TECHNICAL SUPPORT DOCUMENT FOR NON-ROAD MOBILE SOURCES: EMISSIONS INVENTORIES FOR PM2.5 MAINTENANCE SIP, SALT LAKE CITY AREA, BASE YEAR 2017 AND PROJECTION YEARS 2026 AND 2035

June 2019
Utah Division of Air Quality
Planning Branch/Inventory Section/Mobile

ABSTRACT

This document describes the non-road mobile source emissions inventory modeling procedure and results for the PM2.5 Maintenance SIP for the Salt Lake City area, base year 2017 and projection years 2026 and 2035.

Non-road mobile sources include 1) non-road engines and motorized equipment from MOVES2014b, 2) aircraft, 3) airport ground support equipment and 4) diesel locomotives. The majority of non-road emissions come from non-road engines and motorized equipment from MOVES2014b.

In 2017, for NOx, about 42% of total non-road mobile source emissions comes from non-road engines and motorized equipment in MOVES2014b, and another 50% comes from diesel locomotives.

For PM2.5 exhaust, about 75% of total non-road mobile source emissions comes from non-road engines and motorized equipment in MOVES2014b and another 16% comes from diesel locomotives.

For VOC, about 92% of total non-road mobile source emissions comes from MOVES2014b.

For SO2, about 88% of total non-road mobile source emissions comes from aircraft and ground support.

The modeling domain for this SIP includes the entire state of Utah and portions of surrounding states (UDAQ did not create inventories for out-of-state areas in the domain. Instead, the NEI 2014 was used to obtain inventories for these areas.)

Counties included in each PM2.5 non-attainment area (under the 24-hour standard) are as follows:

Salt Lake: Box Elder, Davis, Salt Lake, Tooele and Weber
Provo: Utah (County)
Logan: Cache and portions of southern Idaho counties (in process of redesignation)

Emissions for the non-road sector in the state of Utah were modeled by UDAQ inventory staff.

Temperatures modeled for the base year and projection years are the average temperatures over the three PM2.5 episodes:

Sat, Jan 1 – Wed, Jan 12, 2011
Sat, Dec 7 – Thu, Dec 19, 2013
Mon, Feb 1 – Wed, Feb 17, 2016

This document includes inventory results for the base year 2017 and projection years 2026 and 2035. Units were converted to tons per year for easy comparison to other source groups—point, area, and on-road mobile.

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iii. Introduction

This inventory includes emissions of carbon monoxide (CO), nitrogen oxides (NOx), PM10 and PM2.5 exhaust, sulfur dioxide (SO2), volatile organic compounds (VOC) and ammonia (NH3) from non-road engines, aircraft, airport ground support equipment (GSE) and locomotives.

In addition, for the CAMX air dispersion model, the following additional compounds and groups of compounds were modeled:

Pollutant No.	Abbreviation	Name
1	TGH	Total Gaseous Hydrocarbons
5	CH4	Methane
20	C6H6	Benzene
45	C6H5-CH3	Toluene
46	C6H4-(CH3)2	Xylenes
79	NMHC	Non-Methane Hydrocarbons
80	NMOG	Non-Methane Organic Gases
86	TOG	Total Organic Gases

Inventories were computed for the base year 2017 and for projection years 2026 and 2035.

The PM2.5 domain consists of all 29 counties in Utah and portions of Colorado and Wyoming.

UT County Names, FIPs Codes, Abbreviations and Human Population (2010, 2017 and 2020)

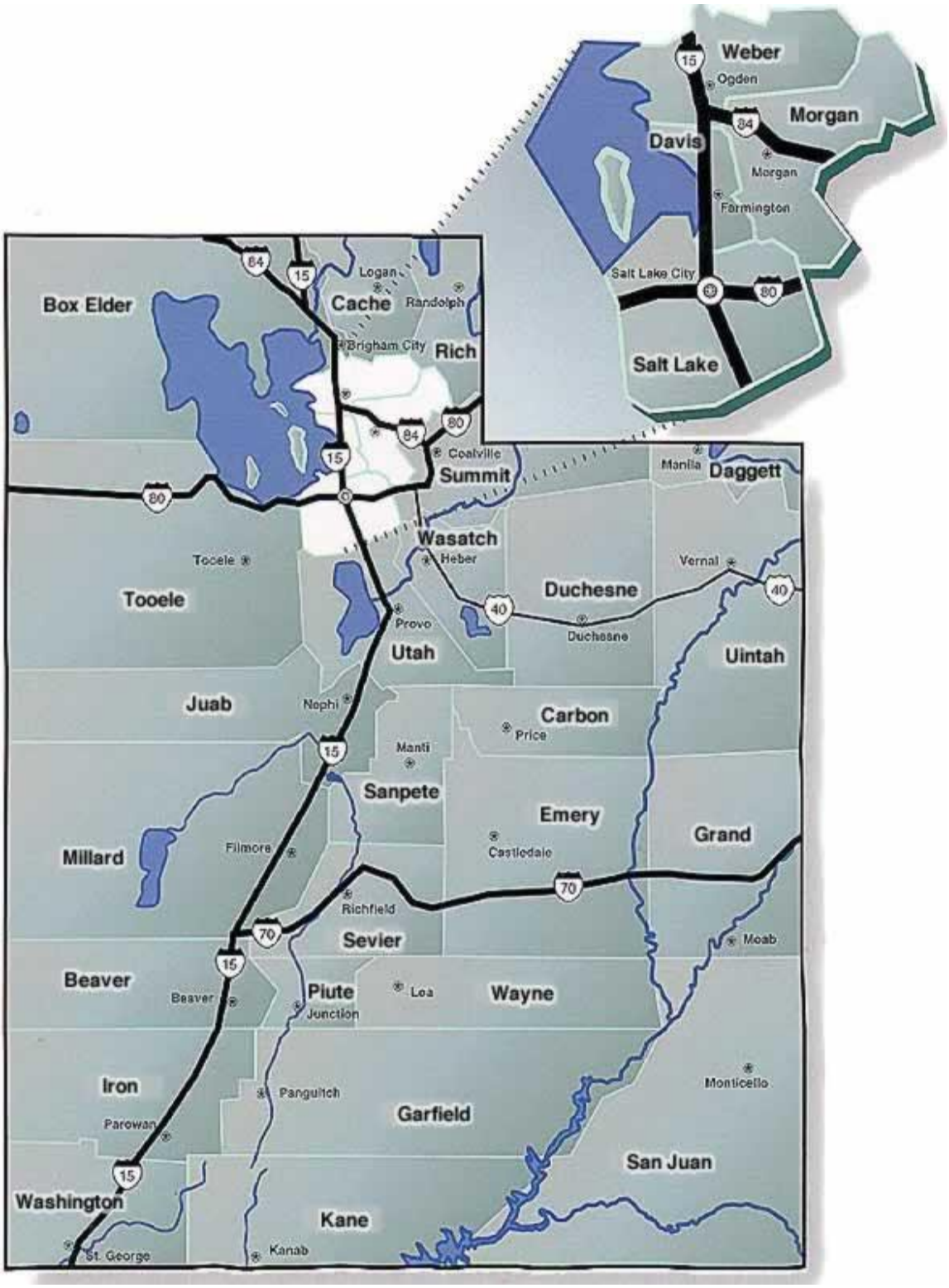
No.	County Name	FIPs	Abbrev	Human Populations and Projections (2010)	(2018)	(2020)
1	Beaver	49001	BE	6,629	7,539	7,766
2	Box Elder	49003	BX	49,975	53,652	54,571
3	Cache	49005	CA	112,656	133,913	139,228
4	Carbon	49007	CR	21,403	21,562	21,602
5	Daggett	49009	DG	1,059	1,367	1,444
6	Davis	49011	DA	306,479	346,870	356,968
7	Duchesne	49013	DU	18,607	21,959	22,797
8	Emery	49015	EM	10,976	11,179	11,230
9	Garfield	49017	GA	5,172	5,885	6,063
10	Grand	49019	GR	9,225	10,085	10,300
11	Iron	49021	IR	46,163	54,877	57,055
12	Juab	49023	JU	10,246	13,049	13,750
13	Kane	49025	KA	7,125	8,111	8,357
14	Millard	49027	MI	12,503	12,730	12,787
15	Morgan	49029	MO	9,469	11,450	11,945
16	Piute	49031	PI	1,556	1,619	1,635
17	Rich	49033	RI	2,264	2,478	2,532
18	Salt Lake	49035	SL	1,029,655	1,150,618	1,180,859
19	San Juan	49037	SJ	14,746	15,464	15,644
20	Sanpete	49039	SP	27,822	30,874	31,637
21	Sevier	49041	SE	20,802	22,064	22,380
22	Summit	49043	SU	36,324	43,658	45,491
23	Tooele	49045	TO	58,218	71,545	74,877

24	Uintah	49047	UI	32,588	37,704	38,982
25	Utah	49049	UT	516,564	638,164	668,564
26	Wasatch	49051	WA	23,530	30,899	32,741
27	Washington	49053	WS	138,115	185,033	196,762
28	Wayne	49055	WY	2,778	2,832	2,845
29	Weber	49057	WE	231,236	255,986	258,423
SUM			ALL	2,763,885	3,200,165	3,309,234

The University of Utah Kem C. Gardner Policy Institute website shows Utah human population projections by county on the following URL:

https://gardner.utah.edu/demographics/population-projections/

See menu item “2015 – 2065 State and County Projections (EXCEL Download)”.


Weber
Ogden
Morgan
Davis
Morgan
Farmington
Salt Lake City
Salt Lake
Box Elder
Logan
Cache
Randolph
Brigham City
Rich
Coalville
Summit
Manila
Daggett
Wasatch
Heber
Tooele
Tooele
Vernal
Duchesne
Duchesne
Provo
Utah
Uintah
Juab
Nephi
Carbon
Price
Manti
Sanpete
Emery
Grand
Millard
Filmore
Castledale
Richfield
Sevier
Moab
Beaver
Beaver
Piute
Junction
Loa
Wayne
Iron
Panguitch
Monticello
Parowan
Garfield
San Juan
Washington
Kane
St. George
Kanab

iv. Overview

The purpose of this document is to explain how the non-road mobile source emission inventories were created for the PM2.5 Maintenance SIP for the base year 2017 and projection years 2026 and 2035. Non-road mobile sources include a) non-road vehicles, motorized equipment and engines from MOVES2014b; b) aircraft; c) airport ground support equipment (GSE) and d) diesel locomotives.

The non-road mobile source inventories for this SIP were modeled by Utah Division of Air Quality (UDAQ), Inventory Section (formerly Mobile Sources and Transportation Section).

The baseline inventory covered a January 2017 day based on the average of temperatures recorded during the three $PM_{2.5}$ episodes which took place during the following periods:

Episode #1: Saturday, January 1 through Wednesday, January 12, 2011 inclusive (12 days);
Episode #2: Monday, February 1 through Wednesday, February 17, 2016 inclusive (17 days);
Episode #3: Saturday, December 7 through Thursday, December 19, 2013 inclusive (13 days).

The base year inventory covers the entire state—all 29 counties. In addition, counties outside Utah were included in the PM2.5 SIP domain. The NEI 2014 was used for these counties.

Emissions units for the base year inventory were tons per year, obtained as follows:

Non-road Sector	Units
Non-road Engines and Motorized Equipment (MOVES2014b)	(5*Wkdy + 2*Wknd)/7 = Daily Emissions * 365.25 = Tons per Year
Aircraft and Airport Ground Support Equipment	(January emissions) * (365.25/31) = Tons per Year
Diesel Locomotives	2017 Annual Emissions x Scaling Factors

The CAMX model then converts the ton-per-year inventories back to tons per winter weekday and tons per winter weekend day.

EPA guidance requires that states create inventories that use the most recent available data for fleet or equipment characterization, fuel parameters and meteorological data.

Agencies involved in discussions or supplying data include:

Bureau of Transportation Statistics/Transtats/Aviation Databases—commercial aircraft
EPA Office of Transportation and Air Quality: Mobile Team (OTAQ)—general questions
Federal Aviation Administration (FAA)—Emissions and Dispersion Modeling System
Federal Aviation Administration (FAA) “Terminal Area Forecast (“TAF”) Database, Current TAF Data (download 2017 data): Airport Operations.xlsx.

Railroad companies operating in Utah—reports of locomotive fuel consumption by county

FAA Airport Master Record—Airport IQ 5010—aircraft activity for small airports--air taxi and general aviation (this is a backup database if data is not found in the FAA TAF db).

Utah Division of Motor Vehicles (UDMV)—snowmobile inventory for Utah
Utah Transit Authority—commuter rail "Front Runner" activity

A. **Emissions from MOVES/NONROAD** (Non-road Vehicles, Equipment and Engines)

Features of MOVES (NONROAD Vehicles and Equipment)

MOVES2014b was used to obtain emission inventories for non-road mobile engines and motorized equipment that operate on unpaved roads or other areas but not on paved roads.

MOVES was run for a January weekday and January weekend day. Emissions were converted to tons per year as shown above.

MOVES models additional compounds that the EPA NONROAD Model does not, including:

CH4, NH3, major mobile HAPs (1,3–butadiene, acetaldehyde, acrolein, benzene, formaldehyde), polycylic aromatic hydrocarbons (PAH), various toxic metals, dioxins and furans).

MOVES Inputs for Non-road Mobile Sources

Using MOVES, inputs of fuel (diesel, gasoline, CNG and LPG) and their properties such as ethanol (E-10) volume percent, E-10 market share, E-10 oxygen weight percent, gasoline RVP and fuel sulfur content are supplied from the main MOVES database, movesdb20181022.

Other inputs include temperature and relative humidity data.

The user must use caution to insure that the MOVES default values for such inputs as fuels and temperatures are appropriate. For example, MOVES default temperatures are generally too low for Utah compared to actual temperatures recorded during the past 20 years (1998 – 2017).

Utah obtained meteorological data from one of several reputable websites generally run by colleges and universities in Utah, or from national meteorological websites such as MESOWEST or Western Regional Climate Center.

Meteorological data for this inventory came from MESOWEST operated by the University of Utah Department of Atmospheric Sciences (http://mesowest.utah.edu/). (1)

B. **Aircraft Emissions and Ground Support Equipment**

Commercial aircraft activity (mostly at Salt Lake City International Airport, but also at other

major airports in Utah, including Ogden, Provo, St. George, Cedar City and Wendover), was obtained from Transtats/Bureau of Transportation Statistics (https://www.transtats.bts.gov/). Activity data is available for any given historical month, but not for specific days. (2)

The aircraft portion of the inventory includes aircraft and helicopter emissions from all the major and minor airports operating in Utah. The Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System software (EDMS 5.1.4.1) was used to obtain emission factors for aircraft.

In addition to commercial aircraft, the aircraft inventory includes air taxi (mostly privately owned or operated small aircraft), general aviation (small aircraft based at small municipal airports in Utah) and military aircraft.

Only three airports are considered major point sources: Salt Lake City International and the military installations Hill Air Force Base in Davis County and Michael Army Air Field (formerly Dugway Proving Ground) in Tooele County. The vast majority of aircraft emissions in Utah come from Salt Lake City International.

Aircraft produce significant amounts of CO and SOx. In fact, the majority of SOx in the non-road inventory comes from aircraft.

