown in Table 3-3.

Compressor engines were modeled as point sources, using typical compressor engine exhaust parameters, with aerodynamic building downwash from the compressor building, and assuming that all emissions are collocated. Receptor sets for both 100 meter and 250 meter fenceline distances were used.

Table 3-5 presents the maximum modeled NO_2, CO, PM_{10} and $PM_{2.5}$ concentrations from proposed compressor engine emissions. When the maximum modeled concentrations are added to representative background concentrations, it is demonstrated that all comply with the WAAQS and NAAQS.

Table 3-5. CD-C Project- Criteria Pollutant Modeling Results for Proposed Compressor Station.

Receptor Scenario	Pollutant	Averaging Time	Direct Modeled ($\mu g/m^3$)	PSD Class II Increment[1] ($\mu g/m^3$)	Background ($\mu g/m^3$)	Total Predicted ($\mu g/m^3$)	WAAQS ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
100 meter	CO	1-hour	118.0	n/a	1,026.0	1,144.0	40,000	40,000
		8-hour	76.7	n/a	798.0	874.7	10,000	10,000
250 meter	CO	1-hour	77.4	n/a	1,026.0	1,103.4	40,000	40,000
		8-hour	55.7	n/a	798.0	853.7	10,000	10,000
100 meter	NO_2	1-hour	72.6[2]	n/a	75.0	147.6	n/a	188
		Annual	4.5	25	9.1	13.6	100	100
250 meter	NO_2	1-hour	49.5[2]	n/a	75.0	124.5	n/a	188
		Annual	3.2	25	9.1	12.3	100	100
100 meter	PM_{10}	24-hour	6.0	30	56.0	62.0	150	n/a
		Annual	0.5	17	13.5	14.0	50	50
250 meter	PM_{10}	24-hour	4.7	30	56.0	60.7	150	n/a
		Annual	0.4	17	13.5	13.9	50	50
100 meter	$PM_{2.5}$	24-hour	6.0	9	9.2	15.2	n/a	35
		Annual	0.5	4	4.2	4.7	n/a	15
250 meter	$PM_{2.5}$	24-hour	4.7	9	9.2	13.9	n/a	35
		Annual	0.4	4	4.2	4.6	n/a	15

[1]The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis

[2]NO_2 1-hour concentrations are calculated as the 3-year average of the 8^{th} highest daily maximum 1-hour concentrations. (The yearly 8^{th} highest daily maximum values are provided in Appendix L, Tables L.1-1a and L.1-1b).

3.5.2 Gas Plant

A new gas processing facility, with a gas throughput capacity of 760 mmscfd, has been proposed as part of the CD-C Project Alternatives. The facility would be similar to the existing Echo Springs gas plant that currently processes gas from wells operating in the CD-C field. The estimated total criteria pollutant emissions for the proposed gas plant are shown in Table 3-3. The emissions for the proposed gas processing facility are described in detail in Appendix H.

Modeling parameters for source emissions at the existing Echo Springs gas plant were obtained from the WDEQ-AQD permit files and were used as a basis for modeling the proposed gas processing facility. The source parameters included point sources, with representative release parameters for each source type, and aerodynamic building downwash parameters calculated for each affected source at the facility. Receptor sets for both 100 meter and 250 meter fenceline distances were used. Figure 3-2 shows the locations for the gas plant sources modeled, and the receptor grid for the 100 meter fenceline distance case.

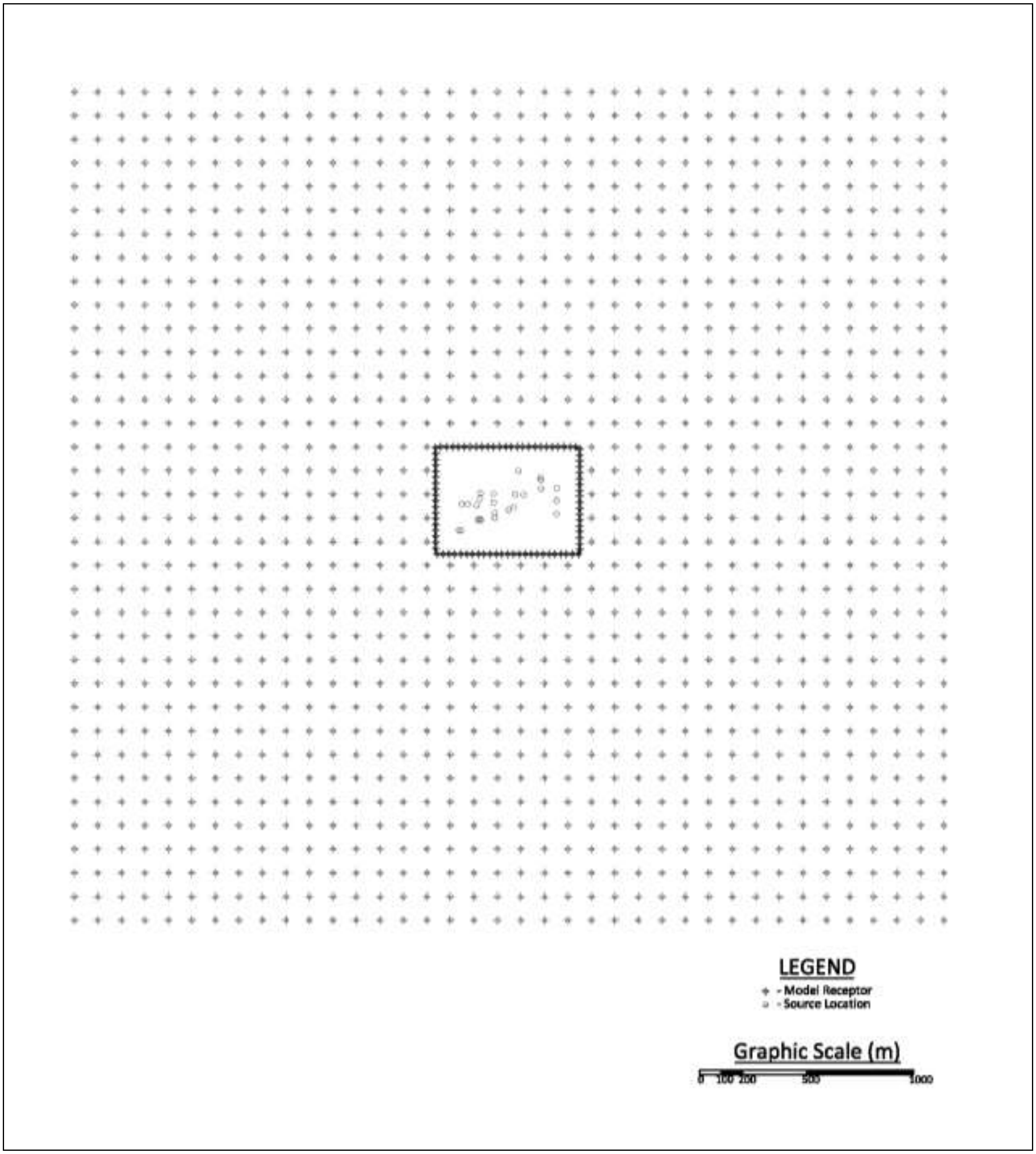

Figure 3-2. Gas plant modeling scenario with 100 meter receptor grid.

Table 3-6 presents the maximum modeled NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$ concentrations from the proposed gas processing facility source emissions. When the maximum modeled concentrations were added to representative background concentrations, it is demonstrated that all comply with the WAAQS and NAAQS.

Table 3-6. CD-C Project - Criteria Pollutant Modeling Results for Proposed Gas Plant.

Receptor Scenario	Pollutant	Averaging Time	Direct Modeled (µg/m³)	PSD Class II Increment[1] (µg/m³)	Background (µg/m³)	Total Predicted (µg/m³)	WAAQS (µg/m³)	NAAQS (µg/m³)
100 meter	CO	1-hour	514.1	n/a	1,026.0	1,540.1	40,000	40,000
		8-hour	315.8	n/a	798.0	1,113.8	10,000	10,000
250 meter	CO	1-hour	388.2	n/a	1,026.0	1,414.2	40,000	40,000
		8-hour	236.2	n/a	798.0	1,034.2	10,000	10,000
100 meter	NO_2	1-hour	105.6[2]	n/a	75.0	180.6	n/a	188
		Annual	11.9	25	9.1	21.0	100	100
250 meter	NO_2	1-hour	99.5[2]	n/a	75.0	174.5	n/a	188
		Annual	8.3	25	9.1	17.4	100	100
100 meter	SO_2	1-hour	0.6[3]	n/a	19.7	20.3	n/a	196
		3-hour	0.6	512	11.5	12.1	1,300	1,300
		24-hour	0.2	91	4.2	4.4	260	365
		Annual	0.03	20	3.8	3.8	60	80
250 meter	SO_2	1-hour	0.4[3]	n/a	19.7	20.1	n/a	196
		3-hour	0.4	512	11.5	11.9	1,300	1,300
		24-hour	0.2	91	4.2	4.4	260	365
		Annual	0.02	20	3.8	3.8	60	80
100 meter	PM_{10}	24-hour	11.5	30	56.0	67.5	150	n/a
		Annual	1.4	17	13.5	14.9	50	50
250 meter	PM_{10}	24-hour	7.2	30	56.0	63.2	150	n/a
		Annual	0.9	17	13.5	14.4	50	50
100 meter	$PM_{2.5}$	24-hour	11.5	9	9.2	20.7	n/a	35
		Annual	1.4	4	4.2	5.6	n/a	15
250 meter	$PM_{2.5}$	24-hour	7.2	9	9.2	16.4	n/a	35
		Annual	0.9	4	4.2	5.1	n/a	15

[1]The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis
[2]NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations. (The yearly 8th highest daily maximum values are provided in Appendix L, Tables L.1-1a and L.1-1b).
[3]SO_2 1-hour concentration are 4th highest daily maximum 1-hour concentration.

3.5.3 Production Wells

Analyses were performed quantify the maximum NO_2 and CO impacts that could occur within and nearby the CD-C Project Area from wells under production. NO_2 and CO were the only pollutant analyzed for production wells since SO_2 and particulate matter emissions are negligible and the maximum impacts of SO_2 and particulate matter would occur from the operation of the gas processing facility.

Three scenarios were analyzed for production wells based on the maximum projected down-hole well spacing in one-section land areas. The first case assumes 16 single wells in production at 40 acre/section spacing. The second scenario is one multi-well pad with 16 wells in production (40 acre/section spacing). The third case is one multi-well pad with 32 wells in production (20 acre/section spacing). Cases 1 and 2 represent the maximum proposed development (40 acre/section spacing) for the range of CD-C Project alternatives. Case 3 (20 acre/section spacing) was modeled for informational purposes to disclose impacts for a more concentrated well development scenario in the event that future field operations support this development level.

Volume sources were used to model the emissions from the well production activities. Monthly emissions scalars were applied to well site heater emissions to account for seasonal operations for these sources. For single wells a 10-meter volume source size was used for the well emissions, for a 16 well pad a 100-meter volume source was used, and for a 32 well pad a 200-meter volume source was used. Receptor sets for both 100 meter and 250 meter fenceline distances from the well emissions were used.

Figures 3-3 through 3-5 illustrate the modeling scenarios for the three well production cases. The receptor grids for the 100 meter fenceline distance cases are shown.

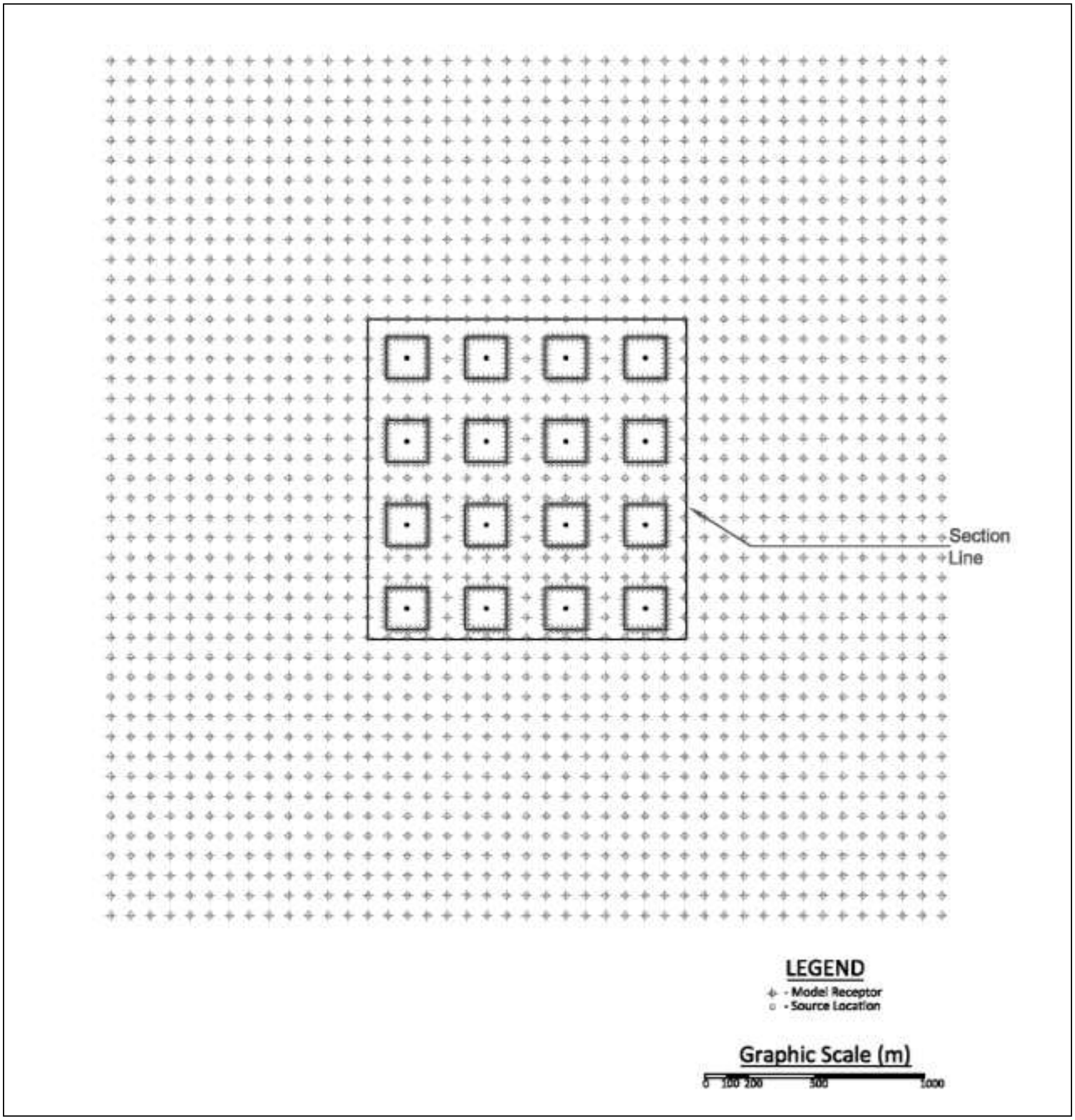

Figure 3-3. 16 Production Wells – single wells, 40 acre/section spacing with 100m receptors.

