APPENDIX F-3

Greenhouse Gas Emissions Model Methodology and Calculations

GREENHOUSE GAS EMISSIONS QUANTIFICATION: METHODOLOGY AND CALCULATIONS

As set forth in CEQA Guidelines Section 15064.4(c), the lead agency has discretion to select the model or methodology it considers most appropriate to enable decision makers to intelligently take into account the project's incremental contribution to climate change. Where direct quantification of emissions is not possible, they may be described qualitatively.

For the purposes of this Environmental Impact Report, the proposed dairy expansion project estimated calculations include greenhouse gas (GHG) emissions that occur at the project dairy farm, but it does not account for the full production system of the dairy beyond the farm boundaries, nor does it include any soil carbon sequestration in the field. More complicated models are useful for understanding farm processes and their interacting effects on overall greenhouse gas emissions, and they can assist in the development and evaluation of mitigation strategies for reducing emissions and improving overall sustainability of dairy farms[1]. However, in order to provide a more direct estimate for decision support, this assessment uses a simpler method based on emission factors and basic calculator models available to estimate GHG emissions from the animals, manure management, lagoons, energy use at the dairy, vehicle use and trucking, and from cropping activities. These simpler emission methodologies generally result in larger overall GHG emissions since they do not include emission sinks that are used in life cycle assessment methodologies.

The proposed dairy project includes increased solid manure exported offsite to be applied to cropland in the area. This analysis assumes animal wastes used as fertilizer would replace all or a portion of existing synthetic fertilizers used on existing cropland, and no feature of general best practices in the San Joaquin Valley would require the application of greater amounts of fertilizer than those currently used. Therefore, it is assumed that N_2O emissions from offsite agricultural fields would not change dramatically, and the GHG emissions from exported manure applied to offsite fields are not included in this analysis.

Listed below are the GHG emission sources and calculation methodologies used for this analysis.

GHG Emissions from the Dairy: Enteric Emissions, Lagoons, Manure Spreading and Storage

The San Joaquin Valley Air Pollution Control District Dairy Calculator (Rev. January 6, 2020) was used to estimate GHG emissions from the existing and proposed herd, including emissions from the lagoon, manure spreading, solid manure storage, and enteric emissions. The calculator uses GHG emission factors by animal type to determine CH_4 and N_2O emissions from these sources, and converting the emissions into carbon dioxide (CO_2) equivalents (see calculations included in this appendix).

[1] Rotz, A. 2018. Modeling greenhouse gas emissions from dairy farms. J. Dairy Sci. 101:6675–6690. July 01, 2018. Accessed on May 4, 2023 at: <https://doi.org/10.3168/jds.2017-13272>

GHG Emissions from Energy Use

Based on annual energy use provided by the project applicant, a factor for energy use per cow per year was developed. This per cow factor was used to calculate estimated energy use for the proposed expanded herd. Because there are energy efficiencies that occur with a larger herd size, this is considered a conservative estimate methodology.

GHG Emissions from Mobile Sources

GHG emissions from vehicle trips (employee trips, milk tanker trucks, commodities transport, solid manure transport, etc.) and off-road equipment sources (feed loading, bedding delivery, manure scraping, manure loading, and feed delivery) were estimated using CalEEMod Version 2020.4.0. Due to the limited amount, estimated GHG emissions from solid waste were included with mobile source emissions.

GHG Emissions from Agricultural Activities

The two major greenhouse gases from field crop agriculture are carbon dioxide (CO_2) and nitrous oxide (N_2O). Carbon dioxide is emitted through fossil fuel use on and off the farm, from activities such as vehicle use and fertilizer production. It can also be emitted or sequestered (stored) in the soil. Whether or not soil carbon sequestration occurs depends on the type of land and the farming practices, for example, soil tillage and plant residue management. Nitrous oxide is a very powerful greenhouse gas and is emitted primarily through soil management activities such as nitrogen fertilizer application. The Michigan State University's US Cropland Greenhouse Gas Calculator accounts for different cropping systems using USDA county-specific data considering crop type, tillage, fertilizer, and environmental variables to calculate greenhouse gas emissions. The Vierra Dairy existing and proposed crop types and acreage were used to estimate the change in GHG emissions from project site cropland with implementation of the expansion.

Michigan State University's US Cropland Greenhouse Gas Calculator. Accessed on March 30, 2023 at <http://carboncalculator.kbs.msu.edu/>

Energy Use at the Vierra Dairy

Energy Use	kWh/mo	kWh/d	kWh/yr	cows	kWh/yr/cow
Average			2,748,010	5,597	490.98
Estimated Proposed			3,494,298	7,117	
kWh/yr/cow				490.98	
Increase			**746,288**		

Greenhouse Gas Emission Rates for Electricity Use		
eGrid State	Average Output Emission Rate (lb CO2e/MWh)	Average Output Emission Rate (lb CO2e/kWh)
California	480.5	0.4805
Source: eGRID2021. Released 1/30/2023. Accessed at: <https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid>		

GHG Emissions from Energy Consumption

	Herd Count	Average Electricity Use (kWh/yr)	GHG Emission Rate (lbs CO_2e/kWh)	GHG Emissions (lbs CO_2e/yr)	GHG Emissions (metric tons CO_2e/yr)
T.I.D. Electricity Use	5,597	2,748,010	0.4805	1,320,419	**599**
Expansion Projection	7,117	3,494,298	0.4805	1,679,010	**762**
Increment of Increase	1,520	746,288	-	358,591	**163**