Airport Ground Support Equipment

Airport Ground Support Equipment (GSE) emissions are included in output from EDMS. UDAQ believes the emission factors from EDMS are more accurate than those from the MOVES/NR model.

C. **Diesel Locomotive Emissions**

There are seven major railroad companies operating in Utah. The vast majority of emissions come from Union Pacific Railroad, which operates in seventeen of the 29 counties in Utah.

We have recently found about 7 more railroad companies supposedly operating in Utah. These are likely very small operations, so this inventory does not include emissions from these. In future work including the NEI 2017, we plan to contact these companies and request locomotive activity data from them.

Locomotives produce significant amounts of NOx, and minor amounts of other pollutants.

Diesel locomotive fuel consumption was reported by the railroads operating in Utah. These reports show annual fuel consumption. Some railroads also report ton-miles by county (Union Pacific Railroad) or miles of track for a round trip, such as reported by AMTRAK and the Utah Transit Authority “Front Runner” commuter rail. Emissions are calculated based on annual diesel fuel consumption.

Federal regulations (Tier IV Non-road Final Rule) require that diesel locomotives operate on ULSD (15 ppm) by 2012. All railroads operating in Utah during 2017 used 15-ppm sulfur diesel except that Salt Lake, Garfield & Western Railway did not return our calls (the latter is an extremely small railroad). Therefore, we set its diesel sulfur content the maximum level of 500 ppm. The most recent data received from SL, G & W was for calendar year 2008. Emissions for 2017 were projected using activity scaling factors (described later).

See Federal Register and rule text at https://www.gpo.gov/fdsys/pkg/FR-2004-06-29/pdf/04-11293.pdf .

D. **Comments**

PM10 and PM2.5 shown above do not include fugitive dust from unpaved roads, which is an Area Source category.

Aircraft emissions from Salt Lake City International Airport are included in the non-road inventory because the point source inventory for SLC Int'l does not include these.

Airport ground support equipment (GSE) emissions from two military bases—Michael Army Air Field (formerly Dugway Proving Ground) and Hill Air Force Base—are reported in the Point Source inventory. GSE emissions from all other sources are included in this non-road inventory.

v. Emission Inventories

A. Base Year Inventory

The base year for this inventory is 2017.

To easily compare emissions from the various sectors and sources, inventories were converted to ton-per-year inventories.

The summary table that follows includes emissions for the following:

Non-road Engines and Motorized Equipment (MOVES2014b)
Aircraft
Aircraft Ground Support Equipment
Locomotives
Total Non-road Mobile Source Emissions

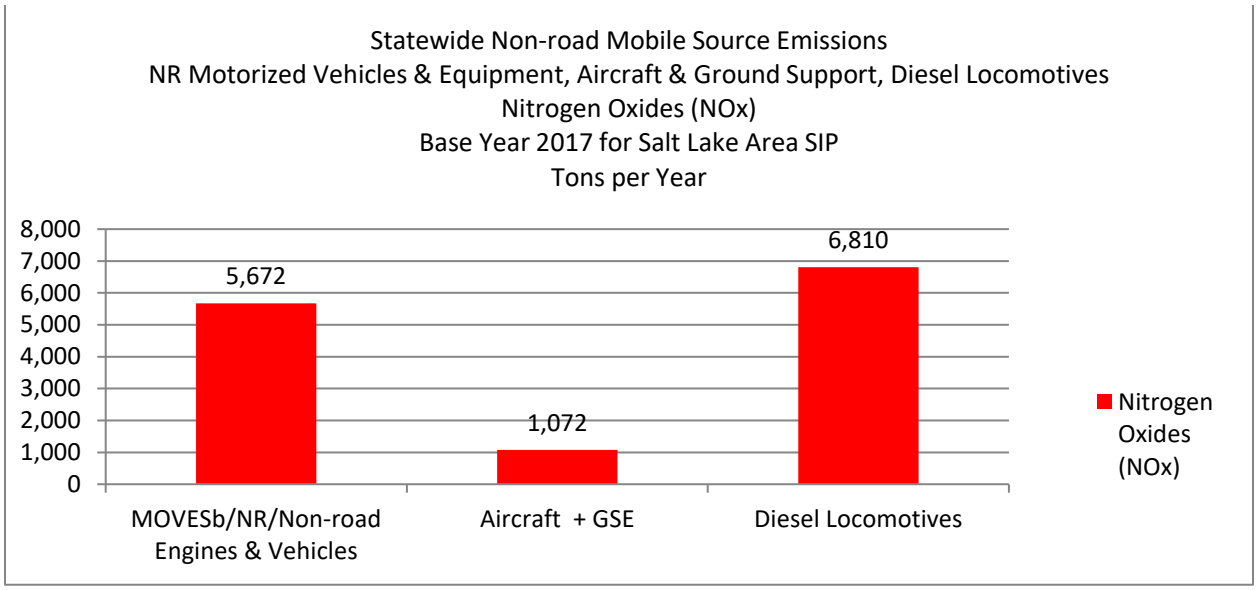
Summary Worksheet for Base Year 2017 Inventory for PM2.5 Maintenance SIP
Statewide Emissions: Non-road Mobile Sources
6/1/2019

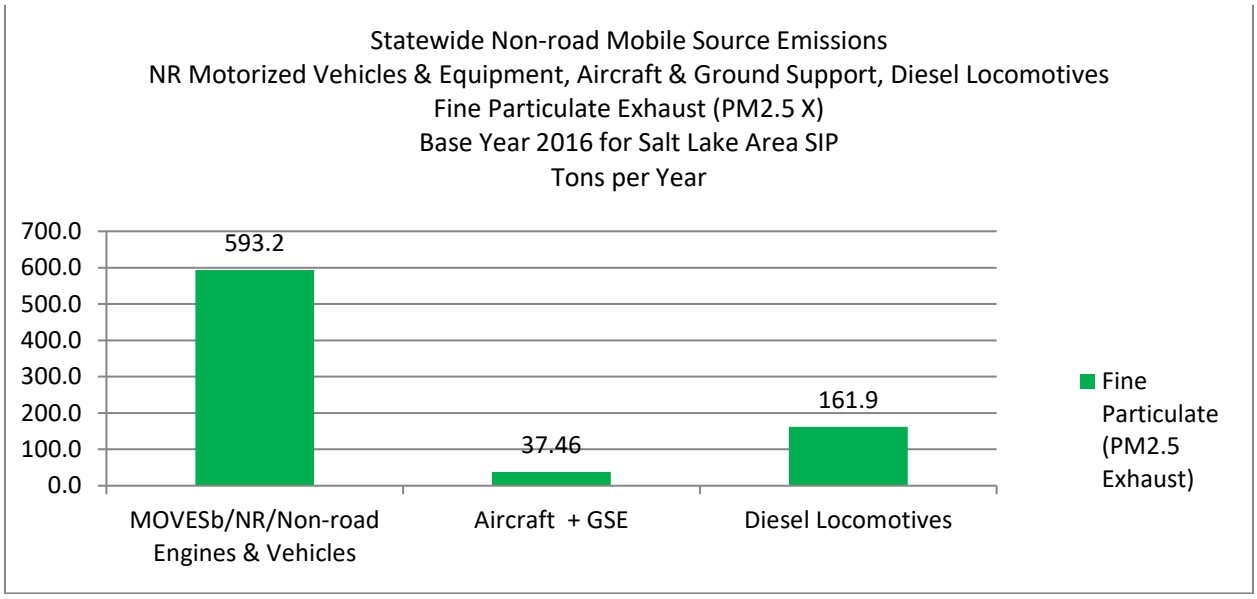
Cal Yr	Domain	Source Category	CO	NOX	PM10 X	PM2.5 X	SO2	VOC*	NH3
			TONS PER YEAR						
2017	Entire State	MOVESb/NR/Non-road Engines & Vehicles	64,412	5,672	627.1	593.2	12.31	8,638	12.06
2017	Entire State	Aircraft	7,997	1,026	40.66	35.65	130.1	353.8	N/A**
2017	Entire State	Airport Ground Support Equipment	449.3	46.26	1.905	1.809	2.302	15.51	N/A**
2017	Entire State	Diesel Locomotives	1,423	6,810	166.9	161.9	4.977	320.2	4.421
2017	Entire State	**SUM**	**74,281**	**13,554**	**833.2**	**792.6**	**149.7**	**9,328**	**16.48**

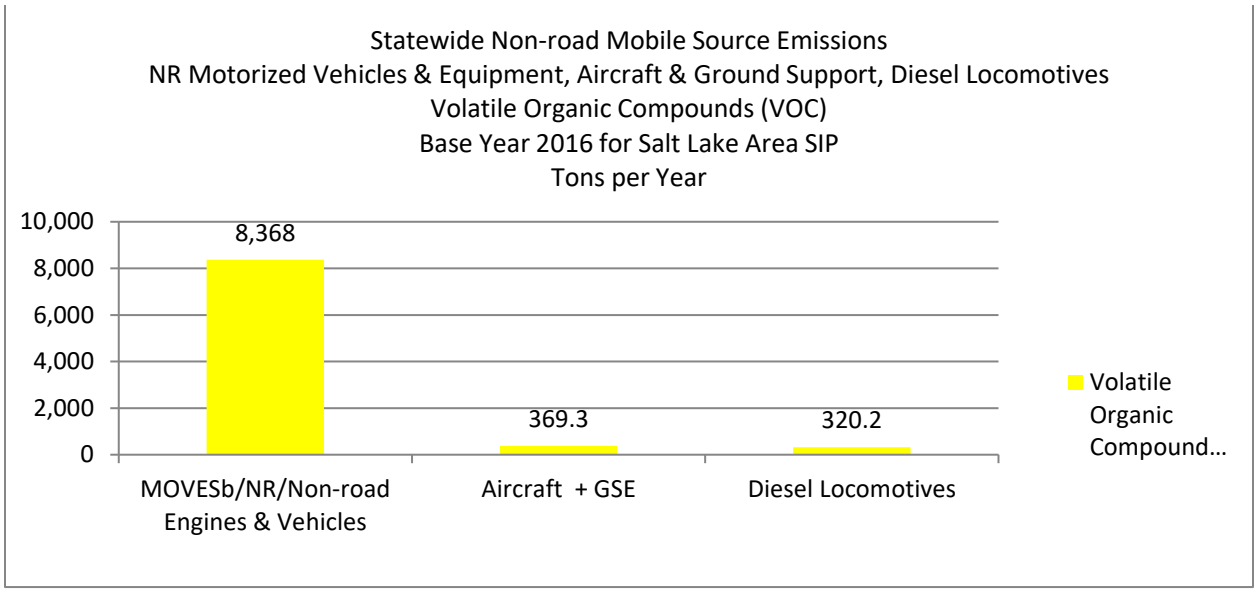
CH4	C6H6	Toluene	Xylene(s)	TGH	NMHC	NMOG	TOG
496.3	177.6	696.7	583.1	8,705	8,208	8,684	9,180

Emissions for miscellaneous pollutants are from MOVES2014b.

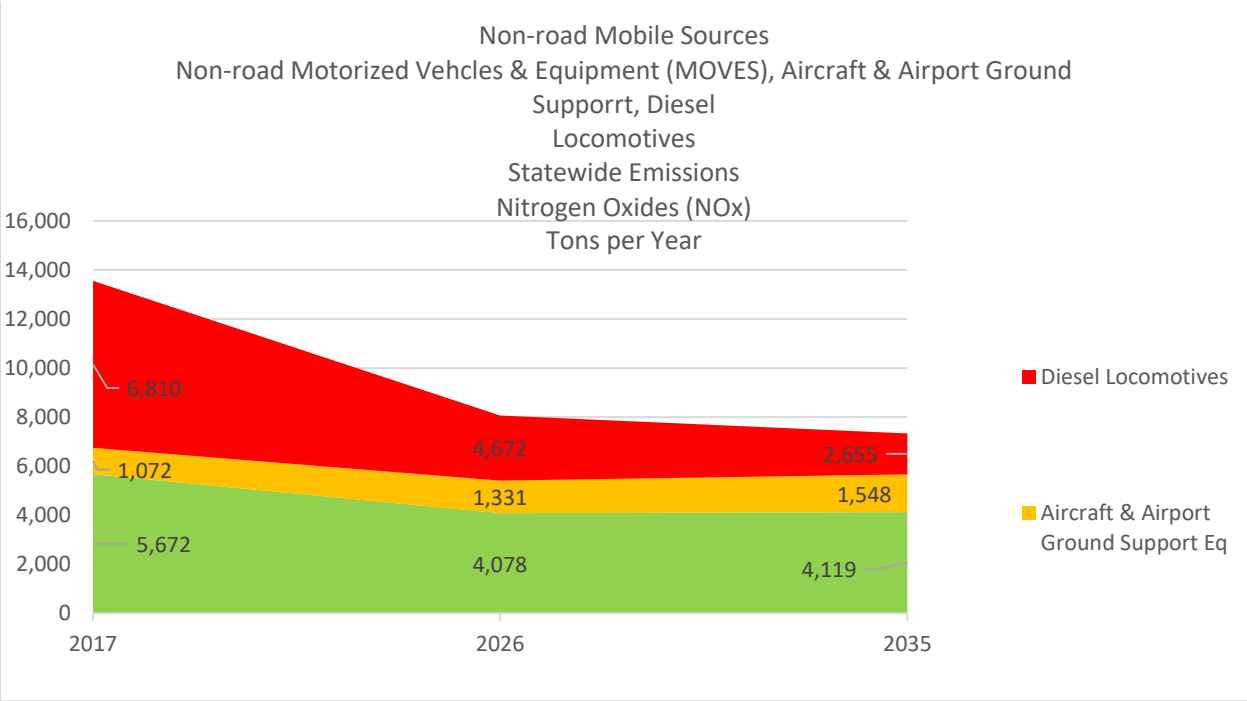
B. Charts of Statewide Non-road Mobile Source Emissions for Base Year 2017: NOx, PM2.5 Exhaust and VOC