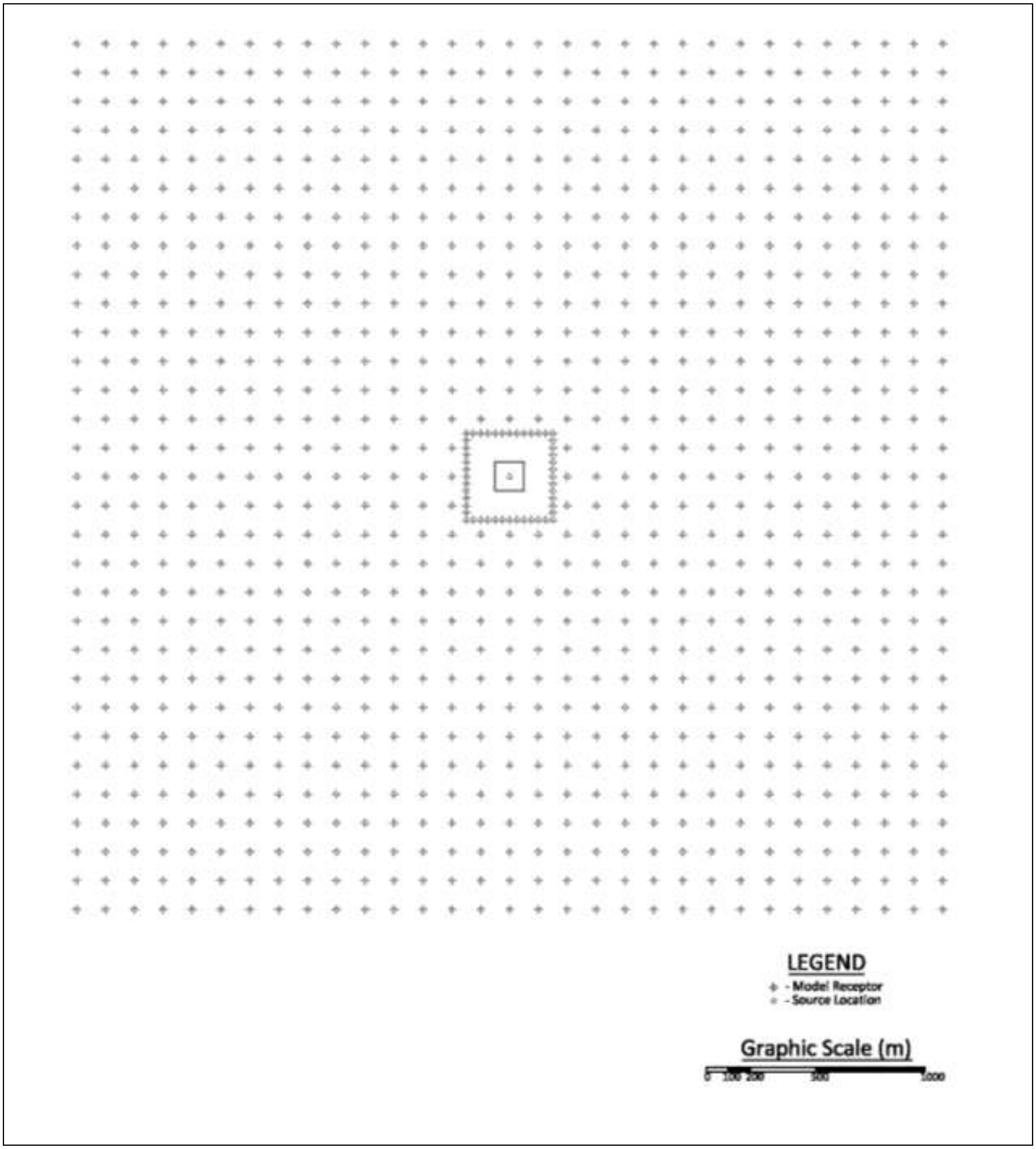

Figure 3-4. 16 Production Wells – 1 multi-well pad, 40 acre/section spacing with 100m receptors.

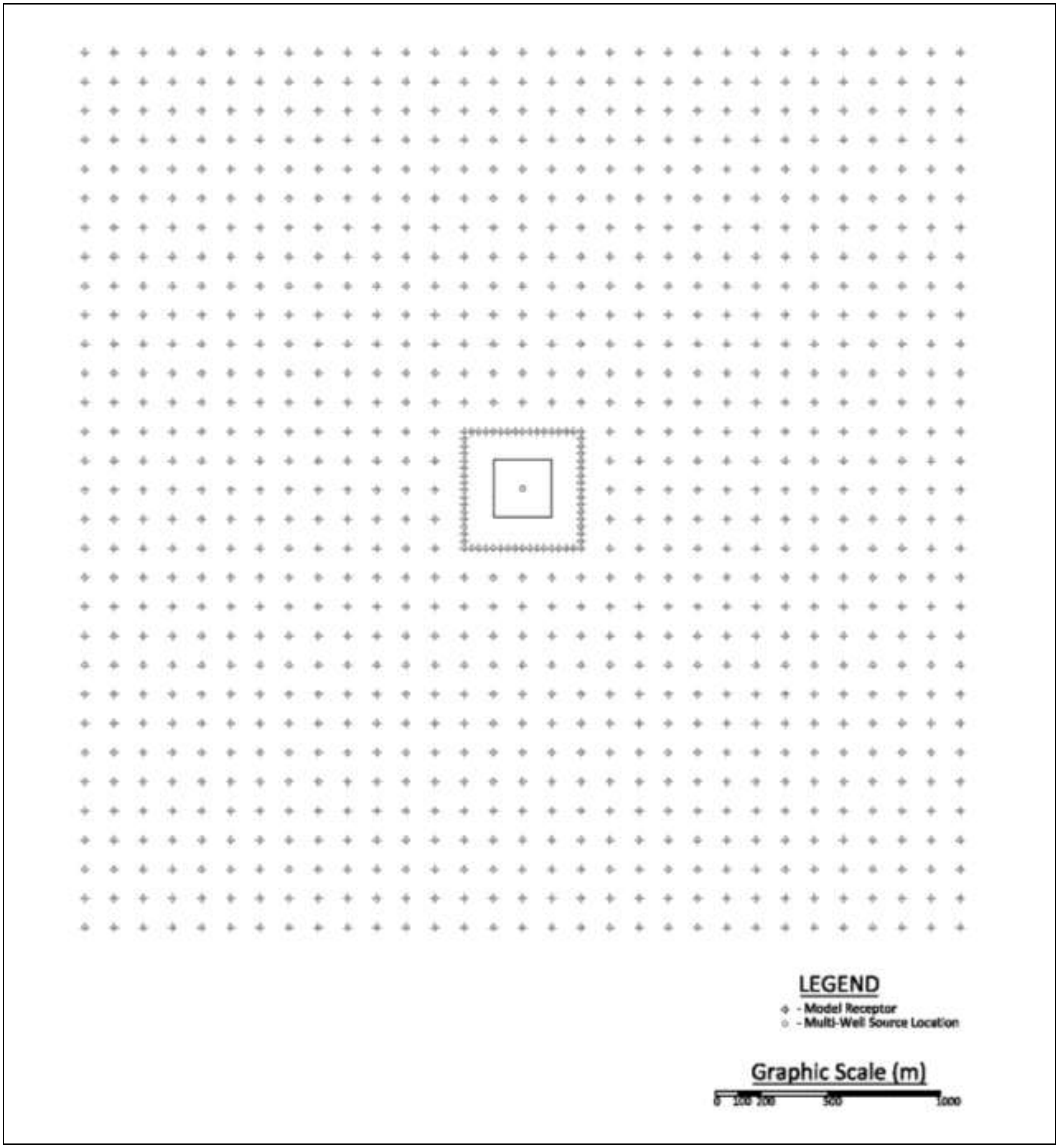

Figure 3-5. 32 Production Wells – 1 multi-well pad, 20 acre/section spacing with 100m receptors.

Tables 3-7 through 3-9 presents the maximum modeled NO_2, and CO concentrations from the three well production cases. When the maximum modeled concentrations were added to representative background concentrations, it is demonstrated that all comply with the WAAQS and NAAQS, with the exception of the single well pad with 32 wells in production case, where the modeled 1-hour NO_2 concentration, including background, is above the NAAQS at the 100 meter receptor distance. However, this production scenario is below the 1-hour NO_2 NAAQS at a 250 meter receptor distance.

Table 3-7. CD-C Project - Criteria Pollutant Modeling Results for Production Well Case: 16 Single Wells, 40 acre spacing.

Scenario	Pollutant	Averaging Time	Direct Modeled (μg/m^3)	PSD Class II Increment[1] (μg/m^3)	Background (μg/m^3)	Total Predicted (μg/m^3)	WAAQS (μg/m^3)	NAAQS (μg/m^3)
100 meter	CO	1-hour	122.1	n/a	1,026.0	1,148.1	40,000	40,000
		8-hour	64.3	n/a	798.0	862.3	10,000	10,000
250 meter	CO	1-hour	75.7	n/a	1,026.0	1,101.7	40,000	40,000
		8-hour	36.9	n/a	798.0	834.9	10,000	10,000
100 meter	NO_2	1-hour	27.7[2]	n/a	75.0	102.7	n/a	188
		Annual	1.4	25	9.1	10.5	100	100
250 meter	NO_2	1-hour	16.6[2]	n/a	75.0	91.6	n/a	188
		Annual	0.6	25	9.1	9.7	100	100

[1]The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis

[2]NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.

Table 3-8. CD-C Project - Criteria Pollutant Modeling Results for Production Well Case: 16 Wells, 1 Multi-well Pad, 40 acre spacing.

Scenario	Pollutant	Averaging Time	Direct Modeled (μg/m^3)	PSD Class II Increment[1] (μg/m^3)	Background (μg/m^3)	Total Predicted (μg/m^3)	WAAQS (μg/m^3)	NAAQS (μg/m^3)
100 meter	CO	1-hour	610.7	n/a	1,026.0	1,636.7	40,000	40,000
		8-hour	400.3	n/a	798.0	1,198.3	10,000	10,000
250 meter	CO	1-hour	504.1	n/a	1,026.0	1,530.1	40,000	40,000
		8-hour	269.6	n/a	798.0	1,067.6	10,000	10,000
100 meter	NO_2	1-hour	112.6[2]	n/a	75.0	187.6	n/a	188
		Annual	7.3	25	9.1	16.4	100	100
250 meter	NO_2	1-hour	101.4[2]	n/a	75.0	176.4	n/a	188
		Annual	3.5	25	9.1	12.6	100	100

[1]The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis

[2]NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.

Table 3-9. CD-C Project - Criteria Pollutant Modeling Results for Production Well Case: 32 Wells, 1 Multi-well Pad, 20 acre spacing.

Scenario	Pollutant	Averaging Time	Direct Modeled (μg/m^3)	PSD Class II Increment[1] (μg/m^3)	Background (μg/m^3)	Total Predicted (μg/m^3)	WAAQS (μg/m^3)	NAAQS (μg/m^3)
100 meter	CO	1-hour	685.5	n/a	1,026.0	1,711.5	40,000	40,000
		8-hour	464.4	n/a	798.0	1,262.4	10,000	10,000
250 meter	CO	1-hour	608.5	n/a	1,026.0	1,634.5	40,000	40,000
		8-hour	364.4	n/a	798.0	1,162.4	10,000	10,000
100 meter	NO_2	1-hour	118.7[2]	n/a	75.0	193.7	n/a	188
		Annual	8.9	25	9.1	18.0	100	100
250 meter	NO_2	1-hour	110.4[2]	n/a	75.0	185.4	n/a	188
		Annual	5.2	25	9.1	14.3	100	100

[1]The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis

[2]NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.

3.5.4 Production Wells and Well Drilling Operations

Modeling scenarios were developed that included wells in production in close proximity to well pads where well drilling operations are occurring. The purpose of these analyses was to determine whether impacts from combined production and well drilling activities could contribute to air quality impacts that are above the level of the NAAQS or WAAQS. As part of these analyses, the impacts from drilling operations alone are also disclosed. The majority of these analyses were focused on NO_2 impacts since NO_x emissions are the primary concern given the emissions levels that could occur from well production and drilling activities. For one of the more concentrated well development cases analyses, CO, SO_2, and PM_{10} impacts are also presented, and these impacts would represent the maximum concentrations for these pollutants that could occur in the CD-C field from well production and well drilling activities. Note that $PM_{2.5}$ analyses from well development and well production activities and additional analyses for PM_{10} from well development are presented in Section 3.5.5.