GHG Emissions from the Dairy - Enteric emissions, lagoons, manure spreading and storage

	Existing Total Emissions (metric tons/yr)	Proposed Total Emissions (metric tons/yr)	Increment of Increase
Tons/Year	24,794	34,189	**9,395**

See SJVAPCD Calculator for GHG Calculation Worksheets and Controls

GHG Emissions from Agricultural Activities

	Acres	Soil	N2O	Fuel	Fertilizer	Total GHG Emissions (metric tons CO_2e/yr)
		Annual Average (Metric Tons CO_2e/Acre/Year)				
Existing Cropping						
Corn/Oats	208	-0.07	0.32	0.04	0.02	64.48
Corn/Oats/Sudangrass Silage	374	-0.08	0.33	0.04	0.02	115.94
Total						**180.42**
Proposed Cropping						
Corn/Oats	770	-0.07	0.32	0.04	0.02	**238.7**
Increment of Increase						**58.28**

The Michigan State University's US Cropland Greenhouse Gas Calculator accounts for different cropping systems using USDA county-specific data considering crop type, tillage, fertilizer, and environmental variables to calculate greenhouse gas emissions. Michigan State University's US Cropland Greenhouse Gas Calculator. Accessed on March 30, 2023 at <http://carboncalculator.kbs.msu.edu/>

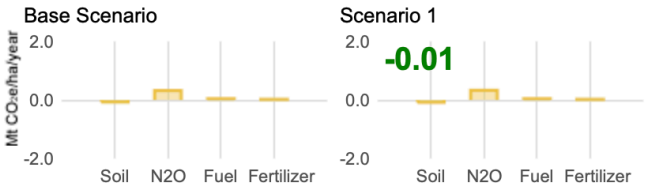
Total Greenhouse Gas Emissions

	Increased Herd (metric tons CO_2e/yr)	Increased Mobile Source* (metric tons CO_2e/yr)	Increased Electricity (metric tons CO_2e/yr)	Increased Farming Emissions (metric tons CO_2e/yr)	GHG Emissions (metric tons CO_2/yr)
Vierra Dairy Expansion	9,395	123	163	58	**9,739**

*GHG emissions from mobile sources were estimated using CalEEMod Version 2020.4.0. Due to the limited amount, estimated solid waste emissions were included with mobile source emissions above.
GHG emissions from the herd were estimated using the SJVAPCD dairy emissions calculator. See Appendix F for calculator emissions.

Conversion Factors	
1 megawatt-hour (MWh)	1,000 kilowatt-hour (kWh)
1 short ton	2,000 pounds (lb)
1.10231 short ton	1 metric ton
2.2046 lb	1 kilogram (kg)

Instructions



Base Scenario for Merced County, CA

Year	Crop	Yield		Tillage	Fertilizer		Soil	N20	Fuel	Fertilizer	Total	
							Greenhouse Gas Costs CO2 equivalents (Mt/ac/year)					
1	corn	148.3	bu/ac	reduced	142.0	lb N/ac	-0.29	0.50	0.04	0.03	0.28	
2	oats	58.0	bu/ac	reduced	66.1	lb N/ac	0.15	0.14	0.04	0.01	0.34	Remove
					Annual Average:		-0.07	0.32	0.04	0.02	0.31	

Add another year to the rotation | Remove last year | Recalculate | Reset

Scenario 1 for Merced County, CA Delete

Year	Crop	Yield		Tillage	Fertilizer		Soil	N20	Fuel	Fertilizer	Total	
							Greenhouse Gas Costs CO2 equivalents (Mt/ac/year)					
1	corn	148.3	bu/ac	reduced	142.0	lb N/ac	-0.29	0.50	0.04	0.03	0.28	
2	oats	58.0	bu/ac	reduced	66.1	lb N/ac	0.15	0.14	0.04	0.01	0.34	Remove
3	silage	14.7	t/ac	reduced	142.0	lb N/ac	-0.11	0.33	0.04	0.01	0.27	Remove
					Annual Average:		-0.08	0.33	0.04	0.02	0.30	

Add another year to the rotation | Remove last year | Recalculate | Reset

Environmental Conditions

Air Temperature 47.9 to 74.8 F
Precipitation 12.16 in

Percent Clay 22 %

Bulk Density 1.5 g/cm ^{3}
Initial Soil Carbon 0.5 %

Rev. January 6, 2020

Pre-Project Facility Information

1. Does this facility house Holstein or Jersey cows? Holstein
   Most facilities house Holstein cows unless explicitly stated on the PTO or application.
2. Does the facility have an anaerobic treatment lagoon? no
3. Does the facility land apply liquid manure? yes
   Answering "yes" assumes worst case.
4. Does the facility land apply solid manure? yes
   Answering "yes" assumes worst case.
5. Is any scraped manure sent to a lagoon/storage pond? no
   Answering "yes" assumes worst case.