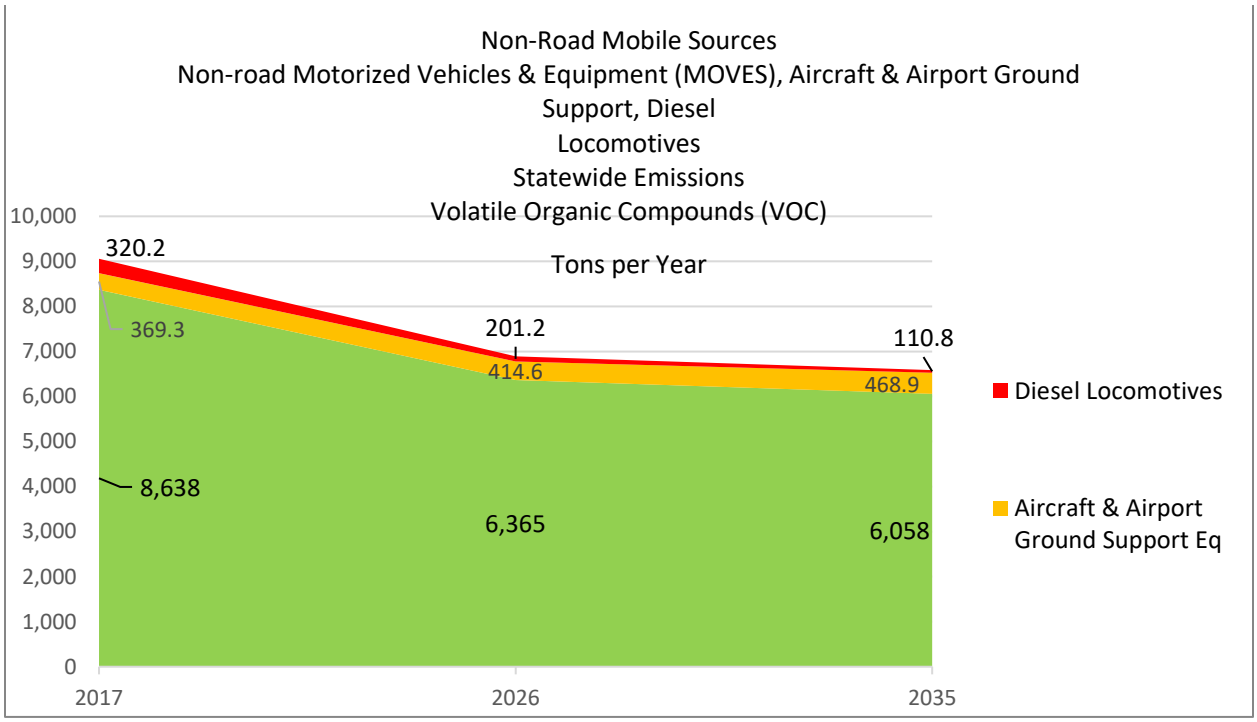


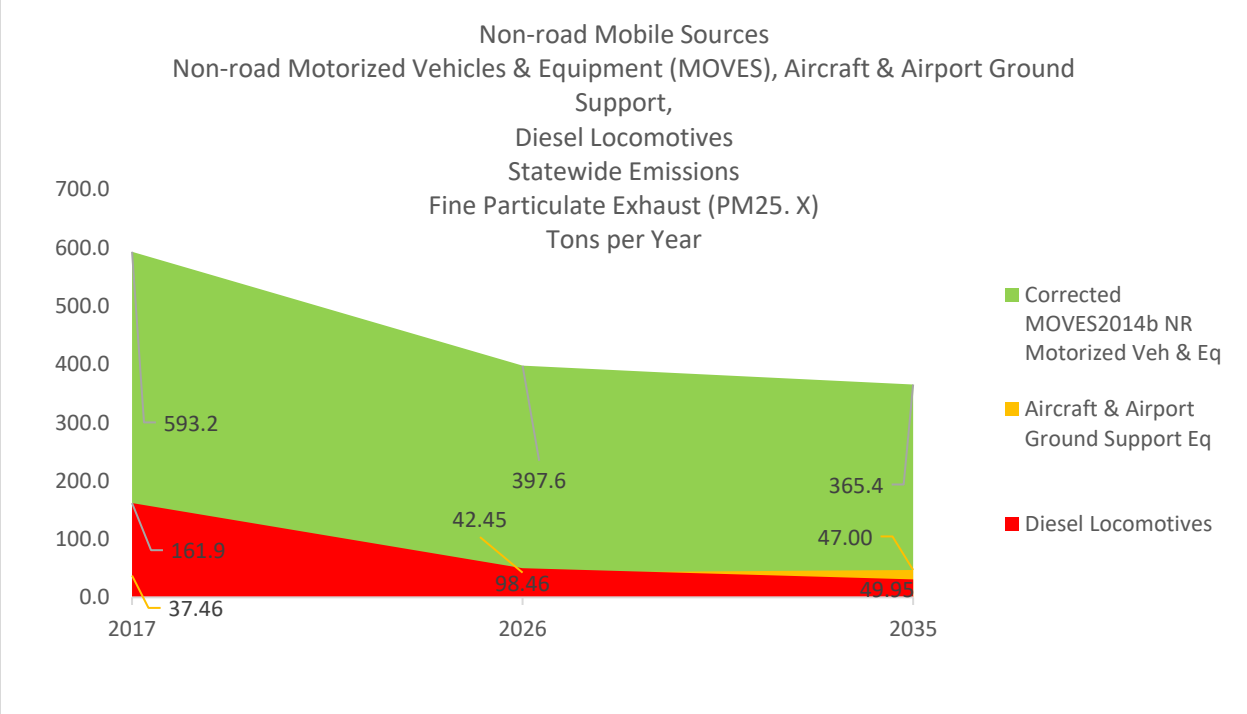



Statewide Non-road Mobile Source Emissions
NR Motorized Vehicles & Equipment, Aircraft & Ground Support, Diesel Locomotives
Volatile Organic Compounds (VOC)
Base Year 2016 for Salt Lake Area SIP
Tons per Year
10,000
8,000
6,000
4,000
2,000
0
8,368
369.3
320.2
MOVESb/NR/Non-road Engines & Vehicles
Aircraft + GSE
Diesel Locomotives
Volatile Organic Compound…

Calendar Year	Source	Counties	CO	NOx	VOC	PM2.5 Exh
2017	MOVES2014b NR Motorized Veh & Eq	ALL	64,412	5,672	8,638	593.2
2026	MOVES2014b NR Motorized Veh & Eq	ALL	67,861	4,078	6,365	397.6
2035	MOVES2014b NR Motorized Veh & Eq	ALL	77,117	4,119	6,058	365.4
2017	Aircraft & Airport Ground Support Eq	ALL	8,446	1,072	369.3	37.46
2026	Aircraft & Airport Ground Support Eq	ALL	9,113	1,331	414.6	42.45
2035	Aircraft & Airport Ground Support Eq	ALL	9,706	1,548	468.9	47.00
2017	Diesel Locomotives	ALL	1,423	6,810	320.2	161.9
2026	Diesel Locomotives	ALL	1,559	4,672	201.2	98.46
2035	Diesel Locomotives	ALL	1,604	2,655	110.8	49.95
2017	SUM	ALL	74,281	13,554	9,328	792.6
2026	SUM	ALL	78,533	10,081	13,749	687.4
2035	SUM	ALL	112,593	8,322	14,908	682.3




Non-Road Mobile Sources
Non-road Motorized Vehicles & Equipment (MOVES), Aircraft & Airport Ground Support, Diesel
Locomotives
Statewide Emissions
Volatile Organic Compounds (VOC)
Tons per Year
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2017
2026
2035
320.2
369.3
8,638
201.2
414.6
6,365
110.8
468.9
6,058
Diesel Locomotives
Aircraft & Airport Ground Support Eq


Non-road Mobile Sources
Non-road Motorized Vehicles & Equipment (MOVES), Aircraft & Airport Ground Support,
Diesel Locomotives
Statewide Emissions
Fine Particulate Exhaust (PM25. X)
Tons per Year
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
2017
2026
2035
593.2
161.9
37.46
397.6
42.45
98.46
365.4
47.00
49.95
Corrected MOVES2014b NR Motorized Veh & Eq
Aircraft & Airport Ground Support Eq
Diesel Locomotives

vi. Nonroad Emissions Sources and Models

A. Non-road Engines & Motorized Equipment	EPA MOVES2014b Model (October 2018)
B. Aircraft (emissions per landing/ takeoff cycle or LTO)	Federal Aviation Administration "Emissions and Dispersion Modeling System" (EDMS), version 5.1.4.1
1. Air Carriers (Commercial)	Bureau of Transportation Statistics (BTS) Transtats" website (2): http://www.transtats.bts.gov/ Number of commercial landings and takeoffs
2. Air Taxi, General Aviation	FAA "Terminal Area Forecast" Db (3) https://www.faa.gov/data_research/aviation/taf/. Number of air taxi and general aviation LTOs
3. Military Aircraft	U.S. Michael Army Air Field (annual report) U.S. Hill Air Force Base (annual report) FAA "Airport Master Records" and consultation with UT Div. of Aeronautics: number of military aircraft takeoffs and landings (LTOs)
C. Airport Ground Support Equipment (GSE)	FAA EDMS 5.1.4.1 Model
D. Diesel Locomotives	Railroad Companies (reports from): AMTRAK Rio Tinto (Kennecott Utah Copper) Salt Lake, Garfield and Western Railway Union Pacific Railroad (includes activity from Burlington Northern Santa Fe) Utah Railway Company (Genesee & Wyoming) Utah Transit Authority (commuter rail): diesel fuel consumption by county and locomotive type: line-haul, yard and commuter

vii. Non-road Engines and Motorized Equipment (MOVES2014b)

The EPA MOVES2014b Model (October 2018) was used to compute non-road emissions.

"MOVES" calculates emissions for twelve non-road categories:

Agricultural Equipment
Airport Ground Support Equipment
Commercial Equipment
Construction Equipment
Industrial Equipment

Lawn & Garden Equipment
Logging Equipment
Oil Field Miscellaneous Equipment
Pleasure Craft
Railroad Miscellaneous Equipment
Recreational Equipment
Underground Mining Equipment

Commercial marine equipment, locomotives and aircraft are not modeled by MOVES2014b (small personal watercraft are included).

MOVES output includes the usual pollutants of carbon monoxide (CO), nitrogen oxides (NOx), PM10 and PM2.5 exhaust, sulfur dioxide (SO2), volatile organic compounds (VOC) and ammonia (NH3).

In addition, for the CAMX air dispersion model, additional materials and compounds were modeled: benzene, CH4, NMHC, NMOG, TOG, TGH, toluene and xylenes. For possible future use, CO2 emissions were also modeled. If the output includes SCC code, then fuel type does not need to be output.

For the base year, emissions were computed for a January weekday and a January weekend day. Output units were grams per winter weekday or grams per winter weekend day.

Next, emissions units were converted to January daily and then ton-per-year emissions using the following equation:

$$(5*Wkdy + 2*Wknd)/7 = \text{Daily Emissions} * 365.25 = \text{Tons per Year}$$

Output was organized into "SMOKE" format and transferred to the CAMX air dispersion model for analysis of pollutant concentrations.

A. MOVES Input Data

Unlike the EPA NONROAD Model, it is not necessary to manually input fuel parameters such as RVP, ethanol content, sulfur content, etc. Instead, the GUI selections automatically choose the correct fuel parameters from the default database based on the county, years, months and days modeled.

Nonetheless, UDAQ carefully reviewed the MOVES default database tables of fuel supply and fuel formulation to insure that the correct fuel properties were modeled.

1. Sulfur Content of Fuels

For non-road diesel, marine diesel, CNG and LPG, we used MOVES default sulfur content. The sulfur content of these fuels varies slightly with calendar year as follows:

Table	fuelRegion ID	fuelYearID	monthGroupID	fuelFormulationID

nrfuelsupply	500,000,000 and 578,000,000	2017	1	3393
“	“	“	“	20008
“	“	“	“	26012
“	“	“	“	28001
“	“	“	“	29001

Table	fuelSubtypeID	RVP	sulfurLevel	ETOHVolume
fuelformulation	12	12.68	30	10
“	23	0.00	11	0
“	24	0.00	56	0
“	30	0.00	7.6	0
“	40	NULL	7.6	NULL

Table	fuelSubtypeID	fuelTypeID	fuelSubtypeDesc
fuelsubtype	12	1	Gasohol (E-10)
“	30	3	Compressed Natural Gas (CNG)
“	40	4	Liquefied Petroleum Gas (LPG)

Table	fuelTypeID	defaultFormulationID	fuelTypeDesc
nrfueltype	23	23	Nonroad Diesel Fuel
“	2	24	Marine Diesel Fuel

Gasoline sulfur content was set at 30 ppmw in calendar year 2017. The reason for this is that Utah receives almost 100% of its gasoline from five local refineries. These are considered small refineries and will not produce 10 ppmw S gasoline until 2020. S content was set to 10 ppm in 2026 and 2035.

In the non-road module of MOVES2014b UDAQ ran sensitivity tests which showed that only SO2 emissions are affected by gasoline sulfur content.

2. Meteorological Data

For SIP meteorological data, Utah obtained data from MESOWEST, a meteorological website designed by the University of Utah Department of Atmospheric Sciences. MOVES default values for met data are only approximate, so these were not used.

Temperature and Relative Humidity Data

Hourly temperature and relative humidity data used for the base year and projection years are the average values from the three PM2.5 episodes as shown below:

Hourly Temperatures by Episode Day and County

January 1 - 12, 2011 Episode

FIPs	County Name	Coldest Day	24-Hr Min T (F)	24-Hr Max T (F)	Warmest Day	24-Hr Min T (F)	24-Hr Max T (F)
49003	Box Elder	010411	-4.6	12.7	010811	6.5	21.7
49005	Cache	010401	-4.6	12.7	010811	6.5	21.7
49011	Davis	011211	11.9	17.1	010811	20.0	26.5
49035	Salt Lake	010111	6.7	19.9	010811	19.0	25.0
49045	Tooele	010111	1.4	19.4	010311	15.8	24.8
49049	Utah	010111	1.4	17.6	010911	14.6	24.8
49057	Weber	010111	6.8	19.3	010811	18.3	25.0

For the 22 PM2.5 attainment counties, temperatures from Salt Lake County were modeled.
Data for Box Elder County was not available, so Cache County data was used.

February 1 - 17, 2016 Episode

FIPs	County Name	Coldest Day	24-Hr Min T (F)	24-Hr Max T (F)	Warmest Day	24-Hr Min T (F)	24-Hr Max T (F)
49003	Box Elder	020216	-4.8	17.8	021616	33.4	48.4
49005	Cache	020216	-4.8	17.8	021616	33.4	48.4
49011	Davis	020216	15.1	29.8	021716	35.1	58.2
49035	Salt Lake	020216	15.3	27.9	021716	37.4	59.9
49045	Tooele	020316	8.4	25.7	021716	33.6	55.9
49049	Utah	020316	11.3	27.1	021716	29.3	58.7
49057	Weber	020216	9.0	24.7	021716	36.6	52.9

December 7 - 19, 2013 Episode

FIPs	County Name	Coldest Day	24-Hr Min T (F)	24-Hr Max T (F)	Warmest Day	24-Hr Min T (F)	24-Hr Max T (F)
49003	Box Elder	120913	-10.4	8.1	121913	19.0	30.4
49005	Cache	120913	-10.4	8.1	121913	19.0	30.4
49011	Davis	120913	-0.8	17.1	121913	26.8	33.0
49035	Salt Lake	120913	3.9	18.4	121913	28.0	33.7
49045	Tooele	120913	-0.4	18.4	121913	26.6	30.2
49049	Utah	121013	-2.2	12.2	121913	29.6	39.2
49057	Weber	120913	3.9	18.4	121913	26.1	33.1

B. Snowmobile Adjustments (MOVES2014b)

The discussion below sometimes refers to the EPA NONROAD Model because this model was in use when the underlying database for snowmobiles was adjusted to match local survey data. MOVES2014b was used to model the NONROAD vehicles and equipment in these inventories.