Volume sources were used to model the emissions from the well production activities. Monthly emissions scalars were applied to well site heater emissions to account for seasonal operations for these sources. For single wells a 10-meter volume source size was used for the well emissions, for a 4 well pad a 50-meter volume source was used, for a 16 well pad a 100-meter volume source was used, and for a 32 well pad a 200-meter volume source was used. Drill rig engines were modeled as point sources, using typical drill rig engine exhaust parameters, and using aerodynamic building downwash parameters that were calculated from drilling rig structures. Receptor sets for both 100 meter and 250 meter fenceline distances from the edge well sources were used.

Similar to the production well analyses that were presented in Section 3.5.3 above, scenarios were developed for the range of Project Alternatives based on the maximum projected down-hole well spacing in one-section land areas. Six combined well development and well production scenarios were analyzed and these are described below:

Scenario 1: Combined well drilling and single well production scenario for a 40 acre/section development level. This case included a drill rig operating on a single well pad, surrounded by 4 single wells in production. Under this scenario, NO_2 impacts were analyzed for a range of well site activities, including production wells operating, drilling operations, and the combination of both drilling and well production occurring simultaneously. Drill rig emissions were modeled at Tier 0, Tier 2, and Tier 4 emissions levels. Figure 3-6 illustrates this modeling scenario. This figure is for the 100 meter receptor case.

Scenario 2: Combined single well drilling and multi-well production scenario for a 40 acre/section development level. This case included a drill rig operating on a single well pad, surrounded by 4 multi-well pads (up to 4 wells each) with a maximum of 16 wells (total) in production. Under this scenario, NO_2 impacts were analyzed for a range of well site activities, including production wells operating, drilling operations, and the combination of both drilling and well production occurring simultaneously. Combinations of drilling and well production modeling cases assume a maximum of 15 wells operating simultaneously with drilling operations. Drill rig emissions were modeled at Tier 0, Tier 2, and Tier 4 emissions levels. Figure 3-7 illustrates this modeling scenario for the 100 meter receptor case.

Scenario 3: Combined multi-well drilling and multi-well production scenario for a 40 acre/section development level. This case included a drill rig operating on a multi-well pad, with a varied number of wells operating (up to 16) in production. Under this scenario, NO_2 impacts were analyzed for a range of well site activities, including production wells operating, drilling operations, and the combination of both drilling and well production occurring simultaneously. Combinations of drilling and well production modeling cases assume a maximum of 15 wells operating simultaneously with drilling operations. Drill rig emissions were modeled at Tier 0, Tier 2, and Tier 4 emissions levels. The well pad modeling parameters and receptor used for analyzing 16 wells in production on a multi-well pad, described in Section 3.5.3 and illustrated in Figure 3-4, were used for this modeling case, with the addition of well drilling operations placed at the center of the well pad.

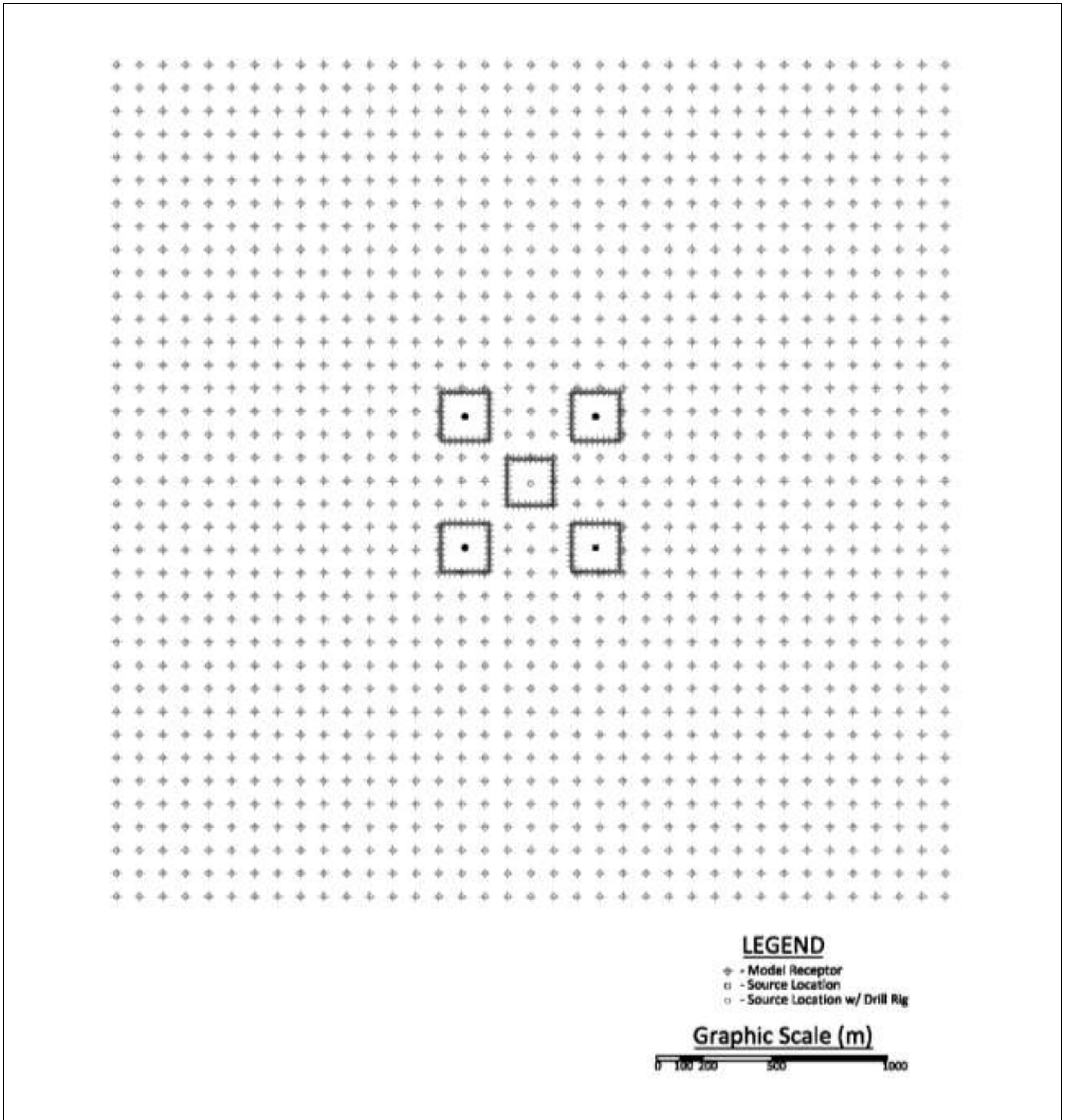

Figure 3-6. Production Wells and Well Drilling – 5 single well pads, 40 acre/section spacing with 100m receptors.

Scenario 4: Combined multi-well drilling and multi-well production scenario for a 20 acre/section development level. This case included a drill rig operating on a multi-well pad, with a varied number of wells operating (up to 32) in production. Under this scenario, NO_2 impacts were analyzed for a range of well site activities, including production wells operating, drilling operations, and the combination of both drilling and well production occurring simultaneously. Combinations of drilling and well production modeling cases assume a maximum of 31 wells operating simultaneously with drilling operations. Drill rig emissions were modeled at Tier 0, Tier 2, and Tier 4 emissions levels. The well pad modeling parameters and receptor used for analyzing 32 wells in production on a multi-well pad, described in Section 3.5.3 and illustrated in Figure 3-5, were used for this modeling case, with the addition of well drilling operations placed at the center of the well pad. This multi-well case, although not proposed under any of the CD-C Project Alternatives, was modeled for informational purposes to disclose impacts for a more concentrated well development scenario in the event that future field operations support this development level.

Scenario 5: Combined well drilling and multi-well production (4 wells/pad) scenario for a 40 acre/section development level. This case included 4 drill rigs operating on 4 multi-well pads in a section. Under this scenario, NO_2 impacts were analyzed for a range of well site activities, including drilling operations, and the combination of both drilling and well production occurring simultaneously. Drill rig emissions were modeled at Tier 0, Tier 2, and Tier 4 emissions levels. Impacts to ambient air concentrations of CO, SO_2, and PM_{10} from drilling operations alone were also modeled. Figure 3-8 illustrates this 4 drill rig/section modeling scenario, and Figures 3-9 and 3-10 illustrate the two additional scenarios used for analyzing 1-hour NO_2 impacts. These figures are for the 100 meter receptor case.

Scenario 6: Combined well drilling and single-well production (4 wells/pad) scenario for a 40 acre/section development level. This case is similar to Scenario 5, however Scenario 6 is a single well pad case which included 4 drill rigs operating on 4 single-well pads in a section. Under this scenario, NO_2 impacts were analyzed for a range of well site activities, including drilling operations, and the combination of both drilling and well production occurring simultaneously. Drill rig emissions were modeled at Tier 0, Tier 2, and Tier 4 emissions levels. Impacts to ambient air concentrations of CO, SO_2, and PM_{10} from drilling operations alone were also modeled.

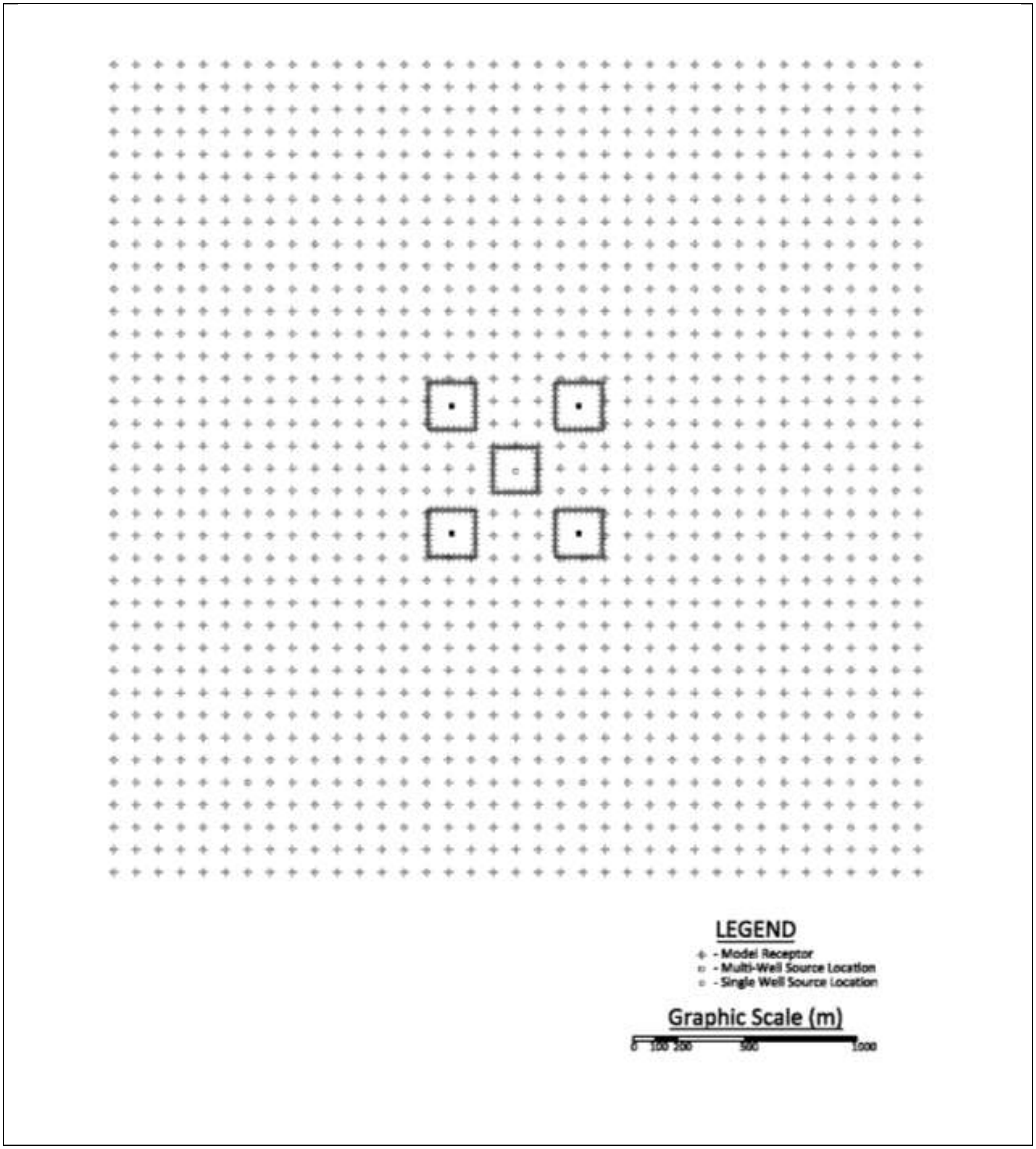

Figure 3-7. Production Wells and Well Drilling – 1 single well pad, 4 multi-well pads, 40 acre/section spacing with 100m receptors.