Pre-Project Herd Size

Herd	Flushed Freestalls	Scraped Freestalls	Flushed Corrals	Scraped Corrals	Total # of Animals
Milk Cows	2,200		450		2,650
Dry Cows			550		550
Support Stock (Heifers, Calves, and Bulls)			1,997		1,997
Large Heifers					0
Medium Heifers					0
Small Heifers					0
Bulls					0

	Calf Hutches				Calf Corrals		
	Aboveground Flushed	Aboveground Scraped	On-Ground Flushed	On-Ground Scraped	Flushed	Scraped	Total # of Calves
Calves						400	400

Total Herd Summary

Total Milk Cows	2,650
Total Mature Cows	3,200
Support Stock (Heifers, Calves, and Bulls)	1,997
Total Calves	400
Total Dairy Head	5,597

Pre-Project Silage Information

Feed Type	Max # Open Piles	Max Height (ft)	Max Width (ft)
Corn			
Alfalfa			
Wheat			

Post-Project Facility Information

1. Does this facility house Holstein or Jersey cows? Holstein
   Most facilities house Holstein cows unless explicitly stated on the PTO or application.
2. Does the facility have an anaerobic treatment lagoon? no
3. Does the facility land apply liquid manure? yes
   Answering "yes" assumes worst case.
4. Does the facility land apply solid manure? yes
   Answering "yes" assumes worst case.
5. Is any scraped manure sent to a lagoon/storage pond? no
   Answering "yes" assumes worst case.
6. Does this project result in an increase or relocation of uncovered surface area for any lagoon/storage pond? no

Post-Project Herd Size

Herd	Flushed Freestalls	Scraped Freestalls	Flushed Corrals	Scraped Corrals	Total # of Animals
Milk Cows	4,170				4,170
Dry Cows			550		550
Support Stock (Heifers, Calves, and Bulls)			1,997		1,997
Large Heifers					0
Medium Heifers					0
Small Heifers					0
Bulls					0

	Calf Hutches				Calf Corrals		
	Aboveground Flushed	Aboveground Scraped	On-Ground Flushed	On-Ground Scraped	Flushed	Scraped	Total # of Calves
Calves					400		400

Total Herd Summary

Total Milk Cows	4,170
Total Mature Cows	4,720
Support Stock (Heifers, Calves, and Bulls)	1,997
Total Calves	400
Total Dairy Head	7,117

Post-Project Silage Information

Feed Type	Max # Open Piles	Max Height (ft)	Max Width (ft)
Corn			
Alfalfa			
Wheat			

This spreadsheet serves only as a resource to calculate potential emissions from dairies, and may not reflect the final emissions used by the District due to parameters not addressed in this spreadsheet and/or omissions from the spreadsheet. Any other permittable equipment (e.g. IC engines, gasoline tanks, etc.) at a facility will need to be calculated separately. All final calculations used in permitting projects will be conducted by District staff.