UDAQ reviewed the PM2.5 SIP inventories from the EPA NONROAD model for the 2008 base year and projection years 2014, 2017 and 2019. Theses showed that, in several counties, a large majority of VOC emissions from equipment in the NONROAD model were emitted by snowmobiles, as shown below:

Calendar Year	County	FIPs	VOC from Snowmobiles (Tons per Win Wkdy)	VOC from NR Model (Tons per Win Wkdy)	Percent from Snowmobiles (%)
2008	Cache	49005	0.262	0.617	42.5
2008	Duchesne	49013	1.085	1.243	87.3
2008	Morgan	49029	2.186	2.206	99.1
2008	Rich	49033	8.290	8.437	98.3
2008	Summit	49043	0.502	0.788	63.7
2008	Wasatch	49051	0.955	1.026	90.2

At the same time, other counties in the domain showed zero VOC emissions from snowmobiles in the EPA NONROAD model.

Questioning the accuracy of the output, UDAQ obtained recent survey data on snowmobile activity from two agencies. The survey data showed that the true number of snowmobiles by county were very different from the allocation in the MOVES2014b default database. (4, 5)

The survey report on snowmobile activity in Utah also showed that activity was spread over the months of December through April inclusive instead of the default months of December through February that are shown in the MOVES default database.

In addition, UDAQ recently obtained counts of registered snowmobiles by county from the Utah Tax Commission (Division of Motor Vehicle registration data) for calendar years 2005 through 2018. (6)

In summary, reports and databases for Utah showed that actual snowmobile activity differed from data stored in the MOVES2014b database. Therefore, UDAQ created input tables to use in place of defaults stored in the MOVES2014b database as follows:

1. Reallocation of Snowmobile Counts in MOVES Database (File “nrstatesurrogate”)

Relative numbers of snowmobiles were reallocated among the counties based on survey data. This was done by modifying the file “nrstatesurrogate” found in the database “movesdb20181022”.

For details of changes to the file “nrstatesurrogate”, see the Appendix.

2. Utah Snowmobile Population Changed in MOVES2014a Database (File “nrbaseyearequippopulation”)

The MOVES file “nrbaseyearequippopulation” shows the default number of snowmobiles in Utah as of calendar year 1990.

From the data supplied by DMV, the Utah snowmobile population for calendar year 1990 was estimated by performing a linear regression on DMV snowmobile counts over calendar years 2005 through 2018. It was found that Utah had 40,135 snowmobiles in 1990. The default value in the MOVES default database “nrbaseyearequippopulation” showed only 21,784 snowmobiles in Utah.

Therefore, the counts of snowmobiles in the “nrbaseyearequippopulation” file were changed. Details of changes to this file are shown in the Appendix.

3. Utah Snowmobile Counts in Future Years Changed in MOVES2014b Database (File “nrgrowthindex”)

The MOVES file “nrgrowthindex” determines counts of equipment in future years.

Because the snowmobile count in the base year (1990) was changed in MOVES, and because data from DMV showed a different annual growth rate of snowmobiles, it was necessary to adjust snowmobile counts in future years. This was done by changing the growth numbers in the “nrgrowthindex” file.

In addition, through trial and error, we determined that the nrgrowthindex values must also be adjusted for Recreational Gasoline/LPG equipment.

IF THE nrgrowthindex values are NOT adjusted for both the specific equipment type (snowmobiles) AND the group (recreational gasoline/LPG equipment), the results will be in error.

Specifically, the values of the nrgrowthindex table were adjusted for growthPatternIDs 1002 – 1010 (which pertain to snowmobiles), and were also adjusted for growthPattern ID 2402, which are recreational gasoline/LPG equipment.

Details of changes to the “nrgrowthindex” file are shown in the appendix.

4. Snowmobile Seasonality Changed in MOVES2014a Database (File “nrmonthallocation)
The MOVES default file “nrmonthallocation” shows that snowmobile activity occurs evenly over the months of January, February and December, as denoted by the values (0.333, 0.333, 0.333).

Snowmobile surveys showed that actual activity in Utah is spread evenly over the months from December through April.

Therefore, the "nrmonthallocation" values were changed to (0.200, 0.200, 0.200, 0.200 and 0.200) for the respective months of December through April.

In MOVES2014b, folders named "nrjan2017_500" and "nrjan2017_578" were added to the MySQL data folder to store changes made to the default snowmobile tables. When the MOVES GUI is opened, the user must go to the menu item "Manage Input Data Series" and choose, using the drop-down list, the name of the data folder that contains the modified snowmobile data ("nrjan2017_500" or "nrjan2017_578").

In summary, MOVES default values in the following files were changed for snowmobiles:

File Name	Description
nrstatesurrogateyear	Relative number of snowmobiles by county in calendar year 2002
nrbaseyearequippopulation	Snowmobile counts by county and source type ID: source type IDs for snowmobiles include: 1002 – 1010
nrgrowthindex	Snowmobile annual growth rate. Snowmobiles have growth pattern IDs 1002 – 1010.
nrgrowthindex	Recreational gasoline/LPG equipment (growth pattern ID = 2402) nrgrowthindex values were changed as well.
nrmonthallocation	Relative snowmobile activity by month

5. Additional MOVES2014b Files Related to Snowmobiles

In addition to changing the default values in the above tables affecting snowmobiles, the following files contain information relevant to snowmobiles, but default values need not be changed. These files help identify source type, growth pattern, and surrogate IDs for snowmobiles.

File Name	Description
nrsourceusetype	Source type IDs by SCC and HP range: snowmobiles are identified as source type IDs 1002 – 1010.
nrgrowthpattern	Growth pattern IDs = 1002 - 1010 identifies snowmobiles
nrgrowthpattern	Growth pattern ID = 2402 = recreational gasoline/LPG x equipment
nrsurrogate	Surrogate ID = 14 identifies residential snowmobiles

6. No Additional Changes to the MOVES2014b Database

No other changes were made to the MOVES2014b default database.

viii. Aircraft

The aircraft source category includes all aircraft types used for public, private, and military purposes. Aircraft emissions inventories are grouped by type of operation rather than aircraft type. Four types of aircraft activity are included: commercial, air taxi, general aviation and military aircraft.

A. Four Main Operation Types for Aircraft

Operation Type	Description	Source of Emission Factors	SCC Code Groups
Commercial Flights/Air Carriers	Operations at Salt Lake City International Airport and smaller municipal airports.	EDMS 5.1.4.1	2275020000
Air Taxi	Small privately-owned commuter planes	EDMS 5.1.4.1	2275060000
General Aviation	Small municipal airport operations (aircraft are "based" in small cities and towns)	EDMS 5.1.4.1	2275050000
Military Aircraft	Military operations	Reports from Military Bases	2275010000

B. Aircraft Activity (Landings and Takeoffs, or LTOs)

For each type of aircraft operation shown above, the first step is to gather the numbers of landings and takeoffs during the relevant time period.

One common error is to count each landing or takeoff as a complete LTO. This is *incorrect*. Instead, one LTO cycle consists of one landing and one takeoff, so care must be taken to observe how aircraft activity is reported. In short, activity from the U.S. DOT BTS "Transtats" website reports commercial activity as separate landings and takeoffs, so the total number of these must be divided by two to obtain LTOs. FAA also reports activity as separate landings and takeoffs. The EDMS emission model assumes that the input is in LTO units. (7)

Air taxi, general aviation and military aircraft operations are treated the same way: one LTO cycle consists of one landing and one takeoff.

For air taxis, general aviation, and military aircraft, only annual activity data are available. Annual activity is reported by the FAA in its "Terminal Area Forecast" database. This database is updated each year.

If the TAF database does not include a given airport, the FAA Airport Master Records can be searched to find the aircraft activity. These records are updated periodically. Some of the airport records have not been updated since 2011, while others are current to December 31, 2017. For those records that are not up-to-date, FAA scaling factors were used to adjust the number of LTOs to the base year. (8)

C. Aircraft Types

1. Commercial

Commercial activity from the U.S. DOT "Transtats" website reports landings and takeoffs by aircraft type using a unique 3-digit code for each aircraft type. Commercial aircraft landings and takeoffs can be downloaded from the Bureau of Transportation Statistics (BTS) "Transtats" website at http://www.transtats.bts.gov/.

Under "Aviation", one chooses "Air Carrier Statistics - Form 41 Traffic - All Carriers", and then "T-100 Domestic Segment—All Carriers". Next, choose "T-100 Domestic Segment (U.S. Carriers)". In the lower right-hand corner of the box, click on "Download". At the top of the screen, under "Download Instructions", choose the state, calendar year and month. For this SIP, calendar year/month was January 2017.

On the web page, boxes are checked for the following:

Aircraft Type
Origin City Name
Destination City Name
Departures Performed

Each "departure performed" is either an arrival or a departure. One landing-takeoff cycle (LTO) consists of one departure and one arrival pair. There were 10,414 LTO cycles that took place in January 2017 where the origin or destination was in Utah.

The vast majority of commercial aircraft activity in Utah takes place at Salt Lake City International Airport. There are about 50 additional smaller municipal airports in the state, but

only about ten municipal airports handle commercial aircraft. Based on January 2017 activity, the annualized number of commercial LTOs in Utah were about 10414 * (365.25/31) = 122,700.

2. Air Taxi and General Aviation

The Utah Department of Transportation, Division of Aeronautics, no longer reports aircraft activity for air taxi and general aviation operations. Instead, activity is reported in the FAA database "Terminal Area Forecast at:
https://www.faa.gov/data_research/aviation/taf/ (3).

As with commercial aircraft, these records report separate landings and takeoffs, so the total must be divided by two to obtain the number of LTOs.

For General Aviation, the Airport Master Record shows, for each airport, the number of based aircraft of each general type: single-engine, multi-engine, and jets. Single- and multi-engine aircraft operate on aviation fuel, which is similar to gasoline, while jets operate on jet fuel.

The Utah Division of Aeronautics was consulted to determine the specific aircraft types used under each general aircraft type—single- and multi-engine and jets.

For Air Taxi, the Airport Master Record for each airport shows the number of landings and takeoffs. The Utah Division of Aeronautics was consulted to determine the specific aircraft types used for air taxis.

3. Military
There are only two major military airports in Utah, each of which sends annual reports of aircraft activity and the inventory to UDAQ:

Hill Air Force Base (Davis County)
Dugway Proving Ground (Tooele County)

In addition, the Airport Master Records show that about seven small municipal airports have military aircraft activity.

Statewide Aircraft LTOs by Calendar Year and Operational Type

Commercial aircraft LTOs were reported for the month of January 2017. The January number of LTOs was multiplied by (365.25/31) to convert the LTOs to an annual count. Air taxi, general aviation and military LTOs were reported in annual units as shown below:

Calendar Year and Month	Commercial	Air Taxi	General Aviation	Military
Jan 2017	(10,414)*(365.25/31)	46,916	364,402	32,537

= 122,700

D. Emissions and Dispersion Modeling System (EDMS) Software

The EDMS model (v. 5.1.4.1) was used to obtain emissions from the numerous aircraft types in the inventory.

The user enters the calendar year and name of airport. A list of all the aircraft and engine types opens, and the user selects the specific aircraft type (and engine type if known—otherwise, the default engine type for the aircraft type is chosen). Then, the number of LTOs (separate landings and takeoffs divided by two) is entered. The entire list of aircraft and engine types operating at a particular airport is entered. The user then merely chooses "Update", and the inventory is generated in the units chosen by the user.

Sensitivity tests showed that the location of the airport has almost no effect on emissions, so Salt Lake City International Airport was selected as the default location.

Emissions reported include CO, NOx, PM10 and PM2.5 exhaust, SO2 and VOC, but not NH3.

A report (2013) from the Journal of Atmospheric Chemistry and Physics states that more research and modeling are needed to determine whether NH3 emissions from aircraft make any meaningful contribution to PM2.5 concentrations. (9)

E. Airport Ground Support Equipment (GSE)

Aircraft ground support emissions (GSE) are generated from the EDMS 5.1.41 model at the same time that aircraft tailpipe emissions are generated.

For example, when a particular aircraft type is modeled in EDMS, the number of landing and takeoff (LTO) cycles is input. The model automatically generates, in addition to aircraft emissions, ground support equipment emissions from this activity.

GSE emissions from two point sources—Hill Air Force Base and Michael Army Air Field—are reported in the point source inventories from these sources. GSE emissions from these sources will not be modeled by UDAQ using EDMS. Care will be taken that these emissions are not double-counted.

ix. <u>Diesel Locomotives</u>

The locomotive source category includes railroad locomotives powered by diesel-electric engines and does not include locomotives powered by electricity or steam. Locomotive diesel engines are significant contributors to NOx emissions

All of the criteria pollutants, VOC, CO, NO_x, SO_x, PM10, PM2.5 and NH3 are included in the

locomotive inventory. Emissions were estimated by applying emission factors to the total amount of diesel fuel used by locomotives. Emission factors for the criteria pollutants were obtained from the EPA guidance document "Emission Factors for Locomotives" (April 2009). (10)

For NH3, the EPA document "Documentation for Locomotive Component of the National Emissions Inventory Methodology" (May 2011) was used because the document "Emission Factors for Locomotives" does not include EFs for NH3. (11)

About 90% of locomotive emissions come from Union Pacific Railroad. The second-highest source of locomotive emissions is the Utah Transit Authority commuter rail, the "Front Runner". Commuter rail currently runs from Ogden in the north (Weber County to Provo in the south (Utah County).

The sulfur content of locomotive diesel fuel affects emissions. UDAQ requested railroad companies to report the sulfur content of diesel fuel along with the volume of fuel used.

Diesel locomotives are grouped by two operations: line haul and yard, or switch.

Diesel locomotive fuel consumption data were reported to UDAQ by the individual railroad companies that operate in Utah. For 2017, these companies include: Amtrak, Burlington Northern Santa Fe Railway (BNSF), Rio Tinto (Kennecott Utah Copper), Union Pacific Railroad Company (UPRR), Utah Railway and Utah Transit Authority (UTA)--commuter rail operations.

In addition, Utah Transit Authority reported its 2017 diesel fuel consumption for commuter rail.

For projections of commuter/passenger diesel fuel consumption, scaling factors were obtained from an AMTRAK report, "AMTRAK Fleet Strategy, v. 3.1". Passenger growth was projected at 2% per year. Thus diesel fuel consumption for passenger locomotives was projected to increase 2% per year as well. (12)

For projections of freight diesel fuel consumption, scaling factors were obtained by searching for documents from reputable sources that projected growth of freight ton-miles from as early as calendar year 2000 through at least calendar year 2026. These documents include the following:

National Petroleum Council, "Rail Transportation Demand, Topic Paper #2", Aug 1, 2012. (13)

U.S. DOE, Energy Efficiency & Renewable Energy (EERE), "Freight Transportation Demand: Energy-Efficient Scenarios for a Low-Carbon Future", March 2013. (14)

U.S. DOT, "National Freight Strategic Plan", 2015. (15)

Each of the above three reports includes charts that show the growth in freight miles or ton-miles to some distant year:

Milestone Years	Cumulative Percent Growth in Freight Ton-Miles		
	National Petroleum Association (Medium Growth)	U.S. DOE EERE (High Growth)	U.S. DOT: Nat'l Freight Strategic Plan (Low Growth)
2017 – 2026	9.00%	16.7%	5.87%

Since we do not know which projection is the most accurate, the "medium-growth" scenario was used, i.e., data from the National Petroleum Association.

x. Output

A. MOVES2014b

MOVES was run for each of the 29 counties in Utah for a January weekday and January weekend day in 2016. Hourly temperature and relative humidity (RH) data were obtained by taking the average hourly temperature and RH values from all the PM2.5 episode days in January 2011, December 2013 and February 2016. These meteorological data were used in the previous SIP for which the base year was 2017.