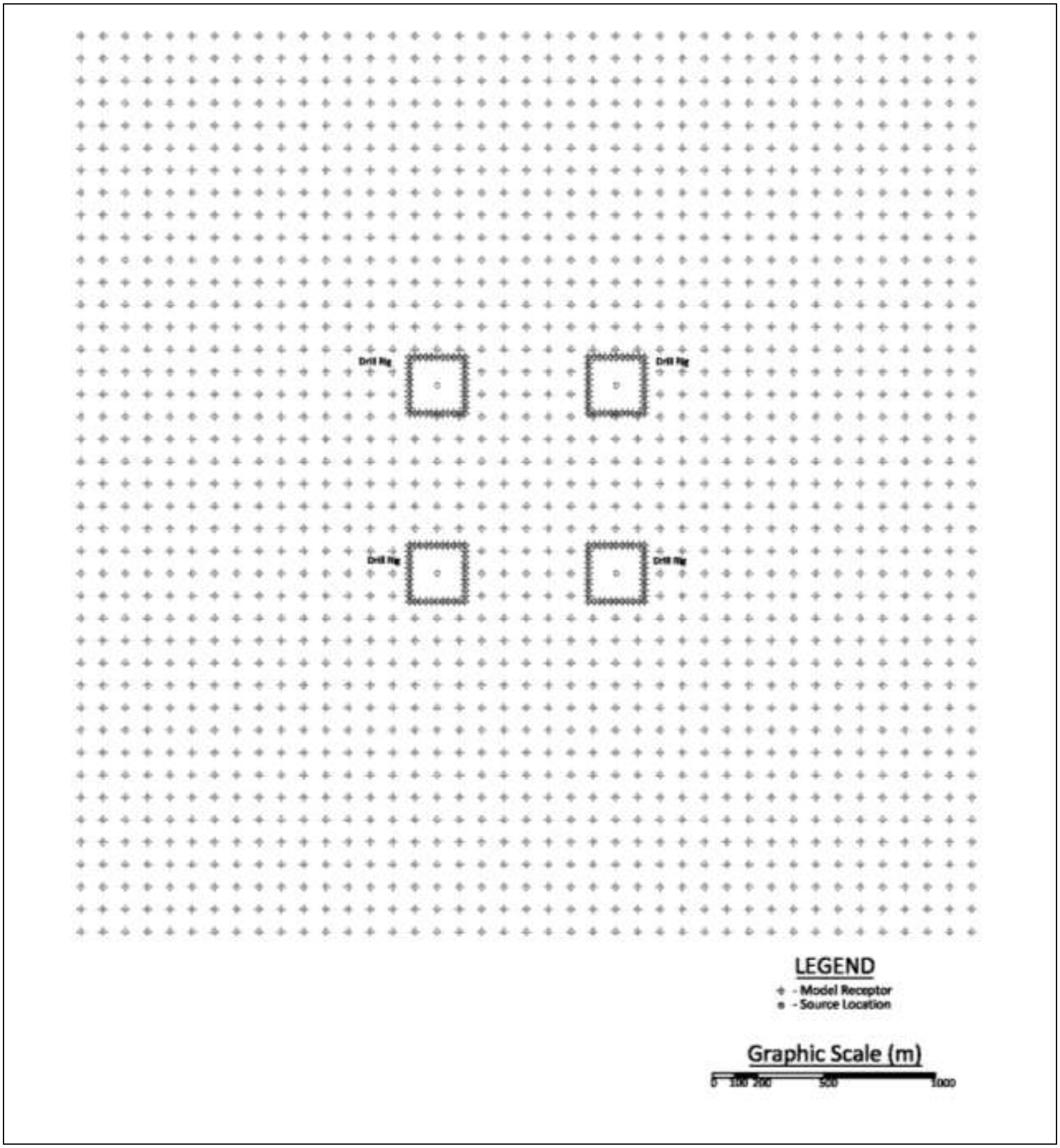

Figure 3-8. Scenario 1: Multiple Well Drilling Operations/Section – 4 multi-well pads, 40 acre/section spacing with 100m receptors.

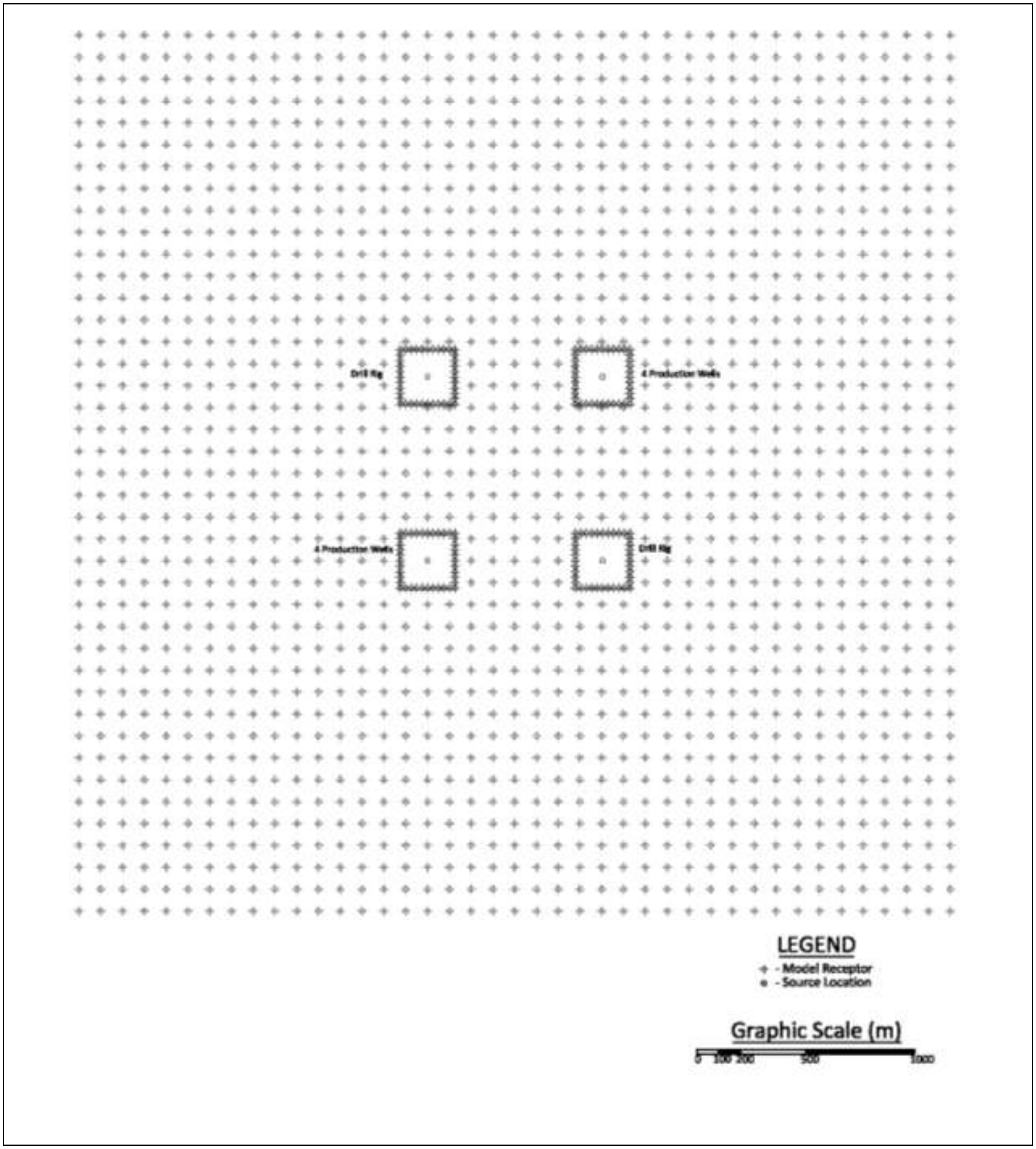

Figure 3-9. Scenario 2: Production Wells and Multiple Well Drilling Operations/Section - 4 multi-well pads, 40 acre/section spacing with 100m receptors.

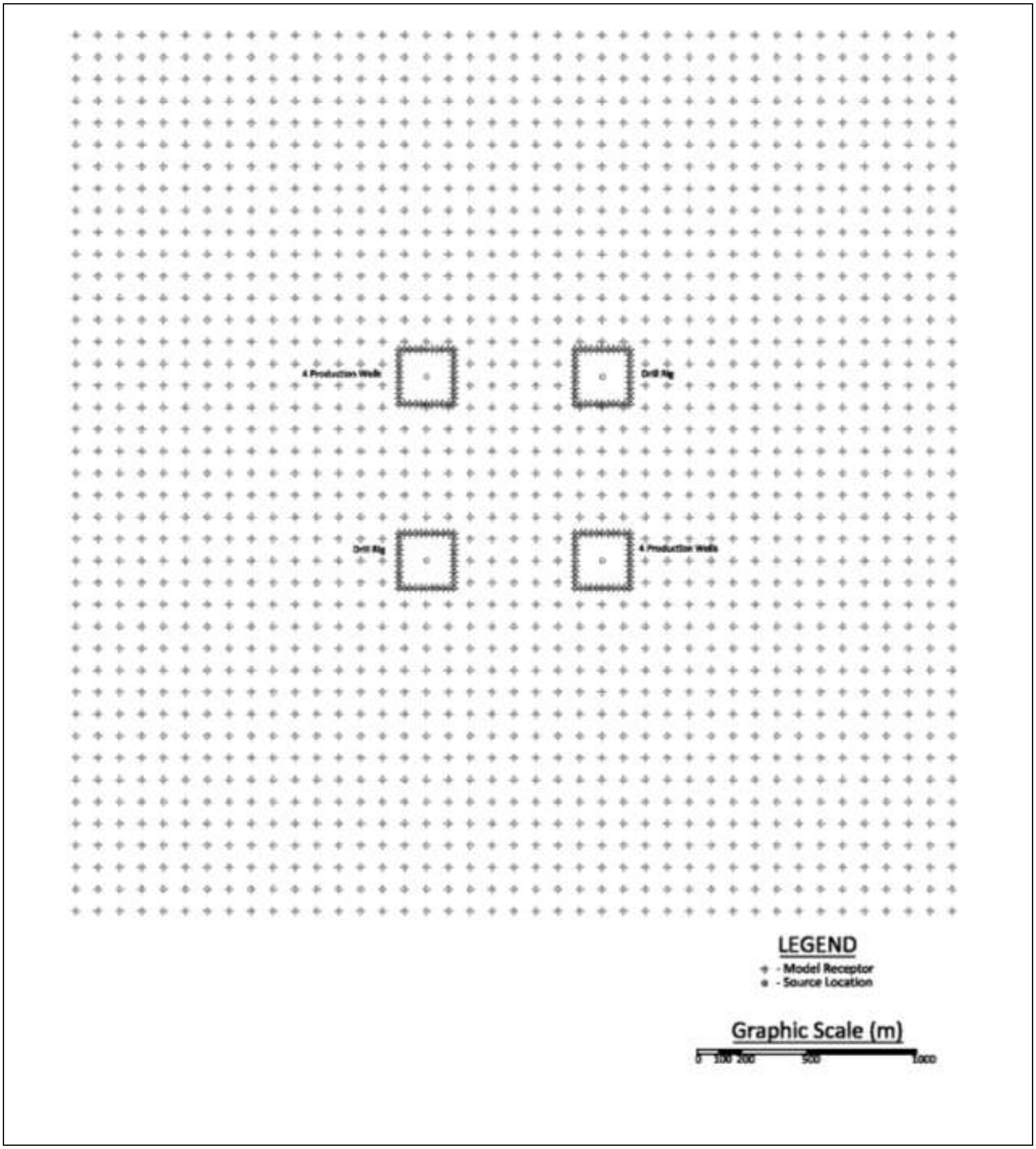

Figure 3-10. Scenario 3: Production Wells and Multiple Well Drilling Operations/Section - 4 multi-well pads, 40 acre/section spacing with 100m receptors.

For 1-hour NO_2 modeling analyses, all modeling scenarios were run for each of the three years of meteorological data. Where the impacts from only well production activities are disclosed, the 1-hour NO_2 concentrations for comparisons to the NAAQS are determined as the 3-year average of the eighth-highest daily maximum 1-hour NO_2 concentrations. For combined cases where well drilling operations and well production activities are modeled, it was assumed that well drilling could occur for a maximum of 2 years at any location. For the combined cases the 1-hour NO_2 concentrations for comparisons to the NAAQS were determined by averaging modeled impacts from 1 year with only well production occurring, with the modeled impacts from 2 years with both well development and well production occurring. These 3-year averaged eighth-highest, daily maximum 1-hour concentrations were determined by averaging the maximum 2 years of eight-highest daily maximum 1-hour concentrations for the combined well drilling and production cases, with the maximum year of eight-highest daily maximum 1-hour values from production alone.

The yearly maximum eighth-highest daily maximum 1-hour NO_2 concentrations for each of the modeled scenarios are provided in Appendix L. Appendix L provides both the maximum modeled 1-hour NO_2 concentrations for each scenario or year that were used for computing the 3-year averaged concentrations (paired in location), and the maximum (unpaired) values for each scenario or year.

Tables 3-10 through 3-15 present the NO_2 modeling results for each of the scenarios analyzed for both the 100 meter and 250 meter receptor distances. Table 3-16 presents additional modeling results for CO, SO_2, and PM_{10} impacts resulting from drill rig operations.

In Tables 3-10 through 3-15, 1-hour and annual NO_2 concentrations (including background concentrations) are shown for comparisons to the 1-hour NAAQS and annual NAAQS and WAAQS. Each of these tables presents several modeling cases, with a varying number of wells in production. Cases where the drill rig is operating with no wells in production are also shown. The tables present two columns, one showing the number of production wells modeled concurrently with drilling activities and the other showing the number of production wells modeled for the years when drilling is not occurring. 1-hour NO_2 concentrations for comparisons to the NAAQS were determined as described above, and for annual concentrations, the maximum annual values for any of the three years of modeled impacts were reported. Given that many of the reported annual values include intermittent drilling activities that would not occur continuously over a year, these concentrations represent conservative upper bound estimates of the actual impacts.

Table 3-10 presents the NO_2 modeling results for Scenario 1, a 40 acre/section single-well pad case that analyzed 5 total single-well pads, a drill rig operating, and up to 5 wells in production. As shown in Table 3-10, all modeled NO_2 concentrations are below the applicable NAAQS and WAAQS, with the exception of the 100 meter receptor distance cases, where analyses that considered drill rig operation at Tier 0 emissions levels are above the level of the 1-hour NO_2 NAAQS.

Table 3-11 presents the NO_2 modeling results for Scenario 2, a 40 acre/section combined multi-well pad and single-well pad case that analyzed 5 total well pads (4 multi-well, 1 single well), a drill rig operating, and up to 16 wells in production. As shown in Table 3-11 all modeled NO_2

concentrations are below the applicable NAAQS and WAAQS, with the exception of the 100 meter receptor distance cases, where analyses that considered drill rig operation at Tier 0 emissions levels are above the level of the 1-hour NO_2 NAAQS.