Dairy Emission Factors

lb/hd-yr Dairy Emissions Factors for Holstein Cows

			Milk Cows				Dry Cows				Large Heifers (15 to 24 months)				Medium Heifers (7 to 14 months)				Small Heifers (3 to 6 months)				Calves (0 - 3 months)				Bulls			
			Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled	
			<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2
Milking Parlor	**VOC**	Enteric Emissions in Milking Parlors	0.43	0.41	0.37	0.37	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-		-	-	-
		Milking Parlor Floor	0.04	0.03	0.03	0.03	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-		-	-	-
		Total	**0.47**	**0.44**	**0.40**	**0.40**	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-		-	-	-
	NH3	**Total**	**0.19**	**0.19**	**0.14**	**0.14**	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-		-	-	-
Cow Housing	**VOC**	Enteric Emissions in Cow Housing	3.89	3.69	3.32	3.32	2.33	2.23	2.01	2.01	1.81	1.71	1.54	1.54	1.23	1.17	1.05	1.05	0.69	0.65	0.58	0.58	0.32	0.31	0.28	0.28	1.10	1.04	0.94	0.94
		Corrals/Pens	10.00	6.60	5.35	4.57	5.40	3.59	2.91	2.49	4.20	2.76	2.23	1.91	2.85	1.88	1.52	1.30	1.60	1.04	0.85	0.72	0.75	0.50	0.41	0.35	2.55	1.67	1.35	1.16
		Bedding	1.05	1.00	0.81	0.81	0.57	0.54	0.44	0.44	0.44	0.42	0.34	0.34	0.30	0.28	0.23	0.23	0.17	0.16	0.13	0.13	0.08	0.08	0.06	0.06	0.27	0.25	0.20	0.20
		Lanes	0.84	0.80	0.65	0.65	0.45	0.44	0.35	0.35	0.35	0.33	0.27	0.27	0.24	0.23	0.18	0.18	0.13	0.13	0.10	0.10	0.06	0.06	0.05	0.05	0.21	0.20	0.16	0.16
		Total	**15.78**	**12.09**	**10.13**	**9.35**	**8.75**	**6.80**	**5.71**	**5.29**	**6.81**	**5.22**	**4.38**	**4.06**	**4.62**	**3.56**	**2.99**	**2.77**	**2.59**	**1.98**	**1.66**	**1.54**	**1.22**	**0.95**	**0.80**	**0.74**	**4.13**	**3.16**	**2.65**	**2.46**
	NH3	Enteric Emissions in Cow Housing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Corrals/Pens	41.90	41.90	15.08	15.08	21.20	21.20	7.63	7.63	11.00	11.00	3.96	3.96	7.90	7.90	2.84	2.84	6.00	6.00	2.16	2.16	1.80	1.80	0.65	0.65	15.30	15.30	5.51	5.51
		Bedding	6.30	6.30	2.37	2.37	3.20	3.20	1.20	1.20	1.70	1.70	0.64	0.64	1.20	1.20	0.45	0.45	0.90	0.90	0.34	0.34	0.30	0.30	0.11	0.11	2.30	2.30	0.87	0.87
		Lanes	5.10	5.10	3.67	3.67	2.60	2.60	1.87	1.87	1.30	1.30	0.94	0.94	1.00	1.00	0.72	0.72	0.70	0.70	0.50	0.50	0.20	0.20	0.14	0.14	1.90	1.90	1.37	1.37
		Total	**53.30**	**53.30**	**21.13**	**21.13**	**27.00**	**27.00**	**10.71**	**10.71**	**14.00**	**14.00**	**5.54**	**5.54**	**10.10**	**10.10**	**4.02**	**4.02**	**7.60**	**7.60**	**3.00**	**3.00**	**2.30**	**2.30**	**0.90**	**0.90**	**19.50**	**19.50**	**7.74**	**7.74**
Liquid Manure Handling	**VOC**	Lagoons/Storage Ponds	1.52	1.30	1.17	0.70	0.82	0.71	0.64	0.38	0.64	0.54	0.49	0.29	0.43	0.37	0.33	0.20	0.24	0.21	0.19	0.11	0.11	0.10	0.09	0.05	0.40	0.33	0.30	0.18
		Liquid Manure Land Application	1.64	1.40	1.26	0.76	0.89	0.76	0.69	0.41	0.69	0.58	0.53	0.32	0.47	0.40	0.36	0.22	0.26	0.22	0.20	0.12	0.12	0.11	0.10	0.06	0.42	0.35	0.32	0.19
		Total	**3.16**	**2.70**	**2.43**	**1.46**	**1.71**	**1.47**	**1.33**	**0.79**	**1.33**	**1.13**	**1.02**	**0.61**	**0.90**	**0.77**	**0.69**	**0.42**	**0.51**	**0.43**	**0.38**	**0.23**	**0.24**	**0.21**	**0.18**	**0.11**	**0.82**	**0.68**	**0.61**	**0.37**
	NH3	Lagoons/Storage Ponds	8.20	8.20	1.18	1.18	4.20	4.20	0.60	0.60	2.20	2.20	0.32	0.32	1.50	1.50	0.22	0.22	1.20	1.20	0.17	0.17	0.35	0.35	0.05	0.05	3.00	3.00	0.43	0.43
		Liquid Manure Land Application	8.90	8.90	6.41	3.72	4.50	4.50	3.24	1.88	2.30	2.30	1.66	0.96	1.70	1.70	1.22	0.71	1.30	1.30	0.94	0.54	0.37	0.37	0.27	0.15	3.23	3.23	2.33	1.35
		Total	**17.10**	**17.10**	**7.59**	**4.90**	**8.70**	**8.70**	**3.84**	**2.48**	**4.50**	**4.50**	**1.97**	**1.28**	**3.20**	**3.20**	**1.44**	**0.93**	**2.50**	**2.50**	**1.11**	**0.72**	**0.72**	**0.72**	**0.32**	**0.20**	**6.23**	**6.23**	**2.76**	**1.78**
Solid Manure Handling	**VOC**	Solid Manure Storage	0.16	0.15	0.14	0.14	0.09	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.04	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.04	0.04	0.04
		Separated Solids Piles	0.06	0.06	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02
		Solid Manure Land Application	0.39	0.33	0.30	0.18	0.21	0.18	0.16	0.10	0.16	0.14	0.12	0.07	0.11	0.09	0.08	0.05	0.06	0.05	0.05	0.03	0.03	0.03	0.02	0.01	0.10	0.08	0.07	0.04
		Total	**0.61**	**0.54**	**0.48**	**0.36**	**0.33**	**0.29**	**0.26**	**0.20**	**0.26**	**0.23**	**0.20**	**0.15**	**0.17**	**0.15**	**0.14**	**0.10**	**0.10**	**0.09**	**0.08**	**0.06**	**0.05**	**0.04**	**0.04**	**0.03**	**0.16**	**0.14**	**0.12**	**0.10**
	NH3	Solid Manure Storage	0.95	0.95	0.95	0.95	0.48	0.48	0.48	0.48	0.25	0.25	0.25	0.25	0.18	0.18	0.18	0.18	0.13	0.13	0.13	0.13	0.04	0.04	0.04	0.04	0.35	0.35	0.35	0.35
		Separated Solids Piles	0.38	0.38	0.38	0.38	0.19	0.19	0.19	0.19	0.10	0.10	0.10	0.10	0.07	0.07	0.07	0.07	0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.02	0.14	0.14	0.14	0.14
		Solid Manure Land Application	2.09	2.09	1.50	1.50	1.06	1.06	0.76	0.76	0.55	0.55	0.40	0.40	0.39	0.39	0.28	0.28	0.30	0.30	0.22	0.22	0.09	0.09	0.06	0.06	0.76	0.76	0.55	0.55
		Total	**3.42**	**3.42**	**2.83**	**2.83**	**1.73**	**1.73**	**1.43**	**1.43**	**0.90**	**0.90**	**0.75**	**0.75**	**0.64**	**0.64**	**0.53**	**0.53**	**0.48**	**0.48**	**0.40**	**0.40**	**0.15**	**0.15**	**0.12**	**0.12**	**1.25**	**1.25**	**1.04**	**1.04**

Silage and TMR (Total Mixed Ration) Emissions (µg/m^2-min)

		Silage Type	Uncontrolled	EF1	EF2
Feed Storage and Handling	**VOC**	Corn Silage	34,681	21,155	21,155
		Alfalfa Silage	17,458	10,649	10,649
		Wheat Silage	43,844	26,745	26,745
		TMR	13,056	10,575	9,518

Assumptions: 1) Each silage pile is completely covered except for the front face and 2) Rations are fed within 48 hours.