The resulting output in units of grams per January weekday or weekend day were converted to January daily emissions using the equation:

$$(5*Wkdy + 2*Wknd)/7 = \text{Daily Emissions} * 365.25 = \text{Tons per Year}$$

B. Aircraft (EDMS v. 5.1.4.1)

Commercial aircraft activity (landings and takeoffs, or LTOs) were downloaded for January 2017. Daily LTO activity for commercial aircraft is not available on the U.S. DOT Bureau of Transportation Statistics (BTS) "Transtats" website, so monthly activity was captured.

For air taxi, general aviation and military aircraft LTOs, only annual data is available from FAA.

Thus the aircraft portion of the inventory is reported in units of tons per year, where the January inventory for commercial aircraft use the conversion factor of (365.25/31) to obtain TPY from January tons.

The final aircraft inventory is reported in tons per year.

Aircraft GSE emissions will also be reported in tons per year.

C. Diesel Locomotives

Reports submitted by railroads included diesel fuel consumed by locomotives by county. Emissions were computed by applying EPA emission factors in units of grams per gallon consumed.

Locomotive diesel fuel consumption was reported on an annual scale only, so the units of locomotive emissions are tons per year.

D. SMOKE Formats for Air Dispersion Model

For the "Comprehensive Air Quality Model with Extensions" (CAMx), emissions were formatted into EXCEL tables. Data in SMOKE formats include calendar year, county name, FIPs code, pollutant id (from MOVES and applied to all non-road sources), SCC and TPY.

xi. APPENDIX ITEMS

A. Inventories

Jan 2017 Emissions: MOVES2014b, Aircraft, Airport Ground Support Equipment, Locomotives
Jan 2026
Jan 2035

B. MOVES2014b Model: Changes to Underlying Database for Snowmobiles
1. nrstatesurrogate table
2. nrbaseyearequippopulation
3. nrgrowthindex
4. nrmonthallocation

January 2017 Emissions from MOVES2014b: Non-road Motorized Vehicles & Equipment
TONS PER YEAR

County	FIPS	CO	NOx	PM10X	PM2.5X	SO2	VOC	NH3
Beaver	49001	104.1	11.20	1.187	1.132	0.0176	8.924	0.0191
Box Elder	49003	1,721	199.7	12.77	12.13	0.4343	259.2	0.3177
Cache	49005	2,772	265.0	32.86	30.98	0.6562	599.0	0.6221
Carbon	49007	976.9	133.6	17.13	16.27	0.2388	246.0	0.2317
Daggett	49009	266.0	9.741	3.244	2.992	0.0577	109.1	0.0462
Davis	49011	4,651	504.9	47.58	45.31	0.9668	412.0	1.0284
Duchesne	49013	528.4	55.87	4.643	4.402	0.1005	67.80	0.0994
Emery	49015	432.9	101.6	11.69	11.16	0.1485	137.4	0.1544
Garfield	49017	266.6	28.23	3.727	3.508	0.0678	72.43	0.0698
Grand	49019	460.6	55.31	4.013	3.813	0.0897	50.89	0.0920
Iron	49021	901.5	101.2	10.97	10.38	0.2147	175.6	0.2159
Juab	49023	384.2	44.50	4.146	3.917	0.0854	70.56	0.0836
Kane	49025	247.7	23.88	1.986	1.871	0.0536	45.14	0.0459
Millard	49027	395.0	48.18	3.151	3.003	0.0919	59.21	0.0730
Morgan	49029	155.9	19.61	1.363	1.310	0.0319	7.809	0.0337
Piute	49031	98.50	4.756	1.283	1.188	0.0221	39.86	0.0183
Rich	49033	1,266	43.36	16.08	14.83	0.2649	502.8	0.2154
Salt Lake	49035	25,559	1,804	189.8	179.8	3.918	1,868	3.799
San Juan	49037	311.1	28.94	2.231	2.104	0.0575	45.63	0.0484
Sanpete	49039	733.0	40.59	8.722	8.116	0.1529	235.4	0.1338
Sevier	49041	596.2	129.7	13.94	13.36	0.1687	97.18	0.1851
Summit	49043	2,444	147.5	30.75	28.65	0.5267	770.4	0.4924
Tooele	49045	686.9	94.00	6.802	6.481	0.1809	98.92	0.1673
Uintah	49047	1,713	250.0	14.72	14.05	0.3824	172.8	0.3897
Utah	49049	6,992	733.3	74.36	70.71	1.416	655.1	1.5221
Wasatch	49051	1,865	93.45	25.55	23.69	0.4376	752.8	0.3882
Washington	49053	2,877	304.4	33.95	32.24	0.5679	283.4	0.6602
Wayne	49055	78.13	6.886	0.9204	0.8676	0.0136	12.26	0.0141
Weber	49057	4,930	388.9	47.59	44.84	0.9456	782.8	0.8962
	SUM	**64,412**	**5,672**	**627.1**	**593.2**	**12.31**	**8,638**	**12.06**

January 2017 Emissions from Aircraft
TONS PER YEAR

County Number	County Name	County FIPs	CO	NOX	PM10X	PM2.5X	SOX	VOC	NH3
1	Beaver	49001	28.55	0.1448	0.0691	0.0671	0.0590	0.6506	N/A
2	Box Elder	49003	179.8	0.5318	0.4015	0.3896	0.2564	2.338	N/A
3	Cache	49005	645.2	2.009	1.460	1.416	0.9737	9.435	N/A
4	Carbon	49007	33.50	1.271	0.0905	0.0884	0.2030	0.8835	N/A
5	Daggett	49009	17.39	0.0358	0.0381	0.0370	0.0217	0.1940	N/A
6	Davis	49011	439.1	35.15	5.771	2.039	3.402	11.49	N/A
7	Duchesne	49013	63.33	0.1584	0.1393	0.1352	0.0827	0.7183	N/A
8	Emery	49015	49.00	0.6702	0.1155	0.1124	0.1372	0.7862	N/A
9	Garfield	49017	61.77	0.3076	0.1405	0.1364	0.1065	0.8991	N/A
10	Grand	49019	120.6	4.486	0.3278	0.3199	0.7451	3.415	N/A
11	Iron	49021	61.35	5.819	1.622	1.575	1.727	15.99	N/A
12	Juab	49023	27.89	0.0469	0.0654	0.0635	0.0432	0.5532	N/A
13	Kane	49025	29.01	0.1285	0.0646	0.0627	0.0454	0.3526	N/A
14	Millard	49027	37.39	0.1610	0.0832	0.0808	0.0579	0.4526	N/A
15	Morgan	49029	39.26	0.0534	0.0863	0.0837	0.0465	0.4565	N/A
16	Piute	49031	8.353	0.0073	0.0182	0.0176	0.0091	0.0890	N/A
17	Rich	49033	0.00	0.00	0.00	0.00	0.00	0.00	N/A
18	Salt Lake	49035	2,741	943.0	19.47	18.92	114.2	243.1	N/A
19	San Juan	49037	71.84	0.3206	0.1600	0.1553	0.1127	0.8741	N/A
20	Sanpete	49039	12.65	0.0420	0.0280	0.0271	0.0179	0.1478	N/A
21	Sevier	49041	95.77	0.2669	0.2111	0.2048	0.1288	1.098	N/A
22	Summit	49043	0.00	0.00	0.00	0.00	0.00	0.00	N/A
23	Tooele	49045	743.0	8.135	3.517	3.129	1.531	11.03	N/A
24	Uintah	49047	118.3	1.820	1.171	1.137	0.3953	7.523	N/A
25	Utah	49049	958.4	7.688	2.276	2.209	2.122	17.24	N/A
26	Wasatch	49051	173.7	1.828	0.4061	0.3947	0.4226	2.790	N/A
27	Washington	49053	565.5	6.564	1.361	1.322	1.698	10.49	N/A
28	Wayne	49055	25.64	0.0946	0.0568	0.0552	0.0376	0.3037	N/A
29	Weber	49057	650.1	5.460	1.514	1.471	1.429	10.57	N/A
ALL		**GRAND TOTAL**	**7,997**	**1,026**	**40.66**	**35.65**	**130.1**	**353.8**	**N/A**

Aircraft VOC above does not include refueling VOCs.
*EDMS does not calculate NH3 for aircraft.

January 2017 Emissions from Airport Ground Support Equipment
Tons per Year

County Number	County Name	County FIPs	CO	NOX	PM10	PM2.5	SOX	VOC
1	Beaver	49001	0.0800	0.0117	0.0002	0.0002	0.0003	0.0038
2	Box Elder	49003	0.3102	0.0602	0.0007	0.0007	0.0012	0.0185
3	Cache	49005	1.200	0.2216	0.0027	0.0027	0.0049	0.0690
4	Carbon	49007	1.057	0.0881	0.0025	0.0025	0.0045	0.0347
5	Daggett	49009	0.0190	0.0050	0.0000	0.0000	0.0001	0.0015
6	Davis	49011	0.1627	0.0782	0.0003	0.0003	0.0006	0.0211
7	Duchesne	49013	0.1040	0.0209	0.0002	0.0002	0.0004	0.0064
8	Emery	49015	0.6440	0.0596	0.0015	0.0015	0.0027	0.0226
9	Garfield	49017	0.2523	0.0319	0.0006	0.0006	0.0011	0.0109
10	Grand	49019	5.684	0.4621	0.0135	0.0135	0.0243	0.1837
11	Iron	49021	5.896	0.5291	0.0136	0.0133	0.0216	0.1883
12	Juab	49023	0.0028	0.0057	0.0000	0.0000	0.0000	0.0014
13	Kane	49025	0.1081	0.0142	0.0003	0.0003	0.0005	0.0048
14	Millard	49027	0.1347	0.0180	0.0003	0.0003	0.0006	0.0061
15	Morgan	49029	0.0209	0.0096	0.0000	0.0000	0.0001	0.0026
16	Piute	49031	0.0009	0.0018	0.0000	0.0000	0.0000	0.0004
17	Rich	49033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	Salt Lake	49035	411.3	42.03	1.798	1.704	2.138	14.05
19	San Juan	49037	0.2703	0.0354	0.0006	0.0006	0.0011	0.0120
20	Sanpete	49039	0.0329	0.0051	0.0001	0.0001	0.0001	0.0017
21	Sevier	49041	0.1969	0.0346	0.0004	0.0004	0.0008	0.0109
22	Summit	49043	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
23	Tooele	49045	2.834	0.4050	0.0096	0.0092	0.0131	0.1281
24	Uintah	49047	2.531	0.2289	0.0083	0.0083	0.0112	0.0846
25	Utah	49049	3.631	0.5545	0.0141	0.0137	0.0165	0.1723
26	Wasatch	49051	1.704	0.1664	0.0040	0.0040	0.0072	0.0619
27	Washington	49053	6.583	0.6889	0.0223	0.0208	0.0314	0.2414
28	Wayne	49055	0.0763	0.0111	0.0002	0.0002	0.0003	0.0037
29	Weber	49057	4.448	0.4886	0.0115	0.0114	0.0189	0.1725
ALL		**GRAND TOTAL**	**449.3**	**46.26**	**1.905**	**1.809**	**2.302**	**15.51**

*EDMS does not report NH3 from airport ground support equipment.

January 2017 Emissions from Diesel Locomotives
Tons per Year

County	FIPs	CO	NOx	PM10	PM2.5	SO2	VOC	NH3
Beaver	49001	51.25	219.4	5.582	5.415	0.1808	9.324	0.1603
Box Elder	49003	125.3	536.7	13.65	13.24	0.4421	22.80	0.3922
Cache	49005	6.481	27.75	0.7059	0.6848	0.0229	1.179	0.0203
Carbon	49007	21.96	93.91	2.386	2.314	0.0775	3.990	0.0687
Daggett	49009	0	0	0	0	0	0	0
Davis	49011	99.07	459.9	11.34	11.00	0.3476	21.19	0.3084
Duchesne	49013	0	0	0	0	0	0	0
Emery	49015	19.83	84.74	2.151	2.087	0.0699	3.608	0.0620
Garfield	49017	0	0	0	0	0	0	0
Grand	49019	28.29	120.9	3.069	2.977	0.0998	5.147	0.0885
Iron	49021	66.74	285.7	7.269	7.051	0.2354	12.14	0.2088
Juab	49023	59.96	256.8	6.531	6.336	0.2115	10.91	0.1876
Kane	49025	0	0	0	0	0	0	0
Millard	49027	207.2	887.0	22.56	21.89	0.7306	37.69	0.6481
Morgan	49029	54.67	234.1	5.954	5.776	0.1928	9.946	0.1710
Piute	49031	0	0	0	0	0	0	0
Rich	49033	0	0	0	0	0	0	0
Salt Lake	49035	236.1	1,480	33.59	32.58	0.8031	82.86	0.7184
San Juan	49037	0	0	0	0	0	0	0
Sanpete	49039	0	0	0	0	0	0	0
Sevier	49041	0	0	0	0	0	0	0
Summit	49043	93.71	401.3	10.21	9.901	0.3305	17.05	0.2932
Tooele	49045	136.3	583.1	14.82	14.38	0.4806	24.79	0.4263
Uintah	49047	0	0	0	0	0	0	0
Utah	49049	114.4	598.7	14.24	13.81	0.3982	30.21	0.3533
Wasatch	49051	1.497	6.399	0.163	0.158	0.0053	0.271	0.0047
Washington	49053	0	0	0	0	0	0	0
Wayne	49055	0	0	0	0	0	0	0
Weber	49057	100.3	533.8	12.68	12.30	0.3486	27.12	0.3092
SUM		**1,423**	**6,810**	**166.9**	**161.9**	**4.977**	**320.2**	**4.421**