Tables 3-12 and 3-13 present the NO_2 modeling results for Scenario 3, a 40 acre/section multi-well pad case that analyzed 1 well pad, a drill rig operating, and up to 16 wells in production. Table 3-12 presents the 100 meter receptor case, and Table 3-13 presents the 250 meter receptor case. As shown in these tables all modeled NO_2 concentrations are below the applicable NAAQS and WAAQS, with the exception of the 100 meter receptor distance cases, where analyses that considered drill rig operation at Tier 0 and Tier 2 emissions levels are all above the level of the 1-hour NO_2 NAAQS. In addition, at the 100 meter receptor distance, there are analyses considering drill rig operation at Tier 4 emissions levels that are above the level of the 1-hour NAAQS.

Tables 3-14 and 3-15 present the NO_2 modeling results for Scenario 4, a 20 acre/section multi-well pad case that analyzed 1 well pad, a drill rig operating, and up to 32 wells in production. Table 3-14 presents the 100 meter receptor case, and Table 3-15 presents the 250 meter receptor case. As shown in Table 3-14, at the 100 meter receptor distance, impacts from 32 wells in production are above the level of the 1-hour NAAQS. With the exception of the case where a Tier 4 drill rig operates for 2 years followed by 32 wells in production in year 3, the 1-hour impacts are above the level of the NAAQS. For scenarios that analyzed 24 wells in production and with drill rig operation, compliance with the 1-hour NAAQS was shown at the 100 meter receptor distance for wells in production and for combined production and drilling activities with Tier 4 emissions levels. At a 250 meter receptor distance all modeled NO_2 concentrations are below the 1-hour NAAQS with the exception of the analyses that considered drill rig operation at Tier 0 emissions levels concurrent with 31 wells in production. For all cases analyzed under Scenario 4 modeled annual NO_2 concentrations are well below the annual NAAQS and WAAQS.

Table 3-16 presents the NO_2 modeling results for Scenarios 5 and 6, which analyzed 4 drill rigs/section operation and multi-well and single-well production assuming 40 acre/section development. As shown in Table 3-16 all modeled NO_2 concentrations are below the applicable NAAQS and WAAQS, with the exception of the 100 meter receptor distance cases, where analyses that considered drill rig operation at Tier 0 and Tier 2 emissions levels, and the 250 meter distance cases that considered drill rig operation at Tier 0 emissions levels, which are above the level of the 1-hour NO_2 NAAQS.

Tables 3-17 and 3-18 present potential CO, SO_2, and PM_{10} impacts from drill rig operation on multi-well pads and single-well pads, respectively. All modeled impacts, with background concentrations added, are well below the applicable NAAQS and WAAQS.

Table 3-10. CD-C Project - NO_2 Modeling Results for Single Well Pad Production and Drill Rig Operation Scenarios (40 acre spacing).

Receptors	Wells in Production with Drill Rig	Wells in Production w/o Drill Rig	Drill Rig Operating	Modeled 1-hour Concentration (µg/m^3)[1]	Total 1-hour Concentration (µg/m3)[2]	1-Hour NAAQS (µg/m^3)	Modeled Annual Concentration (µg/m^3)	Total Annual Concentration (µg/m3)[2]	Annual NAAQS/WAAQS (µg/m^3)
100 meter	0	5	none	18.1	93.1	188	0.9	10.0	100
	4	5	Tier 0	146.6	221.6	188	33.5	42.6	100
	4	5	Tier 2	105.4	180.4	188	25.1	34.2	100
	4	5	Tier 4	92.0	167.0	188	19.1	28.2	100
	0	5	Tier 0	146.6	221.6	188	33.3	42.4	100
	0	5	Tier 2	105.4	180.4	188	24.9	34.0	100
	0	5	Tier 4	92.0	167.0	188	18.9	28.0	100
250 meter	0	5	none	12.0	87.0	188	0.4	9.5	100
	4	5	Tier 0	92.6	167.6	188	19.4	28.5	100
	4	5	Tier 2	78.0	153.0	188	13.3	22.4	100
	4	5	Tier 4	68.2	143.2	188	9.0	18.1	100
	0	5	Tier 0	92.6	167.6	188	19.2	28.3	100
	0	5	Tier 2	78.0	153.0	188	13.1	22.2	100
	0	5	Tier 4	68.2	143.2	188	8.8	17.9	100

Note:
[1] 1-hour NO_2 concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
Where drilling rigs are modeled, the maximum 2-years of concentrations are combined with the maximum 1-year of production concentrations.
The yearly 8th highest daily maximum values are provided in Appendix L, Tables L.1-2a, and L.1-2b
Total concentrations include background concentration of 75 µg/m^3 (1-hour) and 9.1 µg/m^3 (annual).

Table 3-11. CD-C Project - NO_2 Modeling Results for 4 Multi-well Pad Production and Single Well Drilling Scenarios (40 acre spacing).

Receptors	Wells in Production with Drill Rig	Wells in Production w/o Drill Rig	Drill Rig Operating	Modeled 1-hour Concentration (µg/m³)[1]	Total 1-hour Concentration (µg/m3)[2]	1-Hour NAAQS (µg/m³)	Modeled Annual Concentration (µg/m³)	Total Annual Concentration (µg/m3)[2]	Annual NAAQS/WAAQS (µg/m³)
100 meter	0	16	none	67.6	142.6	188	2.7	11.8	100
	0	16	Tier 0	151.6	226.6	188	33.0	42.1	100
	0	16	Tier 2	110.4	185.4	188	24.8	33.9	100
	0	16	Tier 4	96.5	171.5	188	18.9	28.0	100
	15	16	Tier 0	151.6	226.6	188	33.6	42.7	100
	15	16	Tier 2	110.4	185.4	188	25.3	34.4	100
	15	16	Tier 4	96.5	171.5	188	19.4	28.5	100
250 meter	0	16	none	39.7	114.7	188	1.2	10.3	100
	0	0	Tier 0	97.8	172.8	188	19.2	28.3	100
	0	0	Tier 2	83.8	158.8	188	13.1	22.2	100
	0	0	Tier 4	73.2	148.2	188	8.8	17.9	100
	15	16	Tier 0	97.8	172.8	188	19.6	28.7	100
	15	16	Tier 2	83.8	158.8	188	13.5	22.6	100
	15	16	Tier 4	73.2	148.2	188	9.2	18.3	100

Note:
[1] 1-hour NO_2 concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
Where drilling rigs are modeled, the maximum 2-years of concentrations are combined with the maximum 1-year of production concentrations.
The yearly 8th highest daily maximum values are provided in Appendix L, Tables L.1-3a and L.1-3b.
[2] Total concentrations include background concentration of 75 µg/m³ (1-hour) and 9.1 µg/m³ (annual).

Table 3-12. CD-C Project - NO_2 Modeling Results for 1 Multi-well Pad with Drilling Operations (40 acre spacing) - 100 meter receptor case.

Wells in Production with Drill Rig	Wells in Production w/o Drill Rig	Drill Rig Operating	Modeled 1-hour Concentration (μg/m^3)[1]	Total 1-hour Concentration (μg/m3)[2]	1-Hour NAAQS (μg/m^3)	Modeled Annual Concentration (μg/m^3)	Total Annual Concentration (μg/m3)[2]	Annual NAAQS/WAAQS (μg/m^3)
0	16	none	112.6	187.6	188	7.3	16.5	100
0	16	Tier 0	146.6	221.6	188	27.6	36.8	100
0	16	Tier 2	121.6	196.6	188	20.4	29.6	100
0	16	Tier 4	108.9	183.9	188	14.7	23.9	100
12	16	Tier 0	148.1	223.1	188	30.0	39.2	100
12	16	Tier 2	123.1	198.1	188	23.1	32.3	100
12	16	Tier 4	110.5	185.5	188	17.5	26.7	100
15	16	Tier 0	148.5	223.5	188	30.6	39.8	100
15	16	Tier 2	123.5	198.5	188	23.7	32.9	100
15	16	Tier 4	113.9	188.9	188	18.2	27.4	100
0	12	none	103.2	178.2	188	5.7	14.9	100
0	12	Tier 0	140.6	215.6	188	27.6	36.8	100
0	12	Tier 2	117.3	192.3	188	20.4	29.6	100
0	12	Tier 4	105.1	180.1	188	14.7	23.9	100
12	12	Tier 0	142.0	217.0	188	30.0	39.2	100
12	12	Tier 2	118.8	193.8	188	23.1	32.3	100
12	12	Tier 4	107.2	182.2	188	17.5	26.7	100

Note:

1 1-hour NO_2 concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations
Where drilling rigs are modeled, the maximum 2-years of concentrations are combined with the maximum 1-year of production concentrations.
The yearly 8th highest daily maximum values are provided in Appendix L, Tables L.1-4a and L.1-4b.

2 Total concentrations include background concentration of 75 μg/m^3 (1-hour) and 9.1 μg/m^3 (annual).

Table 3-13. CD-C Project - NO_2 Modeling Results for 1 Multi-Well Pad with Drilling Operations (40 acre spacing) - 250 meter receptor case.

Wells in Production with Drill Rig	Wells in Production w/o Drill Rig	Drill Rig Operating	Modeled 1-hour Concentration ($\mu g/m^3$)[1]	Total 1-hour Concentration ($\mu g/m^3$)[2]	1-Hour NAAQS ($\mu g/m^3$)	Modeled Annual Concentration ($\mu g/m^3$)	Total Annual Concentration ($\mu g/m^3$)[2]	Annual NAAQS/WAAQS ($\mu g/m^3$)
0	16	none	101.4	176.4	188	3.5	12.7	100
0	16	Tier 0	109.6	184.6	188	16.1	25.3	100
0	16	Tier 2	99.2	174.2	188	10.7	19.9	100
0	16	Tier 4	85.8	160.8	188	6.9	16.1	100
12	16	Tier 0	110.4	185.4	188	17.0	26.2	100
12	16	Tier 2	99.7	174.7	188	11.7	20.9	100
12	16	Tier 4	95.4	170.4	188	8.0	17.2	100
15	16	Tier 0	110.6	185.6	188	17.3	26.5	100
15	16	Tier 2	102.0	177.0	188	12.0	21.2	100
15	16	Tier 4	101.2	176.2	188	8.3	17.5	100
0	12	none	87.5	162.5	188	2.6	11.8	100
0	12	Tier 0	103.3	178.3	188	16.1	25.3	100
0	12	Tier 2	91.5	166.5	188	10.7	19.9	100
0	12	Tier 4	80.4	155.4	188	6.9	16.1	100
12	12	Tier 0	104.5	179.5	188	17.0	26.2	100
12	12	Tier 2	94.3	169.3	188	11.7	20.9	100
12	12	Tier 4	91.3	166.3	188	8.0	17.2	100

Note:

1 1-hour NO_2 concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations
Where drilling rigs are modeled, the maximum 2-years of concentrations are combined with the maximum 1-year of production concentrations.
The yearly 8th highest daily maximum values are provided in Appendix L, Tables L.1-5a and L.1-5b.

2 Total concentrations include background concentration of 75 $\mu g/m^3$ (1-hour) and 9.1 $\mu g/m^3$ (annual).

Table 3-14. CD-C Project - NO_2 Modeling Results for 1 Multi-well Pad with Drilling Operations (20 acre spacing) - 100 meter receptor case.

Wells in Production with Drill Rig	Wells in Production w/o Drill Rig	Drill Rig Operating	Modeled 1-hour Concentration (µg/m3)1	Total 1-hour Concentration (µg/m3)2	1-Hour NAAQS (µg/m3)	Modeled Annual Concentration (µg/m3)	Total Annual Concentration (µg/m3)2	Annual NAAQS/WAAQS (µg/m3)
0	32	none	118.7	193.7	188	8.9	18.1	100
0	32	Tier 0	134.0	209.0	188	23.1	32.3	100
0	32	Tier 2	116.2	191.2	188	16.2	25.4	100
0	32	Tier 4	106.5	181.5	188	11.3	20.5	100
31	32	Tier 0	135.5	210.5	188	27.6	36.8	100
31	32	Tier 2	119.6	194.6	188	21.1	30.3	100
31	32	Tier 4	118.6	193.6	188	16.3	25.5	100
0	24	none	107.7	182.7	188	7.0	16.2	100
0	24	Tier 0	129.9	204.9	188	23.1	32.3	100
0	24	Tier 2	113.0	188.0	188	16.2	25.4	100
0	24	Tier 4	103.3	178.3	188	11.3	20.5	100
24	24	Tier 0	131.4	206.4	188	26.6	35.8	100
24	24	Tier 2	114.5	189.5	188	20.0	29.2	100
24	24	Tier 4	108.7	183.7	188	15.2	24.4	100

Note:

1 1-hour NO_2 concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations
Where drilling rigs are modeled, the maximum 2-years of concentrations are combined with the maximum 1-year of production concentrations.
The yearly 8^{th} highest daily maximum values are provided in Appendix L, Tables L.1-6a and L.1-6b.

2 Total concentrations include background concentration of 75 $\mu g/m^3$ (1-hour) and 9.1 $\mu g/m^3$ (annual).

Table 3-15. CD-C Project - NO_2 Modeling Results for 1 Multi-well Pad with Drilling Operations (20 acre spacing) - 250 meter receptor case.

Wells in Production with Drill Rig	Wells in Production w/o Drill Rig	Drill Rig Operating	Modeled 1-hour Concentration ($\mu g/m^3$)[1]	Total 1-hour Concentration ($\mu g/m^3$)[2]	1-Hour NAAQS ($\mu g/m^3$)	Modeled Annual Concentration ($\mu g/m^3$)	Total Annual Concentration ($\mu g/m^3$)[2]	Annual NAAQS/WAAQS ($\mu g/m^3$)
0	32	none	110.4	185.4	188	5.2	14.4	100
0	32	Tier 0	109.9	184.9	188.	13.8	23.0	100
0	32	Tier 2	101.1	176.1	188	8.9	18.1	100
0	32	Tier 4	83.4	158.4	188	5.5	14.7	100
31	32	Tier 0	113.3	188.3	188	15.8	25.0	100
31	32	Tier 2	111.9	186.9	188	11.1	20.3	100
31	32	Tier 4	111.9	186.9	188	7.8	17.0	100
0	24	none	101.4	176.4	188	4.0	13.2	100
0	24	Tier 0	106.5	181.5	188	13.8	23.0	100
0	24	Tier 2	97.4	172.4	188	8.9	18.1	100
0	24	Tier 4	80.2	155.2	188	5.5	14.7	100
24	24	Tier 0	107.5	182.5	188	15.3	24.5	100
24	24	Tier 2	103.1	178.1	188	10.6	19.8	100
24	24	Tier 4	103.1	178.1	188	8.6	17.8	100

Note:

1 1-hour NO_2 concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations
Where drilling rigs are modeled, the maximum 2-years of concentrations are combined with the maximum 1-year of production concentrations.
The yearly 8th highest daily maximum values are provided in Appendix L, Tables L.1-7a and L.1-7b.