PM_{10} Emission Factors (lb/hd-yr)

Type of Cow	Dairy EF	Source
Cows in Freestalls	1.37	Based on a Summer 2003 study by Texas A&M ASAE at a West Texas Dairy
Milk/Dry in Loafing Barns	2.73	SJVAPCD
Heifers/Bulls in Loafing Barns	5.28	SJVAPCD
Calves in Loafing Barns	0.69	SJVAPCD
Milk/Dry in Corrals	5.46	Based on a Summer 2003 study by Texas A&M ASAE at a West Texas Dairy
Support Stock (Heifers/Bulls) in Open Corrals	10.55	Based on a USDA/UC Davis report quantifying dairy and feedlot emissions in Tulare & Kern Counties (April '01)
Large Heifers in Open Corrals	8.01	SJVAPCD
Calf (under 3 mo.) open corrals	1.37	SJVAPCD
Calf on-ground hutches	0.343	SJVAPCD
Calf above-ground flushed	0.069	SJVAPCD
Calf above-ground scraped	0.206	SJVAPCD

The controlled PM10 EF will be calculated based on the specific PM10 mitigation measures, if any, for each freestall, corral, or calf hutch area. See the PM Mitigation Measures for calculations.

Dairy Emission Factors

lb/hd-yr Dairy Emissions Factors for Jersey Cows

Note: Jersey cows will be assumed to generate 71% of the amount of VOC and NH3 emissions as a Holstein cow.