January 2017 Emissions from Non-road Mobile Sources
Tons per Year

County	FIPs	CO	NOx	PM10 Exh	PM2.5 Exh	SO2	VOC	NH3
Beaver	49001	184.0	230.8	6.839	6.614	0.2576	18.90	0.1794
Box Elder	49003	2,026	737.0	26.83	25.77	1.134	284.3	0.7099
Cache	49005	3,425	295.0	35.03	33.09	1.658	609.6	0.6424
Carbon	49007	1,033	228.9	19.61	18.68	0.5237	251.0	0.3004
Daggett	49009	283.4	9.782	3.282	3.029	0.0794	109.3	0.0462
Davis	49011	5,189	1,000	64.69	58.35	4.717	444.7	1.337
Duchesne	49013	591.8	56.04	4.782	4.537	0.1836	68.52	0.0994
Emery	49015	502.4	187.1	13.43	13.36	0.3584	141.8	0.2165
Garfield	49017	328.6	28.57	3.649	3.645	0.1754	73.34	0.0698
Grand	49019	615.1	181.1	7.223	7.123	0.9589	59.63	0.1805
Iron	49021	1,036	393.3	19.28	19.02	2.198	203.9	0.4247
Juab	49023	472.1	301.3	10.51	10.32	0.3401	82.03	0.2713
Kane	49025	276.8	24.02	1.94	1.93	0.0994	45.49	0.0459
Millard	49027	639.7	935.4	25.65	24.97	0.8810	97.36	0.7212
Morgan	49029	249.9	253.7	7.351	7.170	0.2712	18.21	0.2047
Piute	49031	106.9	4.766	1.207	1.206	0.0312	39.95	0.0183
Rich	49033	1,266	43.36	14.83	14.83	0.2649	502.8	0.2154
Salt Lake	49035	28,947	4,269	244.6	233.0	121.1	2,208	4.517
San Juan	49037	383.2	29.29	2.391	2.260	0.1713	46.52	0.0484
Sanpete	49039	745.7	40.63	8.750	8.143	0.1710	235.5	0.1338
Sevier	49041	692.1	130.0	14.15	13.56	0.2983	98.29	0.1851
Summit	49043	2,538	548.7	40.96	38.55	0.8572	787.4	0.7856
Tooele	49045	1,569	685.6	25.15	24.00	2.206	134.9	0.5936
Uintah	49047	1,834	252.0	15.90	15.19	0.7889	180.4	0.3897
Utah	49049	8,068	1,340	90.89	86.74	3.953	702.7	1.875
Wasatch	49051	2,041	101.8	26.12	24.25	0.8727	756.0	0.3929
Washington	49053	3,449	311.7	35.34	33.58	2.297	294.1	0.6602
Wayne	49055	103.8	6.992	0.9774	0.9230	0.0515	12.56	0.0141
Weber	49057	5,685	928.6	61.79	58.62	2.742	820.7	1.205
SUM		**74,282**	**13,555**	**833.2**	**792.5**	**149.6**	**9,328**	**16.48**

Jan 2026 MOVES2014b Non-road Motorized Vehicles & Equipment
Tons per Year

County	FIPs	CO	NOx	PM10 Exh	PM2.5 Exh	SO2	VOC	NH3
Beaver	49001	113.9	6.705	0.7633	0.7178	0.0164	9.052	0.0215
Box Elder	49003	1,713	158.2	8.165	7.758	0.3284	151.3	0.3758
Cache	49005	2,491	187.2	18.53	17.42	0.5417	337	0.657
Carbon	49007	849	125.4	12.85	12.27	0.1903	135.9	0.2237
Daggett	49009	154.2	8.35	1.559	1.437	0.0163	49.1	0.0333
Davis	49011	5,252	348.0	32.22	30.33	1.003	399.6	1.232
Duchesne	49013	537.7	30.73	2.458	2.307	0.0795	44.9	0.1067
Emery	49015	320.5	90.7	8.36	8.36	0.1336	71.5	0.1481
Garfield	49017	199.0	17.44	1.681	1.681	0.0501	36.4	0.0693
Grand	49019	460.8	27.62	1.897	1.897	0.0779	35.01	0.1009
Iron	49021	830	62.89	5.46	5.46	0.1799	99.7	0.2282
Juab	49023	353.4	24.18	1.944	1.944	0.0646	39.4	0.0860
Kane	49025	224.5	17.07	0.979	0.979	0.0345	24.77	0.0494
Millard	49027	392.0	34.18	1.510	1.510	0.0584	32.12	0.0810
Morgan	49029	180.1	11.83	0.7056	0.7056	0.0319	7.769	0.0399
Piute	49031	57.7	3.60	0.562	0.562	0.0072	18.03	0.0136
Rich	49033	771	37.0	7.79	7.79	0.0767	232	0.1563
Salt Lake	49035	30,008	1,374	150.9	141.5	3.784	2,049	4.687
San Juan	49037	307.7	19.44	1.322	1.237	0.0367	29.74	0.0527
Sanpete	49039	541	31.49	4.61	4.29	0.0769	117.5	0.1167
Sevier	49041	597.4	113.7	11.40	10.92	0.1814	72.0	0.1967
Summit	49043	1,821	104.0	16.47	15.29	0.2850	387	0.440
Tooele	49045	687.4	67.13	3.864	3.657	0.1511	62.52	0.1933
Uintah	49047	1,759	117.6	6.39	6.04	0.3303	110.5	0.4236
Utah	49049	7,863	507.0	51.37	48.29	1.493	640.7	1.818
Wasatch	49051	1,113	70.8	12.42	11.49	0.1824	344	0.310
Washington	49053	3,205	192.2	23.43	21.95	0.6078	290.0	0.7723
Wayne	49055	73.0	4.134	0.582	0.5434	0.0108	8.56	0.0149
Weber	49057	4,984	285.7	31.28	29.30	0.792	530	0.993
SUM		**67,859**	**4,078**	**421.5**	**397.6**	**10.82**	**6,366**	**13.64**

January 2026 Aircraft Emissions
Tons per Year

County	FIPs	CO	NOX	PM10	PM2.5	SOX	VOC	NH3*
Beaver	49001	29.42	0.1255	0.0709	0.0688	0.0576	0.6611	N/A
Box Elder	49003	185.5	0.4583	0.4129	0.4006	0.2524	2.374	N/A
Cache	49005	665.5	1.751	1.501	1.456	0.9616	9.599	N/A
Carbon	49007	33.87	0.9924	0.0874	0.0852	0.1663	0.7714	N/A
Daggett	49009	17.94	0.0316	0.0393	0.0381	0.0217	0.1979	N/A
Davis	49011	449.7	35.13	5.794	2.061	3.411	11.62	N/A
Duchesne	49013	65.33	0.1369	0.1434	0.1391	0.0818	0.7299	N/A
Emery	49015	50.22	0.5296	0.1162	0.1129	0.1196	0.7396	N/A
Garfield	49017	63.64	0.2551	0.1438	0.1396	0.1015	0.9006	N/A
Grand	49019	122.7	3.607	0.3209	0.3127	0.6380	3.134	N/A
Iron	49021	61.53	4.945	1.196	1.191	1.656	3.680	N/A
Juab	49023	28.80	0.0484	0.0676	0.0655	0.0446	0.5712	N/A
Kane	49025	29.89	0.1060	0.0662	0.0643	0.0432	0.3522	N/A
Millard	49027	38.54	0.1331	0.0853	0.0828	0.0552	0.4525	N/A
Morgan	49029	40.53	0.0509	0.0890	0.0863	0.0474	0.4694	N/A
Piute	49031	8.625	0.0075	0.0188	0.0182	0.0094	0.0919	N/A
Rich	49033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Salt Lake	49035	3,154	1,194	23.95	23.25	143.6	294.7	N/A
San Juan	49037	74.03	0.2643	0.1640	0.1591	0.1073	0.8729	N/A
Sanpete	49039	13.04	0.0353	0.0287	0.0279	0.0174	0.1491	N/A
Sevier	49041	98.78	0.2281	0.2170	0.2106	0.1265	1.112	N/A
Summit	49043	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Tooele	49045	766.5	8.829	3.575	3.185	1.640	11.30	N/A
Uintah	49047	133.3	1.557	1.474	1.430	0.3862	9.274	N/A
Utah	49049	990.4	8.959	2.368	2.297	2.318	17.97	N/A
Wasatch	49051	178.4	1.459	0.4111	0.3994	0.3782	2.691	N/A
Washington	49053	585.6	6.398	1.412	1.371	1.768	10.95	N/A
Wayne	49055	26.44	0.0790	0.0583	0.0566	0.0363	0.3053	N/A
Weber	49057	669.0	4.930	1.549	1.504	1.378	10.53	N/A
		8,581	**1,275**	**45.35**	**40.22**	**159.5**	**396.2**	N/A

*The aircraft model does not produce NH3 emissions.

Jan 2026 Airport Ground Support Equipment Emissions
Tons per Year

County	FIPs	CO	NOX	PM10	PM2.5	SOX	VOC	NH3*
Beaver	49001	0.0626	0.0103	0.0001	0.0001	0.0003	0.0033	N/A
Box Elder	49003	0.2444	0.0551	0.0005	0.0005	0.0010	0.0165	N/A
Cache	49005	0.9632	0.2032	0.0021	0.0021	0.0038	0.0616	N/A
Carbon	49007	0.8320	0.0707	0.0020	0.0020	0.0035	0.0276	N/A
Daggett	49009	0.0151	0.0047	0.0000	0.0000	0.0001	0.0013	N/A
Davis	49011	0.1337	0.0760	0.0002	0.0002	0.0004	0.0202	N/A
Duchesne	49013	0.0820	0.0192	0.0002	0.0002	0.0003	0.0057	N/A
Emery	49015	0.4998	0.0484	0.0012	0.0012	0.0021	0.0180	N/A
Garfield	49017	0.1968	0.0276	0.0005	0.0005	0.0008	0.0092	N/A
Grand	49019	5.147	0.4205	0.0122	0.0122	0.0220	0.1668	N/A
Iron	49021	5.139	0.4771	0.0124	0.0120	0.0186	0.1654	N/A
Juab	49023	0.0028	0.0057	0.0000	0.0000	0.0000	0.0014	N/A
Kane	49025	0.0844	0.0124	0.0002	0.0002	0.0003	0.0041	N/A
Millard	49027	0.1052	0.0157	0.0002	0.0002	0.0004	0.0051	N/A
Morgan	49029	0.0171	0.0093	0.0000	0.0000	0.0001	0.0025	N/A
Piute	49031	0.0009	0.0018	0.0000	0.0000	0.0000	0.0004	N/A
Rich	49033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Salt Lake	49035	497.0	51.73	2.254	2.131	2.621	17.07	N/A
San Juan	49037	0.2110	0.0308	0.0005	0.0005	0.0009	0.0102	N/A
Sanpete	49039	0.0257	0.0046	0.0001	0.0001	0.0001	0.0014	N/A
Sevier	49041	0.1547	0.0314	0.0003	0.0003	0.0006	0.0096	N/A
Summit	49043	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Tooele	49045	2.984	0.4301	0.0109	0.0104	0.0142	0.1342	N/A
Uintah	49047	2.490	0.2312	0.0089	0.0089	0.0112	0.0838	N/A
Utah	49049	3.934	0.6044	0.0166	0.0161	0.0182	0.1857	N/A
Wasatch	49051	1.323	0.1369	0.0031	0.0031	0.0056	0.0499	N/A
Washington	49053	6.524	0.7057	0.0243	0.0223	0.0322	0.2421	N/A
Wayne	49055	0.0597	0.0098	0.0001	0.0001	0.0002	0.0031	N/A
Weber	49057	3.714	0.4368	0.0101	0.0100	0.0159	0.1500	N/A
	TOTAL	**531.9**	**55.81**	**2.361**	**2.235**	**2.774**	**18.45**	**N/A**

*The aircraft model does not produce NH3 emissions for ground support.

January 2026 Emissions from Locomotives
Tons per Year

County	**FIPs**	CO	NOx	PM10	PM2.5	SO2	VOC	NH3
Beaver	49001	55.82	144.65	3.145	3.050	0.1969	5.519	0.1746
Box Elder	49003	136.5	353.8	7.691	7.460	0.4815	13.498	0.4271
Cache	49005	7.058	18.293	0.3977	0.3857	0.0249	0.6979	0.0221
Carbon	49007	24.09	62.06	1.3356	1.2955	0.0849	2.329	0.0754
Daggett	49009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Davis	49011	110.2	314.4	6.929	6.721	0.3868	13.359	0.3432
Duchesne	49013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Emery	49015	21.85	56.09	1.1991	1.1631	0.0771	2.0820	0.0684
Garfield	49017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Grand	49019	31.16	80.02	1.7114	1.6601	0.1099	2.973	0.0975
Iron	49021	72.68	188.4	4.095	3.972	0.2563	7.186	0.2274
Juab	49023	65.31	169.25	3.679	3.569	0.2303	6.457	0.2043
Kane	49025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Millard	49027	225.6	584.7	12.711	12.330	0.7957	22.31	0.7059
Morgan	49029	59.54	154.30	3.354	3.254	0.2100	5.887	0.1863
Piute	49031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Rich	49033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Salt Lake	49035	259.4	1090.7	23.63	22.92	0.8835	56.55	0.7897
San Juan	49037	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sanpete	49039	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sevier	49041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Summit	49043	102.1	264.5	5.750	5.578	0.3600	10.092	0.3193
Tooele	49045	148.9	384.9	8.324	8.074	0.5252	14.562	0.4659
Uintah	49047	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Utah	49049	127.5	424.3	9.264	8.986	0.4439	19.78	0.3939
Wasatch	49051	1.642	4.230	0.0909	0.0882	0.0058	0.1585	0.0051
Washington	49053	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wayne	49055	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Weber	49057	109.7	377.7	8.194	7.948	0.3814	17.74	0.3384
SUM		**1,559**	**4,672**	**101.5**	**98.46**	**5.454**	**201.2**	**4.844**

January 2026 Emissions from Non-road Mobile Sources
Tons per Year

County	FIPs	CO	NOx	PM10	PM2.5	SO2	VOC	NH3
Beaver	49001	199.2	151.5	3.979	3.837	0.2711	15.24	0.1961
Box Elder	49003	2,035	512.5	16.27	15.62	1.063	167.2	0.8029
Cache	49005	3,165	207.4	20.43	19.26	1.532	347.1	0.6795
Carbon	49007	907.6	188.5	14.27	13.65	0.4451	139.0	0.2991
Daggett	49009	172.2	8.387	1.598	1.475	0.0380	49.27	0.0333
Davis	49011	5,812	697.6	44.95	39.11	4.801	424.6	1.575
Duchesne	49013	603.1	30.89	2.602	2.446	0.1616	45.66	0.1067
Emery	49015	393.1	147.3	9.675	9.636	0.3324	74.38	0.2165
Garfield	49017	262.8	17.72	1.825	1.821	0.1524	37.34	0.0693
Grand	49019	619.8	111.7	3.941	3.882	0.8477	41.28	0.1984
Iron	49021	969.7	256.7	10.76	10.64	2.111	110.7	0.4556
Juab	49023	447.5	193.5	5.691	5.579	0.3396	46.47	0.2903
Kane	49025	254.5	17.19	1.045	1.043	0.0781	25.13	0.0494
Millard	49027	656.3	619.0	14.31	13.92	0.9098	54.89	0.7869
Morgan	49029	280.2	166.2	4.149	4.046	0.2894	14.13	0.2262
Piute	49031	66.32	3.606	0.5810	0.5804	0.0166	18.12	0.0136
Rich	49033	770.8	36.97	7.790	7.790	0.0767	232.1	0.1563
Salt Lake	49035	33,918	3,710	200.7	189.8	150.9	2,417	5.477
San Juan	49037	381.9	19.74	1.486	1.397	0.1449	30.62	0.0527
Sanpete	49039	553.7	31.53	4.641	4.313	0.0944	117.7	0.1167
Sevier	49041	696.3	114.0	11.62	11.13	0.3085	73.15	0.1967
Summit	49043	1,923	368.5	22.22	20.87	0.6450	397.1	0.7590
Tooele	49045	1,606	461.2	15.77	14.93	2.331	88.52	0.6592
Uintah	49047	1,895	119.4	7.873	7.479	0.7277	119.9	0.4236
Utah	49049	8,985	940.8	63.02	59.59	4.273	678.6	2.212
Wasatch	49051	1,294	76.62	12.93	11.98	0.5719	347.0	0.3153
Washington	49053	3,797	199.3	24.87	23.34	2.408	301.2	0.7723
Wayne	49055	99.52	4.223	0.6407	0.6001	0.0473	8.868	0.0149
Weber	49057	5,766	668.7	41.03	38.76	2.568	558.8	1.331
SUM		**78,531**	**10,081**	**570.7**	**538.5**	**178.5**	**6,981**	**18.49**