2 Total concentrations include background concentration of 75 $\mu g/m^3$ (1-hour) and 9.1 $\mu g/m^3$ (annual).

Table 3-16. CD-C Project - NO_2 Modeling Results for 4 Drill Rigs Operating/Section Scenarios (40 acre spacing).

Receptors	Drill Rigs Operating in Year 1	Drill Rigs/ Wells in Production Years 2 and 3	Drill Rig	Modeled 1-hour Concentration (µg/m³)¹	Total 1-hour Concentration (µg/m3)²	1-Hour NAAQS (µg/m³)	Modeled Annual Concentration (µg/m³)	Total Annual Concentration (µg/m3)²	Annual NAAQS/WAAQS (µg/m³)
100 meter	4	2/2	Tier 0	189.3	264.3	188	37.7	46.8	100
	4	2/2	Tier 2	133.6	208.6	188	27.3	36.4	100
	4	2.2	Tier 4	102.7	177.7	188	20.3	29.4	100
	4	2/8	Tier 0	177.2	252.2	188	35.3	44.4	100
	4	2/8	Tier 2	125.6	200.6	188	25.6	34.7	100
	4	2/8	Tier 4	100.9	175.9	188	18.6	27.7	100
250 meter	4	2/2	Tier 0	123.2	198.2	188	23.9	33.0	100
	4	2/2	Tier 2	101.5	176.5	188	15.8	24.9	100
	4	2.2	Tier 4	83.4	158.4	188	10.4	19.5	100
	4	2/8	Tier 0	120.6	195.6	188	22.6	31.7	100
	4	2/8	Tier 2	101.1	176.1	188	14.8	23.9	100
	4	2/8	Tier 4	79.2	154.2	188	9.6	18.7	100

Note:

1 1-hour NO_2 concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations The yearly 8th highest daily maximum values are provided in Appendix L, Tables L.1-8a, L.1-8b, L.1-9a, and L.1-9b.

2 Total concentrations include background concentration of 75 µg/m³ (1-hour) and 9.1 µg/m³ (annual)

Table 3-17. CD-C Project – CO, SO_2 and PM_{10} Modeling Results for 4 Drill Rig Operation/Section (multi-well pads).

Receptor Scenario	Drill Rig Emissions Level	Pollutant	Averaging Time	Direct Modeled (μg/m³)	Background (μg/m³)	Total Predicted (μg/m³)	WAAQS (μg/m³)	NAAQS (μg/m³)
100 meter	Tier 0	CO	1-hour	710.8	1,026.0	1,736.8	40,000	40,000
			8-hour	378.0	798.0	1,176.0	10,000	10,000
250 meter	Tier 0	CO	1-hour	349.0	1,026.0	1,375.0	40,000	40,000
			8-hour	144.9	798.0	942.9	10,000	10,000
100 meter	Tier 2,4	CO	1-hour	585.6	1,026.0	1,611.6	40,000	40,000
			8-hour	311.3	798.0	1,109.3	10,000	10,000
250 meter	Tier 2,4	CO	1-hour	287.5	1,026.0	1,313.5	40,000	40,000
			8-hour	119.3	798.0	917.3	10,000	10,000
100 meter	Tier 0,2,4	SO_2	1-hour	24.6	19.7	44.3	n/a	196
			3-hour	15.9	11.5	27.4	1,300	1,300
			24-hour	8.2	4.2	12.4	260	365
			Annual	1.2	3.8	5.0	60	80
250 meter	Tier 0,2,4	SO_2	1-hour	13.1	19.7	32.8	n/a	196
			3-hour	6.9	11.5	18.4	1,300	1,300
			24-hour	2.8	4.2	7.0	260	365
			Annual	0.5	3.8	4.3	60	80
100 meter	Tier 0	PM_{10}	24-hour	20.5	56.0	76.5	150	n/a
			Annual	3.0	13.5	16.5	50	50
100 meter	Tier 0	PM_{10}	24-hour	7.1	56.0	63.1	150	n/a
			Annual	1.2	13.5	14.7	50	50
100 meter	Tier 2	PM_{10}	24-hour	6.1	56.0	62.1	150	n/a
			Annual	0.9	13.5	14.4	50	50
250 meter	Tier 2	PM_{10}	24-hour	2.1	56.0	58.1	150	n/a
			Annual	0.4	13.5	13.9	50	50
100 meter	Tier 4	PM_{10}	24-hour	2.9	56.0	58.9	150	n/a
			Annual	0.4	13.5	13.9	50	50
250 meter	Tier 4	PM_{10}	24-hour	1.0	56.0	57.0	150	n/a
			Annual	0.2	13.5	13.7	50	50

Table 3-18. CD-C Project – CO, SO_2 and PM_{10} Modeling Results for 4 Drill Rig Operation/Section (single-well pads).

Receptor Scenario	Drill Rig Emissions Level	Pollutant	Averaging Time	Direct Modeled (µg/m³)	Background (µg/m³)	Total Predicted (µg/m³)	WAAQS (µg/m³)	NAAQS (µg/m³)
100 meter	Tier 0	CO	1-hour	760.9	1,026.0	1,786.9	40,000	40,000
			8-hour	461.4	798.0	1,259.4	10,000	10,000
250 meter	Tier 0	CO	1-hour	374.6	1,026.0	1,400.6	40,000	40,000
			8-hour	159.1	798.0	957.1	10,000	10,000
100 meter	Tier 2,4	CO	1-hour	626.8	1,026.0	1,652.8	40,000	40,000
			8-hour	380.1	798.0	1,178.1	10,000	10,000
250 meter	Tier 2,4	CO	1-hour	308.6	1,026.0	1,334.6	40,000	40,000
			8-hour	131.0	798.0	929.0	10,000	10,000
100 meter	Tier 0,2,4	SO_2	1-hour	27.6	19.7	47.3	n/a	196
			3-hour	17.5	11.5	29.0	1,300	1,300
			24-hour	9.9	4.2	14.1	260	365
			Annual	1.4	3.8	5.2	60	80
250 meter	Tier 0,2,4	SO_2	1-hour	14.8	19.7	34.5	n/a	196
			3-hour	8.2	11.5	19.7	1,300	1,300
			24-hour	3.1	4.2	7.3	260	365
			Annual	0.5	3.8	4.3	60	80
100 meter	Tier 0	PM_{10}	24-hour	24.6	56.0	80.6	150	n/a
			Annual	3.3	13.5	17.0	50	50
100 meter	Tier 0	PM_{10}	24-hour	7.9	56.0	63.9	150	n/a
			Annual	1.3	13.5	14.8	50	50
100 meter	Tier 2	PM_{10}	24-hour	7.3	56.0	63.3	150	n/a
			Annual	1.0	13.5	14.5	50	50
250 meter	Tier 2	PM_{10}	24-hour	2.3	56.0	58.3	150	n/a
			Annual	0.4	13.5	13.9	50	50
100 meter	Tier 4	PM_{10}	24-hour	3.5	56.0	59.5	150	n/a
			Annual	0.5	13.5	14.0	50	50
250 meter	Tier 4	PM_{10}	24-hour	1.1	56.0	57.1	150	n/a
			Annual	0.2	13.5	13.7	50	50

3.5.5 Well Pad Construction

Maximum localized particulate matter (PM_{10} and $PM_{2.5}$) impacts would result from well pad and road construction activities and from wind erosion are discussed in this section. These emissions would be temporary in nature, and the impacts would be greatest at and immediately adjacent to their source and would decrease rapidly with distance. Modeling scenarios to evaluate well pad and road construction activities for PM_{10}/$PM_{2.5}$ impacts were developed for two project development levels; (1) 4 single well pads, and (2) multiple well pads, assuming 4 wells per pad. Each of these cases is for a 40 acre/section down-hole spacing development level. The single well pad case included 4 well pads and access roads under construction spaced one quarter mile apart, and the multiple well pad case included 4 multi-well pads spaced one half mile apart (16 total wells per section).

The single well pad case included well pads that are 5.4 acres, with 0.9 acre (0.14 mile) access roads. The multiple well pad case included 8 acre (2 acre per well bore) well pads, with a 1.8 acre (0.27 mile) access road.

Receptor sets for both 100 meter and 250 meter fenceline distances from the edge of the well pads were used. Figures 3-11 and 3-12 illustrate these modeling scenarios. These figures show the cases with discrete modeling receptors placed at 100 meters from the well pad sources.

Volume sources were used to represent emissions from well pads and roads. The emissions used for modeling the well pad and resource road construction are shown in Table 3-2 and are further detailed in Appendix H. Hourly emission rate adjustment factors were applied to limit construction emissions to daytime hours. Wind erosion emissions were modeled for all hours where the wind speed exceeded a threshold velocity of 16 meters/second, which was as part of the wind erosion emissions calculations described in Section 2.

For modeling PM_{10} impacts, PM_{10} emissions from well pad and access road construction, and wind erosion were modeled for each of the three years of AERMET-processed meteorological data and the maximum report PM_{10} concentrations were reported.

$PM_{2.5}$ modeling scenarios were developed for a combined 3-year well development and well production case which included one year of well pad and access road construction emissions, and wind erosion, a year with drill rig operations occurring at the center of the well pad, and one year of well production activities. Drill rig emissions were modeled at Tier 0, Tier 2, and Tier 4 emissions levels.

The $PM_{2.5}$ modeling scenarios were run for each of the three years of meteorological data. The 24-hour $PM_{2.5}$ concentrations for comparisons to the NAAQS were determined by averaging modeled impacts from one year with well pad and access road construction, one year with well drilling, and the third year with the wells in production. The maximum 24-hour concentrations from each of the three modeled meteorology years were determined for each of the three well development and well production scenarios, and these values were used to determine the average 24-hour $PM_{2.5}$ concentration for comparison to the NAAQS. Appendix L provides both the maximum modeled 24-hour $PM_{2.5}$ concentrations for each scenario that were used for computing the 3-year averaged concentrations (paired in location), and the maximum (unpaired) values for each scenario.

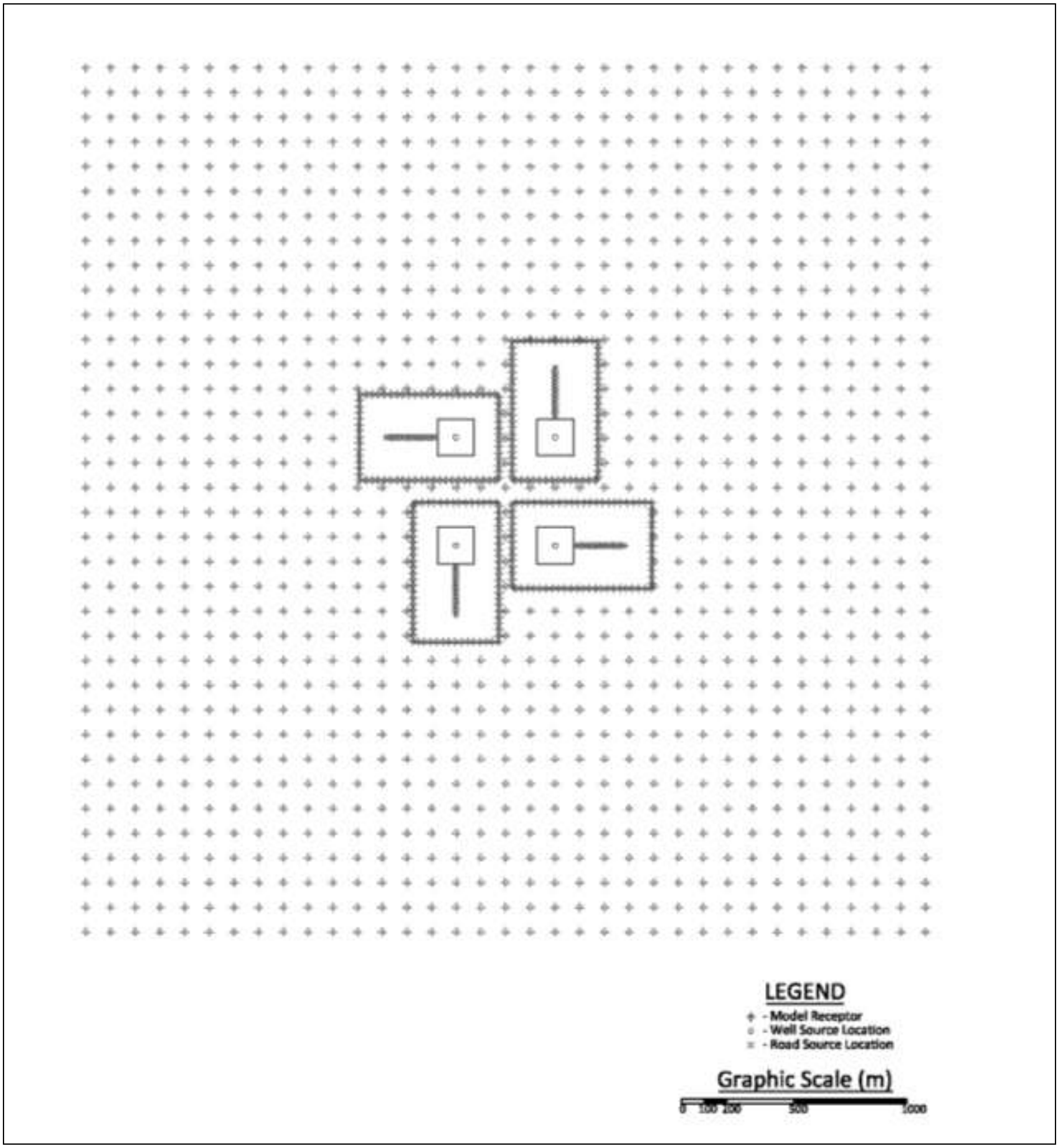

Figure 3-11. Source and Receptor Layout – Single-well pad and access road construction – 4-single well pads, 40 acre/section spacing with 100m receptors.