			Milk Cows				Dry Cows				Large Heifers (15 to 24 months)				Medium Heifers (7 to 14 months)				Small Heifers (3 to 6 months)				Calves (0 - 3 months)				Bulls			
			Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled		Uncontrolled		Controlled	
			<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2	<1000 milk cows	≥1000 milk cows	EF1	EF2
Milking Parlor	**VOC**	Enteric Emissions in Milking Parlors	0.31	0.29	0.26	0.26	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-		-	-	-
		Milking Parlor Floor	0.03	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-		-	-	-
		Total	**0.34**	**0.31**	**0.28**	**0.28**	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-		-	-	-
	NH3	**Total**	**0.13**	**0.13**	**0.10**	**0.10**	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-		-	-	-		-	-	-
Cow Housing	**VOC**	Enteric Emissions in Cow Housing	2.76	2.62	2.36	2.36	1.66	1.58	1.43	1.43	1.29	1.22	1.09	1.09	0.87	0.83	0.75	0.75	0.49	0.46	0.41	0.41	0.23	0.22	0.20	0.20	0.78	0.74	0.66	0.66
		Corrals/Pens	7.10	4.69	3.80	3.25	3.83	2.55	2.07	1.77	2.98	1.96	1.59	1.36	2.02	1.33	1.08	0.92	1.14	0.74	0.60	0.51	0.53	0.36	0.29	0.25	1.81	1.19	0.96	0.82
		Bedding	0.75	0.71	0.58	0.58	0.40	0.39	0.31	0.31	0.31	0.30	0.24	0.24	0.21	0.20	0.16	0.16	0.12	0.11	0.09	0.09	0.06	0.05	0.04	0.04	0.19	0.18	0.14	0.14
		Lanes	0.60	0.57	0.46	0.46	0.32	0.31	0.25	0.25	0.25	0.24	0.19	0.19	0.17	0.16	0.13	0.13	0.10	0.09	0.07	0.07	0.04	0.04	0.03	0.03	0.15	0.14	0.12	0.12
		Total	**11.20**	**8.58**	**7.19**	**6.64**	**6.21**	**4.83**	**4.06**	**3.76**	**4.83**	**3.71**	**3.11**	**2.88**	**3.28**	**2.53**	**2.12**	**1.97**	**1.84**	**1.40**	**1.18**	**1.09**	**0.86**	**0.67**	**0.57**	**0.52**	**2.93**	**2.24**	**1.88**	**1.74**
	NH3	Enteric Emissions in Cow Housing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Corrals/Pens	29.75	29.75	10.71	10.71	15.05	15.05	5.42	5.42	7.81	7.81	2.81	2.81	5.61	5.61	2.02	2.02	4.26	4.26	1.53	1.53	1.28	1.28	0.46	0.46	10.86	10.86	3.91	3.91
		Bedding	4.47	4.47	1.68	1.68	2.27	2.27	0.86	0.86	1.21	1.21	0.45	0.45	0.85	0.85	0.32	0.32	0.64	0.64	0.24	0.24	0.21	0.21	0.08	0.08	1.63	1.63	0.61	0.61
		Lanes	3.62	3.62	2.61	2.61	1.85	1.85	1.33	1.33	0.92	0.92	0.66	0.66	0.71	0.71	0.51	0.51	0.50	0.50	0.36	0.36	0.14	0.14	0.10	0.10	1.35	1.35	0.97	0.97
		Total	**37.84**	**37.84**	**15.00**	**15.00**	**19.17**	**19.17**	**7.60**	**7.60**	**9.94**	**9.94**	**3.93**	**3.93**	**7.17**	**7.17**	**2.85**	**2.85**	**5.40**	**5.40**	**2.13**	**2.13**	**1.63**	**1.63**	**0.64**	**0.64**	**13.85**	**13.85**	**5.50**	**5.50**
Liquid Manure Handling	**VOC**	Lagoons/Storage Ponds	1.08	0.92	0.83	0.50	0.58	0.50	0.45	0.27	0.45	0.39	0.35	0.21	0.31	0.26	0.24	0.14	0.17	0.15	0.13	0.08	0.08	0.07	0.06	0.04	0.28	0.23	0.21	0.13
		Liquid Manure Land Application	1.16	0.99	0.89	0.54	0.63	0.54	0.49	0.29	0.49	0.42	0.37	0.22	0.33	0.28	0.25	0.15	0.19	0.16	0.14	0.08	0.09	0.08	0.07	0.04	0.30	0.25	0.22	0.13
		Total	**2.24**	**1.92**	**1.72**	**1.04**	**1.21**	**1.04**	**0.94**	**0.56**	**0.94**	**0.80**	**0.72**	**0.43**	**0.64**	**0.55**	**0.49**	**0.29**	**0.36**	**0.30**	**0.27**	**0.16**	**0.17**	**0.15**	**0.13**	**0.08**	**0.58**	**0.48**	**0.43**	**0.26**
	NH3	Lagoons/Storage Ponds	5.82	5.82	0.84	0.84	2.98	2.98	0.43	0.43	1.56	1.56	0.22	0.22	1.07	1.07	0.15	0.15	0.85	0.85	0.12	0.12	0.25	0.25	0.04	0.04	2.13	2.13	0.31	0.31
		Liquid Manure Land Application	6.32	6.32	4.55	2.64	3.20	3.20	2.30	1.33	1.63	1.63	1.18	0.68	1.21	1.21	0.87	0.50	0.92	0.92	0.66	0.39	0.26	0.26	0.19	0.11	2.29	2.29	1.65	0.96
		Total	**12.14**	**12.14**	**5.39**	**3.48**	**6.18**	**6.18**	**2.73**	**1.76**	**3.20**	**3.20**	**1.40**	**0.91**	**2.27**	**2.27**	**1.02**	**0.66**	**1.78**	**1.78**	**0.79**	**0.51**	**0.51**	**0.51**	**0.22**	**0.15**	**4.42**	**4.42**	**1.96**	**1.26**
Solid Manure Handling	**VOC**	Solid Manure Storage	0.11	0.11	0.10	0.10	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.03
		Separated Solids Piles	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
		Solid Manure Land Application	0.28	0.23	0.21	0.13	0.15	0.13	0.11	0.07	0.12	0.10	0.09	0.05	0.08	0.07	0.06	0.04	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.07	0.06	0.05	0.03
		Total	**0.43**	**0.38**	**0.34**	**0.25**	**0.23**	**0.21**	**0.19**	**0.14**	**0.18**	**0.16**	**0.14**	**0.11**	**0.12**	**0.11**	**0.10**	**0.07**	**0.07**	**0.06**	**0.05**	**0.04**	**0.03**	**0.03**	**0.03**	**0.02**	**0.11**	**0.10**	**0.09**	**0.07**
	NH3	Solid Manure Storage	0.67	0.67	0.67	0.67	0.34	0.34	0.34	0.34	0.18	0.18	0.18	0.18	0.13	0.13	0.13	0.13	0.09	0.09	0.09	0.09	0.03	0.03	0.03	0.03	0.25	0.25	0.25	0.25
		Separated Solids Piles	0.27	0.27	0.27	0.27	0.13	0.13	0.13	0.13	0.07	0.07	0.07	0.07	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.01	0.01	0.01	0.01	0.10	0.10	0.10	0.10
		Solid Manure Land Application	1.48	1.48	1.07	1.07	0.75	0.75	0.54	0.54	0.39	0.39	0.28	0.28	0.28	0.28	0.20	0.20	0.21	0.21	0.15	0.15	0.06	0.06	0.05	0.05	0.54	0.54	0.39	0.39
		Total	**2.43**	**2.43**	**2.01**	**2.01**	**1.23**	**1.23**	**1.02**	**1.02**	**0.64**	**0.64**	**0.53**	**0.53**	**0.45**	**0.45**	**0.38**	**0.38**	**0.34**	**0.34**	**0.28**	**0.28**	**0.11**	**0.11**	**0.09**	**0.09**	**0.89**	**0.89**	**0.74**	**0.74**

Silage and TMR (Total Mixed Ration) Emissions (µg/m^2-min)

		Silage Type	Uncontrolled	EF1	EF2
Feed Storage and Handling	**VOC**	Corn Silage	34,681	21,155	21,155
		Alfalfa Silage	17,458	10,649	10,649
		Wheat Silage	43,844	26,745	26,745
		TMR	13,056	10,575	9,518

Assumptions: 1) Each silage pile is completely covered except for the front face and 2) Rations are fed within 48 hours.