Jan 2035 MOVES2014b NR Motorized Vehicles & Equipment
Tons per Year

County	FIPs	CO	NOx	PM10 Exh	PM2.5 Exh	SO2	VOC	NH3
Beaver	49001	130.6	5.745	0.6522	0.6071	0.0175	10.04	0.0237
Box Elder	49003	1,909	168.7	8.252	7.859	0.4120	139.2	0.4443
Cache	49005	2,646	188.8	14.94	14.07	0.6183	256	0.703
Carbon	49007	870	127.0	11.58	11.09	0.1989	100.4	0.2238
Daggett	49009	101.4	6.00	0.874	0.806	0.0118	27.4	0.0229
Davis	49011	6,162	351.2	30.53	28.58	1.143	442.2	1.402
Duchesne	49013	584.3	27.44	1.952	1.822	0.0837	39.4	0.1131
Emery	49015	282.3	90.2	7.81	7.52	0.1353	49.0	0.1441
Garfield	49017	166.3	14.16	1.124	1.050	0.0492	23.4	0.0663
Grand	49019	474.5	24.40	1.581	1.480	0.0814	29.9	0.1065
Iron	49021	875	58.29	4.39	4.12	0.1949	76.4	0.2392
Juab	49023	359.9	20.84	1.509	1.411	0.0666	29.6	0.0874
Kane	49025	219.8	15.80	0.789	0.739	0.0365	19.35	0.0514
Millard	49027	424.4	31.11	1.180	1.115	0.0643	27.86	0.0886
Morgan	49029	213.7	11.20	0.6036	0.5695	0.0356	8.813	0.0454
Piute	49031	39.4	2.58	0.341	0.315	0.0055	10.22	0.0099
Rich	49033	547	25.9	5.43	5.00	0.0560	135	0.1085
Salt Lake	49035	36,091	1,487	154.8	144.6	4.546	2,358	5.596
San Juan	49037	323.6	18.44	1.162	1.083	0.0398	27.11	0.0568
Sanpete	49039	485	28.06	3.17	2.95	0.0771	76.8	0.1053
Sevier	49041	651.5	115.2	10.96	10.49	0.1929	67.0	0.2085
Summit	49043	1,627	84.3	11.36	10.53	0.2691	254	0.392
Tooele	49045	743.9	65.29	3.317	3.125	0.1694	58.84	0.2139
Uintah	49047	1,888	102.7	4.83	4.54	0.3433	94.8	0.4469
Utah	49049	9,213	516.8	48.99	45.83	1.710	702.5	2.072
Wasatch	49051	784	52.5	7.27	6.72	0.1551	196	0.243
Washington	49053	3,664	179.1	21.83	20.32	0.6576	318.2	0.8463
Wayne	49055	72.0	3.484	0.491	0.4557	0.0110	7.42	0.0152
Weber	49057	5,569	296.6	28.42	26.59	0.916	475	1.101
SUM		**77,117**	**4,119**	**390.1**	**365.4**	**12.30**	**6,058**	**15.18**

Jan 2035 Aircraft Emissions
Tons per Year

County	FIPs	CO	NOX	PM10	PM2.5	SOX	VOC	NH3*
Beaver	49001	30.22	0.1339	0.0729	0.0707	0.0598	0.6809	N/A
Box Elder	49003	190.5	0.4895	0.4242	0.4116	0.2617	2.445	N/A
Cache	49005	683.4	1.865	1.542	1.496	0.9966	9.885	N/A
Carbon	49007	34.93	1.087	0.0911	0.0888	0.1800	0.8229	N/A
Daggett	49009	18.42	0.0336	0.0404	0.0392	0.0224	0.2037	N/A
Davis	49011	458.7	35.15	5.814	2.081	3.423	11.74	N/A
Duchesne	49013	67.09	0.1461	0.1473	0.1429	0.0847	0.7518	N/A
Emery	49015	51.64	0.5777	0.1199	0.1166	0.1274	0.7744	N/A
Garfield	49017	65.37	0.2750	0.1479	0.1436	0.1060	0.9304	N/A
Grand	49019	126.9	3.957	0.3356	0.3272	0.6950	3.375	N/A
Iron	49021	64.08	5.356	1.209	1.204	1.725	3.927	N/A
Juab	49023	29.57	0.0497	0.0694	0.0673	0.0458	0.5864	N/A
Kane	49025	30.70	0.1144	0.0681	0.0661	0.0451	0.3640	N/A
Millard	49027	39.58	0.1436	0.0877	0.0851	0.0577	0.4677	N/A
Morgan	49029	41.61	0.0532	0.0914	0.0886	0.0488	0.4823	N/A
Piute	49031	8.855	0.0077	0.0193	0.0187	0.0096	0.0944	N/A
Rich	49033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Salt Lake	49035	3,504	1,397	27.62	26.82	167.9	340.9	N/A
San Juan	49037	76.03	0.2853	0.1686	0.1636	0.1120	0.9024	N/A
Sanpete	49039	13.39	0.0380	0.0295	0.0287	0.0181	0.1538	N/A
Sevier	49041	101.4	0.2442	0.2230	0.2164	0.1312	1.146	N/A
Summit	49043	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Tooele	49045	786.9	9.598	3.627	3.236	1.758	11.63	N/A
Uintah	49047	145.6	1.729	1.707	1.656	0.4295	10.74	N/A
Utah	49049	1,018	10.22	2.448	2.376	2.510	18.71	N/A
Wasatch	49051	183.4	1.588	0.4238	0.4117	0.4004	2.802	N/A
Washington	49053	604.5	7.199	1.471	1.428	1.948	11.72	N/A
Wayne	49055	27.15	0.0850	0.0600	0.0582	0.0377	0.3151	N/A
Weber	49057	687.3	5.423	1.596	1.550	1.464	10.92	N/A
SUM		**9,089**	**1,483**	**49.65**	**44.39**	**184.6**	**447.5**	**N/A**

The aircraft model does not produce NH3 emissions.

Jan 2035 Airport Ground Support Equipment Emissions
Tons per Year

County	FIPS	CO	NOX	PM10	PM2.5	SOX	VOC	NH3*
Beaver	49001	0.0683	0.0108	0.0002	0.0002	0.0003	0.0035	N/A
Box Elder	49003	0.2662	0.0568	0.0006	0.0006	0.0011	0.0172	N/A
Cache	49005	1.050	0.2099	0.0023	0.0023	0.0042	0.0643	N/A
Carbon	49007	0.9145	0.0771	0.0022	0.0022	0.0039	0.0302	N/A
Daggett	49009	0.0164	0.0048	0.0000	0.0000	0.0001	0.0014	N/A
Davis	49011	0.1433	0.0767	0.0003	0.0003	0.0005	0.0205	N/A
Duchesne	49013	0.0893	0.0197	0.0002	0.0002	0.0004	0.0059	N/A
Emery	49015	0.5475	0.0521	0.0013	0.0013	0.0023	0.0195	N/A
Garfield	49017	0.2152	0.0290	0.0005	0.0005	0.0009	0.0098	N/A
Grand	49019	5.768	0.4687	0.0137	0.0137	0.0246	0.1863	N/A
Iron	49021	5.572	0.5156	0.0139	0.0134	0.0206	0.1796	N/A
Juab	49023	0.0028	0.0057	0.0000	0.0000	0.0000	0.0014	N/A
Kane	49025	0.0923	0.0130	0.0002	0.0002	0.0004	0.0043	N/A
Millard	49027	0.1150	0.0165	0.0003	0.0003	0.0005	0.0054	N/A
Morgan	49029	0.0184	0.0094	0.0000	0.0000	0.0001	0.0025	N/A
Piute	49031	0.0009	0.0018	0.0000	0.0000	0.0000	0.0004	N/A
Rich	49033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Salt Lake	49035	578.3	60.31	2.635	2.491	3.056	19.87	N/A
San Juan	49037	0.2306	0.0324	0.0005	0.0005	0.0010	0.0108	N/A
Sanpete	49039	0.0281	0.0047	0.0001	0.0001	0.0001	0.0015	N/A
Sevier	49041	0.1687	0.0324	0.0004	0.0004	0.0007	0.0100	N/A
Summit	49043	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	N/A
Tooele	49045	3.351	0.4686	0.0124	0.0119	0.0161	0.1468	N/A
Uintah	49047	2.831	0.2619	0.0103	0.0103	0.0128	0.0949	N/A
Utah	49049	4.475	0.6662	0.0191	0.0186	0.0209	0.2057	N/A
Wasatch	49051	1.449	0.1467	0.0034	0.0034	0.0061	0.0539	N/A
Washington	49053	7.417	0.7908	0.0279	0.0257	0.0368	0.2720	N/A
Wayne	49055	0.0652	0.0102	0.0001	0.0001	0.0003	0.0033	N/A
Weber	49057	4.067	0.4679	0.0112	0.0111	0.0174	0.1616	N/A
		617.3	**64.76**	**2.757**	**2.608**	**3.228**	**21.38**	**N/A**

The aircraft model does not produce ground support equipment emissions.

Jan 2035 Diesel Locomotive Emissions
Tons per Year

County	FIPs	CO	NOx	PM10	PM2.5	SO2	VOC	NH3
Beaver	49001	55.82	77.57	1.468	1.423	0.1969	2.870	0.1746
Box Elder	49003	136.6	189.8	3.592	3.484	0.4818	7.024	0.4274
Cache	49005	7.103	9.871	0.1867	0.1811	0.0251	0.3652	0.0222
Carbon	49007	24.88	34.24	0.6372	0.6181	0.0878	1.226	0.0779
Daggett	49009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Davis	49011	116.60	180.24	3.556	3.450	0.4091	6.865	0.3629
Duchesne	49013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Emery	49015	22.96	31.40	0.5782	0.5609	0.0810	1.100	0.0718
Garfield	49017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Grand	49019	32.69	44.74	0.8245	0.7998	0.1153	1.570	0.1023
Iron	49021	72.68	101.0	1.911	1.854	0.2563	3.737	0.2274
Juab	49023	65.31	90.76	1.717	1.666	0.2303	3.358	0.2043
Kane	49025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Millard	49027	225.6	313.5	5.932	5.754	0.7957	11.60	0.7059
Morgan	49029	59.54	82.74	1.565	1.518	0.2100	3.061	0.1863
Piute	49031	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Rich	49033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Salt Lake	49035	278.77	671.24	13.494	13.089	0.9498	33.908	0.8485
San Juan	49037	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sanpete	49039	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sevier	49041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Summit	49043	102.1	141.8	2.683	2.603	0.3600	5.248	0.3193
Tooele	49045	150.4	208.0	3.902	3.785	0.5305	7.567	0.4706
Uintah	49047	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Utah	49049	137.87	253.86	5.040	4.889	0.4799	10.971	0.4258
Wasatch	49051	1.703	2.342	0.0435	0.0422	0.0060	0.0836	0.0053
Washington	49053	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wayne	49055	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Weber	49057	113.85	221.62	4.369	4.238	0.3955	10.243	0.3509
SUM		**1,604**	**2,655**	**51.50**	**49.95**	**5.611**	**110.8**	**4.984**

Jan 2035 Total Non-road Mobile Sources
Tons per Year

County	FIPs	CO	NOx	PM10	PM2.5	SO2	VOC	NH3
Beaver	49001	216.7	83.46	2.193	2.101	0.2745	13.59	0.1983
Box Elder	49003	2,237	359.1	12.27	11.76	1.157	148.7	0.8717
Cache	49005	3,338	200.8	16.67	15.75	1.644	266.4	0.7256
Carbon	49007	931.1	162.4	12.31	11.80	0.4705	102.5	0.3017
Daggett	49009	119.8	6.041	0.9146	0.8451	0.0343	27.58	0.0229
Davis	49011	6,737	566.7	39.90	34.11	4.976	460.8	1.765
Duchesne	49013	651.5	27.60	2.099	1.965	0.1688	40.14	0.1131
Emery	49015	357.5	122.2	8.512	8.198	0.3461	50.86	0.2159
Garfield	49017	231.9	14.47	1.273	1.194	0.1561	24.33	0.0663
Grand	49019	639.8	73.56	2.755	2.621	0.9164	35.01	0.2088
Iron	49021	1,018	165.2	7.518	7.188	2.197	84.19	0.4666
Juab	49023	454.7	111.6	3.295	3.144	0.3428	33.57	0.2917
Kane	49025	250.6	15.93	0.8573	0.8052	0.0821	19.72	0.0514
Millard	49027	689.7	344.8	7.199	6.954	0.9181	39.93	0.7945
Morgan	49029	314.8	94.00	2.260	2.177	0.2944	12.36	0.2317
Piute	49031	48.28	2.587	0.3601	0.3334	0.0152	10.31	0.0099
Rich	49033	547.2	25.89	5.429	5.002	0.0560	134.6	0.1085
Salt Lake	49035	40,452	3,616	198.5	187.0	176.4	2,752	6.445
San Juan	49037	399.9	18.76	1.331	1.247	0.1528	28.02	0.0568
Sanpete	49039	498.2	28.11	3.196	2.974	0.0953	76.97	0.1053
Sevier	49041	753.1	115.5	11.18	10.70	0.3248	68.18	0.2085
Summit	49043	1,729	226.2	14.04	13.13	0.6291	258.9	0.7114
Tooele	49045	1,684	283.3	10.86	10.16	2.474	78.18	0.6845
Uintah	49047	2,036	104.7	6.547	6.209	0.7856	105.6	0.4469
Utah	49049	10,373	781.6	56.50	53.11	4.720	732.4	2.498
Wasatch	49051	970.2	56.56	7.739	7.181	0.5677	199.0	0.2485
Washington	49053	4,276	187.1	23.33	21.77	2.643	330.1	0.8463
Wayne	49055	99.21	3.579	0.5514	0.5140	0.0490	7.736	0.0152
Weber	49057	6,374	524.1	34.39	32.39	2.792	495.9	1.452
SUM		**88,428**	**8,322**	**494.0**	**462.3**	**205.7**	**6,638**	**20.16**

B. MOVES2014b Model: Changes to Underlying Database for Snowmobiles

The following files in the MOVES2014b database were changed, as discussed in the body of the report:

1. File Name: “nrstatesurrogate”

Counts show the relative numbers of snowmobiles by county.