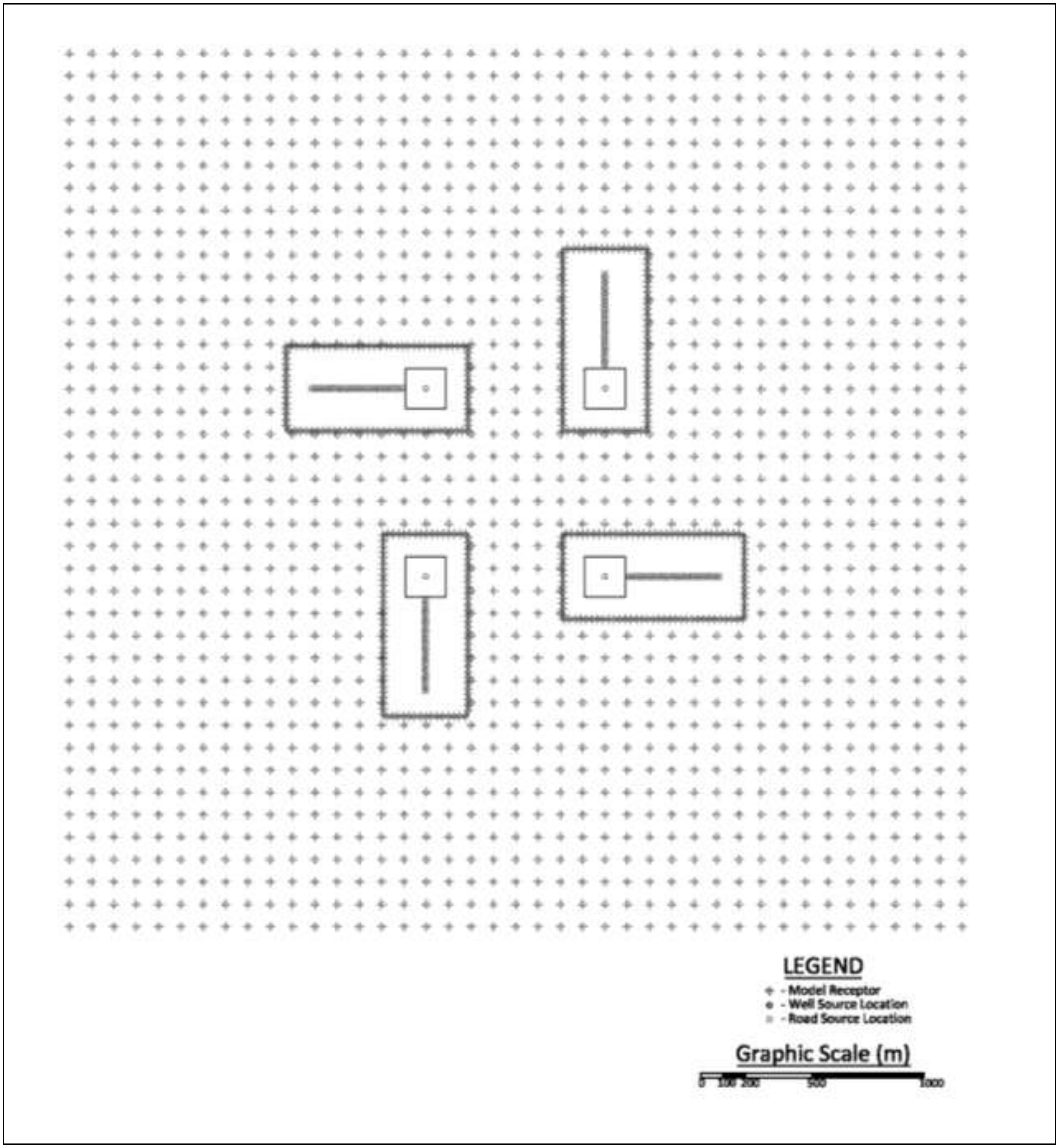

Figure 3-12. Source and Receptor Layout – Multi-well pad and access road construction – 4 multi-well pads, 40 acre/section spacing with 100m receptors.

Table 3-19 presents the maximum modeled PM_{10}/$PM_{2.5}$ concentrations, for the single well pad and access road construction modeling scenarios. When the modeled concentrations are added to representative background concentrations, it was demonstrated that 24-hour PM_{10} and $PM_{2.5}$ concentrations are above the level of the WAAQS and NAAQS at 100 meters, and are below the WAAQS and NAAQS at 250 meters. All annual concentrations are below the WAAQS and NAAQS. Given that reported annual values include intermittent construction operations that would not occur continuously over a year, these concentrations are likely overstated.

Table 3-19. CD-C Project - PM_{10} and $PM_{2.5}$ Modeling Results for Single-well Pad and Access Road Construction.

Scenario	Pollutant	Averaging Time	Drill Rig Emissions	Direct Modeled ($\mu g/m^3$)	Background ($\mu g/m^3$)	Total Predicted ($\mu g/m^3$)	WAAQS ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
100 meter	PM_{10}	24-Hour	N/A	123.2[1]	56.0	179.2	150	--
		Annual	N/A	7.5	13.5	21.0	50	50
	$PM_{2.5}$	24-Hour	Tier 0 Tier 2 Tier 4	33.3[2] 31.4[2] 31.0[2]	9.2	42.5 40.6 40.2	--	35
		Annual	N/A	4.8	4.2	9.0	--	15
250 meter	PM_{10}	24-Hour	N/A	76.2[1]	56.0	132.3	150	--
		Annual	N/A	3.0	13.5	16.5	50	50
	$PM_{2.5}$	24-Hour	Tier 0 Tier 2 Tier 4	24.8[2] 23.7[2] 23.4[2]	9.2	34.0 32.9 32.6	--	35
		Annual	N/A	2.4	4.2	6.6	--	15

Notes:

1 Modeled highest second-high value

2 3-year average of the maximum modeled 24-hour concentrations (includes well pad construction, drill rig operation, and well production activities). The yearly maximum 24-hour values are provided in Appendix L, Tables L.2-1a and L.2-1b.

Table 3-20 presents the maximum modeled PM_{10}/$PM_{2.5}$ concentrations, for the multi-well pad and access road construction modeling scenarios. When the modeled concentrations are added to representative background concentrations, it was demonstrated that all PM_{10} and $PM_{2.5}$ concentrations are below the WAAQS and NAAQS at both the 100 meter and 250 meter receptor distances.

Table 3-20. CD-C Project - PM_{10} and $PM_{2.5}$ Modeling Results for Multi-well Pad and Access Road Construction.

Scenario	Pollutant	Averaging Time	Drill Rig Emissions	Direct Modeled (µg/m³)	Background (µg/m³)	Total Predicted (µg/m³)	WAAQS (µg/m³)	NAAQS (µg/m³)
100 meter	PM_{10}	24-Hour	N/A	83.3[1]	56.0	139.3	150	--
		Annual	N/A	4.9	13.5	18.4	50	50
	$PM_{2.5}$	24-Hour	Tier 0 Tier 2 Tier 4	25.4[2] 23.9[2] 23.6[2]	9.2	34.6 33.1 32.8	--	35
		Annual	N/A	3.1	4.2	7.3	--	15
250 meter	PM_{10}	24-Hour	N/A	60.1[1]	56.0	116.1	150	--
		Annual	N/A	2.5	13.5	16.0	50	50
	$PM_{2.5}$	24-Hour	Tier 0 Tier 2 Tier 4	16.5[2] 15.8[2] 15.7[2]	9.2	25.7 25.0 24.9	--	35
		Annual	N/A	1.6	4.2	5.8	--	15

Notes:

1 Modeled highest second-high value

2 3-year average of the maximum modeled 24-hour concentrations (includes well pad construction, drill rig operation, and well production activities). The yearly maximum 24-hour values are provided in Appendix L, Tables L.2-2a and L.2-2b.

3.6 HAP IMPACT ASSESSMENT

Near-field HAP concentrations were calculated for assessing impacts both in the immediate vicinity of Project Area emission sources for short-term (acute) and long term (annual)) exposure assessments and for calculation of long-term risk. Since HAPs will be emitted predominantly during the Project production phases, analyses were performed for only for production activities. Sources of HAPs include well-site production emissions (benzene, toluene, ethyl benzene, xylene, n-hexane, and formaldehyde), and compressor station and gas plant combustion emissions (formaldehyde).

The modeling scenarios used for the HAP impact assessment were developed as part of the criteria pollutant analysis for the proposed compression emissions, for the gas plant and for the two multi-well pad cases; (1) with 16 wells in production (40 acre/section spacing), and (2) with 32 wells in production (20 acre/section spacing). As mentioned in Section 3.5, the single pad, multi-well case with 16 well represents the maximum proposed development for the range of CD-C Project alternatives, and the 32 well/pad case (20 acre/section spacing), although not proposed under any of the CD-C Project Alternatives, was modeled for informational purposes at the request of the WDEQ-AQD to disclose impacts for a more concentrated well development scenario in the event that future field operations support this development level.

Similar to the criteria pollutant modeling, the two sets (100 meter and 250 meter) of flat terrain discrete modeling receptor sets were used for each modeling scenario. For long-term incremental risk determinations 100 meter and 250 meter receptor sets were used, in addition, polar receptor grids at quarter mile increments were used to determine the distance required to be below a one-in-one-million cancer risk factor.

AERMOD was used to determine model short-term (1-hour) and long-term (annual) HAP impacts. The three years of AERMET-processed Wamsutter meteorological data (2008-2010) used for the criteria pollutant assessment were used for the HAPs analyses.

Short-term (1-hour) HAP concentrations were compared to acute Reference Exposure Levels (RELs) (EPA, 2011b) shown in Table 3-21. RELs are defined as concentrations at or below which no adverse health effects are expected. No RELs are available for ethyl benzene and n-hexane; instead, the available Immediately Dangerous to Life or Health divided by 10 (IDLH/10) values are used. These IDLH values were determined by the National Institute for Occupational Safety and Health (NIOSH) and were obtained from EPA's Air Toxics Database (EPA, 2011b). These values are approximately comparable to mild effects levels for 1-hour exposures.

Long-term HAPs concentrations were compared to Reference Concentrations for Chronic Inhalation (RfCs). An RfC is defined by EPA as the daily inhalation concentration at which no long-term adverse health effects are expected. RfCs exist for both non-carcinogenic and carcinogenic effects on human health (EPA, 2010b). Annual modeled HAP concentrations for all HAPs emitted were compared directly to the non-carcinogenic RfCs shown in Table 3-22. RfCs for suspected carcinogens benzene, ethyl benzene, and formaldehyde are expressed as unit risk factors, shown in Table 3-29, and were used to evaluate the potential incremental risk from these pollutants.

Table 3-21. Acute RELs (1-Hour Exposure).

HAP	REL ($\mu g/m^3$)
Benzene	1,300[1]
Toluene	37,000[1]
Ethyl Benzene	350,000[2]
Xylene	22,000[1]
n-Hexane	390,000[2]
Formaldehyde	55[1]

1 EPA Air Toxics Database, Table 2 (EPA, 2011b).
2 No REL available for these HAPs. Values shown are from Immediately Dangerous to Life or Health (IDLH/10), EPA Air Toxics Database, Table 2 (EPA, 2011b).

Table 3-22. Non-Carcinogenic HAP RfCs (Annual Average). [1]

HAP	Non-CarcinogenicRfC[1] ($\mu g/m^3$)
Benzene	30
Toluene	5000
Ethyl Benzene	1,000
Xylenes	100
n-Hexane	700
Formaldehyde	9.8

1 EPA Air Toxics Database, Table 1 (EPA, 2010).

Tables 3-23 and 3-24 present the modeled formaldehyde impacts for the proposed compression station and gas plant, respectively. As shown in these tables both the short-term (1-hour) and long-term (annual) formaldehyde impacts are well below the RELs and RfCs for both the proposed compressor station and gas plant.

Tables 3-25 and 3-26 present the short-term and long-term HAP modeling results for the single pad multi-well case that analyzed 16 wells in production. As shown in these tables HAP impacts are below the applicable short-term RELs or IDLH/10 values, and the long-term non-carcinogenic RfCs.

Tables 3-27 and 3-28 present the short-term and long-term HAP modeling results for the single pad multi-well case that analyzed 32 wells in production. As shown in these tables all HAP impacts are below the applicable short-term RELs or IDLH/10 values, and the long-term non-carcinogenic RfCs, with the exception of the modeled formaldehyde concentration for the 100 meter receptor case, which is slightly above the short-term REL threshold.

Table 3-23. CD-C Project – Formaldehyde Modeling Results for Proposed Compression Emissions.

Scenario	Modeled 1-hour Concentration (μg/m^3)	REL (μg/m^3)	Modeled Annual Concentration (μg/m^3)	Non-carcinogenic RfC (μg/m^3)
100 meter receptors	5.4	55	0.2	9.8
250 meter receptors	3.3	55	0.1	9.8

Table 3-24. CD-C Project – Formaldehyde Modeling Results for Proposed Gas Plant Emissions.

Scenario	Modeled 1-hour Concentration (μg/m^3)	REL (μg/m^3)	Modeled Annual Concentration (μg/m^3)	Non-carcinogenic RfC (μg/m^3)
100 meter receptors	5.8	55	0.4	9.8
250 meter receptors	5.3	55	0.4	9.8

Table 3-25. CD-C Project – Short-Term (1-hour) HAP Modeling Results for Production Well Case: 16 Wells, 1 Multi-well Pad, 40 acre spacing.