PM_{10} Emission Factors (lb/hd-yr)

Type of Cow	Dairy EF	Source
Cows in Freestalls	1.37	Based on a Summer 2003 study by Texas A&M ASAE at a West Texas Dairy
Milk/Dry in Loafing Barns	2.73	SJVAPCD
Heifers/Bulls in Loafing Barns	5.28	SJVAPCD
Calves in Loafing Barns	0.69	SJVAPCD
Milk/Dry in Corrals	5.46	Based on a Summer 2003 study by Texas A&M ASAE at a West Texas Dairy
Support Stock (Heifers/Bulls) in Open Corrals	10.55	Based on a USDA/UC Davis report quantifying dairy and feedlot emissions in Tulare & Kern Counties (April '01)
Large Heifers in Open Corrals	8.01	SJVAPCD
Calf (under 3 mo.) open corrals	1.37	SJVAPCD
Calf on-ground hutches	0.343	SJVAPCD
Calf above-ground flushed	0.069	SJVAPCD
Calf above-ground scraped	0.206	SJVAPCD

The controlled PM10 EF will be calculated based on the specific PM10 mitigation measures, if any, for each freestall, corral, or calf hutch area. See the PM Mitigation Measures for calculations.

Uncontrolled GHG Emission Factors (lbs/hd-yr)						
Animal Type	CH4 (Anaerobic Treatment Lagoon)	CH4 (Lagoon)	CH4 (Manure Spreading)	CH4 (Solid Manure Storage)	CH4 (Enteric)	CO2 Equivalent Multiplier for CH4
Milk Cows	513	307.8	3.5	27.7	271.5	21
Dry Cows	513	307.8	3.5	27.7	271.5	21
Support Stock*	110.4	110.4	1.6	–	151.6	21
Large Heifers	110.4	110.4	1.6	–	151.6	21
Medium Heifers	110.4	110.4	1.6	–	100.5	21
Small Heifers	110.4	110.4	1.6	–	100.5	21
Calves	–	–	–	–	–	–
Bulls*	110.4	110.4	1.6	–	151.6	21

Uncontrolled GHG Emission Factors (lbs/hd-yr)					
Animal Type	N2O (Anaerobic Treatment Lagoon)	N2O (Manure Spreading)	N2O (Solid Manure Storage)	N2O (Enteric)	CO2 Equivalent Multiplier for N2O
Milk Cows	1.5	0	2.6	0	310
Dry Cows	1.5	0	2.6	0	310
Support Stock*	1.4	0	–	0	310
Large Heifers	1.4	0	–	0	310
Medium Heifers	1.4	0	–	0	310
Small Heifers	1.4	0	–	0	310
Calves	–	0	–	0	–
Bulls*	1.4	0	–	0	310

*Emission factors for Suppot Stock and Bulls assumed to be the same as Large Heifers.

1 short ton = 0.9072 metric ton

CO2e from CH4 = [CH4 (anaerobic treatment) lagoon + CH4 manure spreading + CH4 solid manure storage + CH4 enteric] x 21 x 0.9072 metric tons/short tons ÷ 2000 lb/ton

CO2e from N2O= [N20 anearobic treatment lagoon + N2O manure spreading + N20 solid manure storage + N2O enteric] x 310 x 0.9072 metric tons/short tons ÷ 2000 lb/ton

Pre-Project CO2e Emissions

Pre-Project Lagoon CO2e Emissions from CH4 (metric tons/yr)				
Animal Type	Number of Cows	CH4 Lagoons (lb/hd-yr)	CO2e Multiplier	CO2e Lagoons (metric tons/yr)
Milk Cows	2,650	307.8	21.0	7,770
Dry Cows	550	307.8	21.0	1,613
Support Stock	1,997	110.4	21.0	2,100
Large Heifers	0	110.4	21.0	0
Medium Heifers	0	110.4	21.0	0
Small Heifers	0	110.4	21.0	0
Calves	0	–	–	0
Bulls	0	110.4	21.0	0

Pre-Project Non-Lagoons CO2e Emissions from CH4 (metric tons/yr)						
Animal Type	Number of Cows	CH4 Manure Spreading (lbs/hd-yr)	CH4 Solid Manure Storage (lbs/hd-yr)	CH4 Enteric (lbs/hd-yr)	Multiplier	CO2e Non-Lagoons (metric tons/yr)
Milk Cows	2,650	3.5	27.7	271.5	21.0	7,641
Dry Cows	550	3.5	27.7	271.5	21.0	1,586
Support Stock	1,997	1.6	--	151.6	21.0	2,914
Large Heifers	0	1.6	--	151.6	21.0	0
Medium Heifers	0	1.6	--	100.5	21.0	0
Small Heifers	0	1.6	--	100.5	21.0	0
Calves	400	--	--	--	--	0
Bulls	0	1.6	--	151.6	21.0	0

Pre-Project Lagoon CO2e Emissions from N2O (metric tons/yr)				
Animal Type	Number of Cows	N2O Lagoons (lb/hd-yr)	CO2e Multiplier	CO2e Lagoons (metric tons/yr)
Milk Cows	2,650	0.0	310.0	0
Dry Cows	550	0.0	310.0	0
Support Stock	1,997	0.0	310.0	0
Large Heifers	0	0.0	310.0	0
Medium Heifers	0	0.0	310.0	0
Small Heifers	0	0.0	310.0	0
Calves	0	0.0	--	0
Bulls	0	0.0	310.0	0