Surrogate ID	County ID	Surrogate Year ID	Original Count	Revised Count	
14	49000	2002	1,891	1,891	UT
14	49001	2002	0	0	Beaver
14	49003	2002	0	0	Box Elder
14	49005	2002	10	226	Cache
14	49007	2002	0	96	Carbon
14	49009	2002	0	48	Daggett
14	49011	2002	0	0	Davis
14	49013	2002	67	16	Duchesne
14	49015	2002	0	55	Emery
14	49017	2002	217	19	Garfield
14	49019	2002	0	0	Grand
14	49021	2002	0	64	Iron
14	49023	2002	0	24	Juab
14	49025	2002	0	0	Kane
14	49027	2002	0	0	Millard
14	49029	2002	135	0	Morgan
14	49031	2002	724	18	Piute
14	49033	2002	512	226	Rich
14	49035	2002	0	0	Salt Lake
14	49037	2002	0	0	San Juan
14	49039	2002	43	100	Sanpete
14	49041	2002	52	18	Sevier
14	49043	2002	31	330	Summit
14	49045	2002	0	0	Tooele
14	49047	2002	38	48	Uintah
14	49049	2002	3	29	Utah
14	49051	2002	59	349	Wasatch
14	49053	2002	0	0	Washington
14	49055	2002	0	0	Wayne
14	49057	2002	0	226	Weber

2. File Name: “nrbaseyearequippopulation”

Based on estimated snowmobile counts obtained from the Utah Tax Commission for calendar year 1990, the populations of snowmobiles were adjusted upwards as follows:

FIPS	Year	Source Type ID	Equipment Description	HP Min	HP Max	Original Population	Revised Population
49000	1990	1002	2-Str Snowm	1	3	87.54	161.3
49000	1990	1003	2-Str Snowm	3	6	51.64	95.15

49000	1990	1004	2-Str Snowm	11	16	55.45	95.15
49000	1990	1005	2-Str Snowm	16	25	4,419.	8,142.
49000	1990	1006	2-Str Snowm	25	40	4,461.	8,218.
49000	1990	1007	2-Str Snowm	40	50	2,002.	3,689.
49000	1990	1008	2-Str Snowm	50	75	7,053.	12,995.
49000	1990	1009	2-Str Snowm	75	100	2,899.	5,341.
49000	1990	1010	2-Str Snowm	100	175	755.2	1,391.
SUM						21,784.	40.135.

3. File Name: nrgrowthindex

The 1990 base year population of snowmobiles in Utah was changed. Therefore, snowmobile growth factors in future years were also changed.

However, data from Utah Tax Commission showed snowmobile counts actually decreased over calendar years 2005 through 2018. Therefore, growth factors also decrease over calendar years as follows:

Note that the growth index values are the same for each growth pattern ID from 1002 – 1010 because Utah does not have snowmobile counts by HP class.

Snowmobile Indicator Codes: 1002 - 1010
SCC: 226001020
Type: 2-Stroke Snowmobile

By trial and error, we found that, if the above growth index values are changed, the INPUT and OUTPUT populations of snowmobiles do not agree. In fact, the output populations are 3 to 8 or times higher than the input populations.

To fix this problem, staff reviewed related tables in the MOVES2014b default database.

The table “nrgrowthpatternfinder” gives a clue as to what might be going on inside the model. The SCC for snowmobiles is not included, but a “generic” SCC is found, which is 2260-001-1000. For stateID = 49, the growthPatternID = 2402.

When we adjusted the nrgrowthindex values for the growth pattern IDs 1002 – 1010 AND for 2402, then input and output snowmobile populations agreed.

Thus the nrgrowthindex values were adjusted for growth pattern ID = 2402 such that the complete set of nrgrowthindex values are as shown below:

growthPatternID	yearID	growthIndex	n	NEW values →	growthPatternID	yearID	growthIndex
1002 - 1010	1990	1000	40,135		2402	1990	861.0
1002 - 1010	1999	1083	33,913		2402	1999	727.5
1002 - 1010	2000	1093	33,222		2402	2000	712.7
1002 - 1010	2001	1101	32,531		2402	2001	697.9
1002 - 1010	2002	1108	31,839		2402	2002	683.0
1002 - 1010	2003	1114	31,148		2402	2003	668.2
1002 - 1010	2004	1121	30,457		2402	2004	653.4
1002 - 1010	2005	1127	29,765		2402	2005	638.5
1002 - 1010	2006	1135	29,074		2402	2006	623.7
1002 - 1010	2007	1141	28,383		2402	2007	608.9
1002 - 1010	2008	1147	27,691		2402	2008	594.1
1002 - 1010	2009	1153	27,000		2402	2009	579.2
1002 - 1010	2010	1158	26,309		2402	2010	564.4
1002 - 1010	2011	1164	25,618		2402	2011	549.6
1002 - 1010	2012	1169	24,926		2402	2012	534.7
1002 - 1010	2013	1175	24,235		2402	2013	519.9
1002 - 1010	2014	1180	23,544		2402	2014	505.1
1002 - 1010	2015	1187	22,852		2402	2015	490.2
1002 - 1010	2016	1194	22,161		2402	2016	475.4
1002 - 1010	2017	1201	21,470		2402	2017	460.6
1002 - 1010	2018	1208	20,778		2402	2018	445.8
1002 - 1010	2019	1215	20,087		2402	2019	430.9
1002 - 1010	2020	1222	19,396		2402	2020	416.1
1002 - 1010	2021	1228	18,704		2402	2021	401.3
1002 - 1010	2022	1234	18,013		2402	2022	386.4
1002 - 1010	2023	1240	17,322		2402	2023	371.6
1002 - 1010	2024	1246	16,631		2402	2024	356.8
1002 - 1010	2025	1252	15,939		2402	2025	341.9
1002 - 1010	2026	1259	15,248		2402	2026	327.1
1002 - 1010	2027	1265	14,557		2402	2027	312.3
1002 - 1010	2028	1271	13,865		2402	2028	297.4
1002 - 1010	2029	1278	13,174		2402	2029	282.6
1002 - 1010	2030	1284	12,483		2402	2030	267.8
1002 - 1010	2031	1289	11,791		2402	2031	253.0
1002 - 1010	2032	1293	11,100		2402	2032	238.1
1002 - 1010	2033	1297	10,409		2402	2033	223.3
1002 - 1010	2034	1301	9,718		2402	2034	208.5
1002 - 1010	2035	1305	9,026		2402	2035	193.6
1002 - 1010	2036	1310	8,335		2402	2036	178.8

1002 - 1010	2037	1314	7,644
1002 - 1010	2038	1318	6,952
1002 - 1010	2039	1323	6,261
1002 - 1010	2040	1327	5,570

2402	2037	164.0
2402	2038	149.1
2402	2039	134.3
2402	2040	119.5

UT Tax Commission--Statewide Snowmobile Counts

6/11/2019

2005	28,248
2006	28,222
2007	29,241
2008	30,782
2009	28,768
2010	26,294
2011	26,167
2012	22,144
2013	23,184
2014	20,993
2015	21,747
2016	23,603
2017	24,015
2018	20,398

The oldest year in the UT Tax Comm db for SNO is 2005.

Procedure

For MOVES, we need base year (1990) estimate.

SLOPE	-691.301
INTERCEPT	1415824
CORREL	-0.8493

Predicted Pop from L.R.

1990	40,135
1991	39,444
1992	38,752

Motor Vehicle Stats\Registrations: 1990s and 2000s\2005\
Utah Vehicle Registrations Classified by County\

https://tax.utah.gov/econstats/mv/registrations

Home Page UT Tax Commission	https://tax.utah.gov/
GO TO Box "Useful Info"	https://tax.utah.gov/info
Click on "Economics & Statistics"	https://tax.utah.gov/econstats
Click on "Motor Vehicle Statistics"	

Click on "Vehicle Registrations" and choose year.
Open EXCEL workbook and move right through tabs to Off-road registrations.

1993	38,061
1994	37,370
1995	36,678
1996	35,987
1997	35,296
1998	34,604
1999	33,913
2000	33,222
2001	32,531
2002	31,839
2003	31,148
2004	30,457
2005	29,765
2006	29,074
2007	28,383
2008	27,691
2009	27,000
2010	26,309
2011	25,618
2012	24,926
2013	24,235
2014	23,544
2015	22,852
2016	22,161
2017	21,470
2018	20,778
2019	20,087
2020	19,396
2021	18,704
2022	18,013
2023	17,322
2024	16,631
2025	15,939
2026	15,248
2027	14,557
2028	13,865
2029	13,174
2030	12,483
2031	11,791
2032	11,100
2033	10,409

2034	9,718
2035	9,026
2036	8,335
2037	7,644
2038	6,952
2039	6,261
2040	5,570
2041	4,878
2042	4,187
2043	3,496
2044	2,805
2045	2,113
2046	1,422
2047	731
2048	39
2049	-652
2050	-1,343

4. File Name: nrmonthallocation

In the default file, fractions of annual activity by month were changed for snowmobiles (SCC = 2260001020 as follows:

State	SCC	Equipment Description	Jan	Feb	Mar	Apr	Dec
0	2260001020	Snowmobiles	0.200	0.200	0.200	0.200	0.200

(Fractions for all other months are zero.)

5. File Name: zonemonthhour (see EXCEL workbook, "Jan 2017 MOVES2014b Zone Month Hour.xlsx".

xii. Footnotes

1. University of Utah "MESOWEST" website (http://mesowest.utah.edu/)

2. U.S. Department of Transportation "Transtats" website, http://www.transtats.bts.gov/

Under "Aviation", one chooses "Air Carrier Statistics - Form 41 Traffic - All Carriers", and then "T-100 Domestic Segment—All Carriers". In the lower right-hand corner of the box, click on "Download". At the top of the screen, under "Download Instructions", choose the state, calendar year and month. For this SIP, calendar year and month was January 2017. In addition to the boxes already checked, put a check mark in front of the following parameters:

Aircraft Type
Origin City Name
Destination City Name
Departures Performed

3. Federal Aviation Administration: "Terminal Area Forecast" Db, https://www.faa.gov/data_research/aviation/taf/.

4. McCoy, N., Fujisaki, I., Keith, J., *An Economic and Social Assessment of Snowmobiling in Utah*, January 2001.
http://static.stateparks.utah.gov/plans/snowmobilingassessment.pdf

5. Utah Snowmobile Association, Utah State Parks OHV Program, *2012 Snowmobile User Survey Results*, February 2012.

6. Utah Tax Commission\Utah Division of Motor Vehicles: Snowmobile Counts by Year and County
https://tax.utah.gov/econstats/mv

a. Click on "Registrations – 1990s and 2000s". Data for snowmobiles is available for calendar years 2005 – 2009.

b. Click on "Vehicle Registrations – Recent". Data for snowmobiles is available for calendar years 2010 – 2018. Under a given calendar year, go to the menu item or tab "Off-road Registrations".

7. Federal Aviation Administration, Office of Environment and Energy, "Aviation Emissions and Air Quality Handbook, v. 3, update 1, January 2015, Glossary, Landing and Takeoff (LTO):

> **"Landing and Takeoff (LTO) -**LTO refers to an aircraft's landing and takeoff cycle. One aircraft LTO is equivalent to two aircraft operations (one landing and one takeoff). The standard L TO cycle begins when the aircraft crosses into the mixing zone as it approaches the airport on its descent from cruising altitude, lands and taxis to the gate. The cycle continues as the aircraft taxis back out to the runway for takeoff and climbout as its heads out of the mixing zone and back up to cruising altitude. The five specific operating modes in a standard LTO are: approach, taxi/idle-in, taxi/idle-out, takeoff, and climbout. Most aircraft go through this sequence during a complete standard operating cycle."

https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/airquality_handbook/media/Air_Quality_Handbook_Appendices.pdf

Google search keys: FAA aircraft operations and LTO

Finding: FAA "aviation emissions and air quality handbook"

8. Aircraft Activity Scaling Factors
http://www.faa.gov/data_research/aviation/aerospace_forecasts/
The scaling factors are found in the EXCEL document under the bold heading "FY 2018-2038 Forecast Tables", (choose TOTAL COMBINED OPERATIONS/ Tables 32 – 34).

9. Atmospheric Chemistry and Physics, "Impacts of aircraft emissions on the air quality near the ground", 2013, http://www.atmos-chem-phys.net/13/5505/2013/acp-13-5505-2013.pdf.

10. U.S. EPA, *Emission Factors for Locomotives* (EPA-420-F-09-025), April 2009, https://nepis.epa.gov/Exe/ZyPDF.cgi/P100500B.PDF?Dockey=P100500B.PDF

11. Bergin, Michelle S., "Locomotive Emission Inventories for the United States from ERTAC Rail", 2012, http://www.epa.gov/ttnchie1/conference/ei20/session8/mbergin.pdf (emission factor for ammonia from diesel locomotives).

12. AMTRAK, "2013 AMTRAK Sustainability Report".
https://www.amtrak.com/content/dam/projects/dotcom/english/public/documents/environmental1/2013-Amtrak-Sustainability-Report.pdf

13. National Petroleum Council, "Rail Transportation Demand, Topic Paper #2", Aug 1, 2012.
https://www.npc.org/FTF_Topic_papers/2-Rail_Transportation_Demand.pdf

14. U.S. DOE, Energy Efficiency & Renewable Energy, "Freight Transportation Demand: Energy-Efficient Scenarios for a Low-Carbon Future", Rail Freight Ton-Miles 1980 – 2030, pp. 32 – 33, March 2013.
https://www.nrel.gov/docs/fy13osti/55641.pdf (copy and paste link into browser)

15. U.S. DOT, "National Freight Strategic Plan: DRAFT FOR PUBLIC COMMENT", 2015, https://www.bmwe.org/cms/file/02152016_171655_DOT_NFSP_Public_Comment.pdf

xiii. References

The following documents were used as references in creating the non-road mobile source PM2.5 SIP emissions inventories:

1. Federal Aviation Administration, *Emissions and Dispersion Modeling System (EDMS) User's Manual*, FAA-AEE-07-01, (Rev. 10 – 060713, June 2013),
https://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf

2. U.S. EPA, "MOVES2014a User Guide", EPA-420-B-15-095, November 2015, https://nepis.epa.gov/Exe/ZyPDF.cgi/P100NNCY.PDF?Dockey=P100NNCY.PDF

3. U.S. EPA, "MOVES2014, MOVES2014a and MOVES2014b Technical Guidance: Using

MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity", EPA-420-B-15-093, August 2018, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100V7EY.pdf

4. Western Regional Climate Center, http://www.wrcc.dri.edu/Climsum.html (on map, click on "Utah").

Reports from Railroads

5. AMTRAK 2017.xlsx fuel consumption (Utah), Laura Fotiou, Laura.Fotiou@amtrak.com

6. Rio Tinto (Kennecott Utah Copper) Locomotives (2017), Jenny Esker, Environmental Engineer, Air Quality Permitting & Compliance, Jenny Esker@riotinto.com .

7. Salt Lake Garfield & Western Railway, 2008 fuel consumption, Donald M. Hogle, 801-322-3429.

8. Union Pacific Railroad Company (UPRR), James L. Brannen, Manager Environmental, Sept 14, 2018, 2017 Est Fuel Consumption (Utah), JLBRANNEN@up.com . The report includes fuel consumption from Burlington Northern & Santa Fe Railroad.

9. Utah Railway, "Genesee & Wyoming – Utah Railway 2017 submittal, Greg Feyerabend, Greg.Feyerabend@gwrr.com.

10. Utah Transit Authority, "2017 Front Runner Locomotive Inventory Worksheet", Daniel Locke, DLocke@rideuta.com.

11. U.S. EPA, Federal Register, "Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel", Final Rule, June 29, 2004, https://www.gpo.gov/fdsys/pkg/FR-2004-06-29/pdf/04-11293.pdf.