HAP	Direct Modeled Concentration by Modeling Scenario (μg/m^3)		REL or IDLH (μg/m^3)
	100 meter receptors	250 meter receptors	
Benzene	6.2	5.5	1,300[1]
Toluene	8.4	7.4	37,000[1]
Ethylbenzene	0.2	0.2	350,000[2]
Xylene	3.8	3.3	22,000[1]
n-Hexane	33.6	29.6	390,000[2]
Formaldehyde	47.3	41.6	55[1]

1 Reference Exposure Level

2 Immediately Dangerous to Life or Health value divided by 10.

Table 3-26. CD-C Project – Long-Term (annual) HAP Modeling Results for Production Well Case: 16 Wells, 1 Multi-well Pad, 40 acre spacing.

HAP	Direct Modeled Concentration by Modeling Scenario (µg/m³)		Non-carcinogenic RfC (µg/m³)
	100 meter receptors	250 meter receptors	
Benzene	0.2	0.1	30
Toluene	0.3	0.1	5,000
Ethylbenzene	0.01	0.003	1,000
Xylene	0.1	0.06	100
n-Hexane	1.2	0.6	700
Formaldehyde	1.7	0.8	9.8

Table 3-27. CD-C Project – Short-Term (1-hour) HAP Modeling Results for Production Well Case: 32 Wells, 1 Multi-well Pad, 20 acre spacing.

HAP	Direct Modeled Concentration by Modeling Scenario (µg/m³)		REL or IDLH (µg/m³)
	100 meter receptors	250 meter receptors	
Benzene	7.3	6.6	1,300[1]
Toluene	9.9	8.8	37,000[1]
Ethylbenzene	0.2	0.2	350,000[2]
Xylene	4.4	4.0	22,000[1]
n-Hexane	39.7	35.4	390,000[2]
Formaldehyde	55.8	49.8	55[1]

1 Reference Exposure Level
2 Immediately Dangerous to Life or Health value divided by 10.

Table 3-28. CD-C Project – Long-Term (annual) HAP Modeling Results for Production Well Case: 32 Wells, 1 Multi-well Pad, 20 acre spacing.

HAP	Direct Modeled Concentration by Modeling Scenario (µg/m³)		Non-carcinogenic RfC (µg/m³)
	100 meter receptors	250 meter receptors	
Benzene	0.3	0.2	30
Toluene	0.4	0.2	5,000
Ethylbenzene	0.01	0.005	1,000
Xylene	0.2	0.1	100
n-Hexane	2.2	0.9	700
Formaldehyde	1.5	1.2	9.8

Long-term exposures to emissions of suspected carcinogens (benzene ethyl benzene and formaldehyde) were evaluated based on estimates of the increased latent cancer risk over a 70-year lifetime. This analysis presents the potential incremental risk from these pollutants, and does not represent a total risk analysis. The cancer risks were calculated using the maximum predicted annual concentrations and EPA's chronic inhalation unit risk factors (URF) for carcinogenic constituents (EPA 2010b. Estimated cancer risks were evaluated based on the Superfund National Oil and Hazardous Substances Pollution Contingency Plan (EPA 1990a), where a cancer risk range of 1 to 100 x 10^{-6} is generally acceptable. Two estimates of cancer risk are presented: 1) a most likely exposure (MLE) scenario; and 2) a maximum exposed individual (MEI) scenario. The estimated cancer risks are adjusted to account for duration of exposure and time spent at home.

The adjustment for the MLE scenario is assumed to be 9 years, which corresponds to the mean duration that a family remains at a residence (EPA 1993). This duration corresponds to an adjustment factor of 9/70 = 0.13. The duration of exposure for the MEI scenario is assumed to be 60 years (i.e., the LOP), corresponding to an adjustment factor of 60/70 = 0.86. A second adjustment is made for time spent at home versus time spent elsewhere. For the MLE scenario, the at-home time fraction is 0.64 (EPA 1993), and it is assumed that during the rest of the day the individual would remain in an area where annual HAP concentrations would be one quarter as large as the maximum annual average concentration. Therefore, the final MLE adjustment factor is (0.13) x [(0.64 x 1.0) + (0.36 x 0.25)] = 0.0949. The MEI scenario assumes that the individual is at home 100% of the time, for a final MEI adjustment factor of (0.86 x 1.0) = 0.86. Table 3-29 provides RfCs for suspected carcinogens benzene, ethyl benzene, and formaldehyde, expressed as unit risk factors, and the exposure adjustment factors used to evaluate the potential incremental risk from these pollutants.

Table 3-29. Carcinogenic HAP RfCs and Exposure Adjustment Factors.

Analysis[1]	HAP Constituent	Carcinogenic RfC (Unit Risk Factor)[2] $1/(\mu g/m^3)$[3]	Exposure Adjustment Factor
MLE	Benzene	7.8×10^{-6}	0.0949
MLE	Ethyl Benzene	2.5×10^{-6}	0.0949
MLE	Formaldehyde	1.3×10^{-5}	0.0949
MEI	Benzene	7.8×10^{-6}	0.86
MEI	Ethyl Benzene	2.5×10^{-6}	0.86
MEI	Formaldehyde	1.3×10^{-5}	0.86

1 LE = most likely exposure; MEI = maximally exposed individual.
2 EPA Air Toxics Database, Table 1 (EPA, 2010).
3 Annual Average Concentration.

For each constituent, the cancer risk is computed by multiplying the maximum predicted annual concentration by the URF and by the overall exposure adjustment factor. The cancer risks for both constituents are then summed to provide an estimate of the total inhalation cancer risk.

For the incremental risk determinations, modeling was performed for both the 100 and 250 meter receptor sets, and using polar grid receptors at quarter mile increments from project sources in order to determine the distances from proposed project sources where HAP impacts would not contribute to a total inhalation cancer risk that is above one-in-one-million.

The modeled long-term risk from formaldehyde concentrations resulting from the proposed compression and gas plant emissions are shown in Table 3-30. The distance required to be below a one-in-one-million cancer risk level for either the MLE or MEI analysis was 0.25 miles for the compressor station, and 1.0 miles for the proposed gas plant.

Table 3-30. CD-C Project - Long-term Modeled Formaldehyde MLE and MEI Cancer Risk Analyses for Proposed Compression and Gas Plant.

Modeling Scenario	Distance	Analysis	Modeled Concentration ($\mu g/m^3$)	Unit Risk Factor $1/(\mu g/m^3)$	Exposure Adjustment Factor	Cancer Risk
Compression	100 meters	MLE	0.19	1.3×10^{-5}	0.0949	0.2×10^{-6}
Compression	100 meters	MEI	0.19	1.3×10^{-5}	0.86	2.1×10^{-6}
Gas Plant	100 meters	MLE	0.36	1.3×10^{-5}	0.0949	0.4×10^{-6}
Gas Plant	100 meters	MEI	0.36	1.3×10^{-5}	0.86	4.0×10^{-6}
Compression	250 meters	MLE	0.14	1.3×10^{-5}	0.0949	0.2×10^{-6}
Compression	250 meters	MEI	0.14	1.3×10^{-5}	0.86	1.6×10^{-6}
Gas Plant	250 meters	MLE	0.36	1.3×10^{-5}	0.0949	0.4×10^{-6}
Gas Plant	250 meters	MEI	0.36	1.3×10^{-5}	0.86	4.0×10^{-6}
Compression	0.25 miles	MLE	0.08	1.3×10^{-5}	0.0949	0.1×10^{-6}
Compression	0.25 miles	MEI	0.08	1.3×10^{-5}	0.86	0.9×10^{-6}
Gas Plant	1.0 miles	MEI	0.08	1.3×10^{-5}	0.0949	0.1×10^{-6}
Gas Plant	1.0 miles	MEI	0.08	1.3×10^{-5}	0.86	0.9×10^{-6}

The modeled long-term risk from benzene, ethyl benzene, and formaldehyde emissions resulting from the single well pad production cases are shown in Table 3-31 (16 wells) and Table 3-32 (32 wells). The distance required to be below a one-in-one-million cancer risk level for either the MLE or MEI analysis was 1.25 miles for the single pad, 16 wells in production case, and 2.0 miles for the single pad, 32 wells in production case.

Table 3-31. CD-C Project - Long-term Modeled MLE and MEI Cancer Risk Analyses for Production Well Case: 16 Wells, 1 Multi-well Pad, 40 acre spacing.

Modeling Scenario	Analysis	HAP Constituent	Modeled Concentration ($\mu g/m^3$)	Unit Risk Factor $1/(\mu g/m^3)$	Exposure Adjustment Factor	Cancer Risk
16 wells/pad case: 100 meter receptors	MLE	Benzene	0.23	7.8×10^{-6}	0.0949	0.2×10^{-6}
		Ethyl Benzene	0.007	2.5×10^{-6}	0.0949	0.001×10^{-6}
		Formaldehyde	1.7	1.3×10^{-5}	0.0949	2.1×10^{-6}
Total Combined[1]						2.3×10^{-6}
16 wells/pad case: 100 meter receptors	MEI	Benzene	0.23	7.8×10^{-6}	0.86	1.5×10^{-6}
		Ethyl Benzene	0.007	2.5×10^{-6}	0.86	0.01×10^{-6}
		Formaldehyde	1.7	1.3×10^{-5}	0.86	19.1×10^{-6}
Total Combined[1]						20.7×10^{-6}
16 wells/pad case: 250 meter receptors	MLE	Benzene	0.10	7.8×10^{-6}	0.0949	0.08×10^{-6}
		Ethyl Benzene	0.003	2.5×10^{-6}	0.0949	0.001×10^{-6}
		Formaldehyde	0.79	1.3×10^{-5}	0.0949	1.0×10^{-6}
Total Combined[1]						1.0×10^{-6}
16 wells/pad case: 250 meter receptors	MEI	Benzene	0.10	7.8×10^{-6}	0.86	0.7×10^{-6}
		Ethyl Benzene	0.003	2.5×10^{-6}	0.86	0.006×10^{-6}
		Formaldehyde	0.79	1.3×10^{-5}	0.86	8.8×10^{-6}
Total Combined[1]						9.5×10^{-6}
16 wells/pad case: receptors 1.25 miles from well pad	MLE	Benzene	0.01	7.8×10^{-6}	0.0949	0.008×10^{-6}
		Ethyl Benzene	0.0003	2.5×10^{-6}	0.0949	0.00001×10^{-6}
		Formaldehyde	0.08	1.3×10^{-5}	0.0949	0.09×10^{-6}
Total Combined[1]						0.1×10^{-6}
16 wells/pad case: receptors 1.25 miles from well pad	MEI	Benzene	0.01	7.8×10^{-6}	0.86	0.07×10^{-6}
		Ethyl Benzene	0.0003	2.5×10^{-6}	0.86	0.001×10^{-6}
		Formaldehyde	0.08	1.3×10^{-5}	0.86	0.9×10^{-6}
Total Combined[1]						0.9×10^{-6}

[1]Total risk is calculated here; however, the additive effects of multiple chemicals are not fully understood and this should be taken into account when viewing these results.

Table 3-32. CD-C Project - Long-term Modeled MLE and MEI Cancer Risk Analyses for Production Well Case: 32 Wells, 1 Multi-well Pad, 40 acre spacing.

Modeling Scenario	Analysis	HAP Constituent	Modeled Concentration ($\mu g/m^3$)	Unit Risk Factor $1/(\mu g/m^3)$	Exposure Adjustment Factor	Cancer Risk
32 wells/pad case: 100 meter receptors	MLE	Benzene	0.28	7.8×10^{-6}	0.0949	0.2×10^{-6}
		Ethyl Benzene	0.008	2.5×10^{-6}	0.0949	0.002×10^{-6}
		Formaldehyde	2.2	1.3×10^{-5}	0.0949	2.7×10^{-6}
Total Combined[1]						2.9×10^{-6}
32 wells/pad case: 100 meter receptors	MEI	Benzene	0.28	7.8×10^{-6}	0.86	1.9×10^{-6}
		Ethyl Benzene	0.008	2.5×10^{-6}	0.86	0.02×10^{-6}
		Formaldehyde	2.2	1.3×10^{-5}	0.86	24.1×10^{-6}
Total Combined[1]						26.0×10^{-6}
32 wells/pad case: 250 meter receptors	MLE	Benzene	0.16	7.8×10^{-6}	0.0949	0.1×10^{-6}
		Ethyl Benzene	0.005	2.5×10^{-6}	0.0949	0.001×10^{-6}
		Formaldehyde	1.2	1.3×10^{-5}	0.0949	1.5×10^{-6}
Total Combined[1]						1.6×10^{-6}
32 wells/pad case: 250 meter receptors	MEI	Benzene	0.16	7.8×10^{-6}	0.86	1.1×10^{-6}
		Ethyl Benzene	0.005	2.5×10^{-6}	0.86	0.01×10^{-6}
		Formaldehyde	1.2	1.3×10^{-5}	0.86	13.4×10^{-6}
Total Combined[1]						14.4×10^{-6}
32 wells/pad case: receptors 2.0 miles from well pad	MLE	Benzene	0.01	7.8×10^{-6}	0.0949	0.007×10^{-6}
		Ethyl Benzene	0.0003	2.5×10^{-6}	0.0949	0.00001×10^{-6}
		Formaldehyde	0.08	1.3×10^{-5}	0.0949	0.09×10^{-6}
Total Combined[1]						0.1×10^{-6}
32 wells/pad case: receptors 2.0 miles from well pad	MEI	Benzene	0.01	7.8×10^{-6}	0.86	0.07×10^{-6}
		Ethyl Benzene	0.0003	2.5×10^{-6}	0.86	0.001×10^{-6}
		Formaldehyde	0.08	1.3×10^{-5}	0.86	0.8×10^{-6}
Total Combined[1]						0.9×10^{-6}

[1]Total risk is calculated here; however, the additive effects of multiple chemicals are not fully understood and this should be taken into account when viewing these results.