Pre-Project Non-Lagoons CO2e Emissions from N2O (metric tons/yr)						
Animal Type	Number of Cows	N2O Manure Spreading (lbs/hd-yr)	N2O Solid Manure Storage (lbs/hd-yr)	N2O Enteric (lbs/hd-yr)	Multiplier	CO2e Non-Lagoons (metric tons/yr)
Milk Cows	2,650	0.0	2.6	0.0	310.0	969
Dry Cows	550	0.0	2.6	0.0	310.0	201
Support Stock	1,997	0.0	--	0.0	310.0	0
Large Heifers	0	0.0	--	0.0	310.0	0
Medium Heifers	0	0.0	--	0.0	310.0	0
Small Heifers	0	0.0	--	0.0	310.0	0
Calves	400	0.0	--	0.0	--	0
Bulls	0	0.0	--	0.0	310.0	0

Total Pre-Project CO2e Emissions (metric tons/yr)			
Animal Type	CO2e from CH4	CO2e from N2O	Total
Milk Cows	15,411	969	16,380
Dry Cows	3,198	201	3,400
Support Stock	5,014	0	5,014
Large Heifers	0	0	0
Medium Heifers	0	0	0
Small Heifers	0	0	0
Calves	0	0	0
Bulls	0	0	0
		Total	**24,794**

Post-Project CO2e Emissions

Post-Project Lagoon CO2e Emissions from CH4 (metric tons/yr)				
Animal Type	Number of Cows	CH4 Lagoons (lb/hd-yr)	CO2e Multiplier	CO2e Lagoons (metric tons/yr)
Milk Cows	4,170	307.8	21.0	12,226
Dry Cows	550	307.8	21.0	1,613
Support Stock	1,997	110.4	21.0	2,100
Large Heifers	0	110.4	21.0	0
Medium Heifers	0	110.4	21.0	0
Small Heifers	0	110.4	21.0	0
Calves	400	–	–	0
Bulls	0	110.4	21.0	0

Post-Project Non-Lagoons CO2e Emissions from CH4 (metric tons/yr)						
Animal Type	Number of Cows	CH4 Manure Spreading (lbs/hd-yr)	CH4 Solid Manure Storage (lbs/hd-yr)	CH4 Enteric (lbs/hd-yr)	Multiplier	CO2e Non-Lagoons (metric tons/yr)
Milk Cows	4,170	3.5	27.7	271.5	21.0	12,024
Dry Cows	550	3.5	27.7	271.5	21.0	1,586
Support Stock	1,997	1.6	--	151.6	21.0	2,914
Large Heifers	0	1.6	--	151.6	21.0	0
Medium Heifers	0	1.6	--	100.5	21.0	0
Small Heifers	0	1.6	--	100.5	21.0	0
Calves	400	--	--	--	--	0
Bulls	0	1.6	--	151.6	21.0	0

Post-Project Lagoon CO2e Emissions from N2O (metric tons/yr)				
Animal Type	Number of Cows	N2O Lagoons (lb/hd-yr)	CO2e Multiplier	CO2e Lagoons (metric tons/yr)
Milk Cows	4,170	0.0	310.0	0
Dry Cows	550	0.0	310.0	0
Support Stock	1,997	0.0	310.0	0
Large Heifers	0	0.0	310.0	0
Medium Heifers	0	0.0	310.0	0
Small Heifers	0	0.0	310.0	0
Calves	400	0.0	--	0
Bulls	0	0.0	310.0	0

Post-Project Non-Lagoons CO2e Emissions from N2O (metric tons/yr)						
Animal Type	Number of Cows	N2O Manure Spreading (lbs/hd-yr)	N2O Solid Manure Storage (lbs/hd-yr)	N2O Enteric (lbs/hd-yr)	Multiplier	CO2e Non-Lagoons (metric tons/yr)
Milk Cows	4,170	0.0	2.6	0.0	310.0	1,525
Dry Cows	550	0.0	2.6	0.0	310.0	201
Support Stock	1,997	0.0	--	0.0	310.0	0
Large Heifers	0	0.0	--	0.0	310.0	0
Medium Heifers	0	0.0	--	0.0	310.0	0
Small Heifers	0	0.0	--	0.0	310.0	0
Calves	400	0.0	--	0.0	--	0
Bulls	0	0.0	--	0.0	310.0	0

Total Post-Project CO2e Emissions (metric tons/yr)			
Animal Type	CO2e from CH4	CO2e from N2O	Total
Milk Cows	24,250	1,525	25,775
Dry Cows	3,198	201	3,400
Support Stock	5,014	0	5,014
Large Heifers	0	0	0
Medium Heifers	0	0	0
Small Heifers	0	0	0
Calves	0	0	0
Bulls	0	0	0
		Total	**34,189**

Change in CO2e Emissions

Change in Project GHG Emissions			
Animal Type	Pre-Project CO2e (metric tons/yr)	Post-Project CO2e (metric tons/yr)	Change (metric tons/yr)
Milk Cows	16,380	25,775	9,395
Dry Cows	3,400	3,400	0
Support Stock	5,014	5,014	0
Large Heifers	0	0	0
Medium Heifers	0	0	0
Small Heifers	0	0	0
Calves	0	0	0
Bulls	0	0	0
		Total	**9,395**