Uinta Basin Mobile Source Oil & Gas Inventory
for Base Year 2013

May 9, 2014

ABSTRACT

This is the first emissions inventory for non-road mobile sources operating in the oil and gas fields in the Uinta Basin, comprising Duchesne and Uintah Counties.

The base year for this inventory is 2013.

ENVIRON International Corporation developed a methodology to estimate non-road mobile source emissions from oil and gas activity that can be applied to any area. The method was originally developed for the oil and gas fields in the Piceance Basin, Colorado.

Emissions from the non-road mobile sector for oil and gas activity come from two main groups: VMT-based traffic from light- and heavy-duty trucks, and non-road diesel working equipment. The majority of emissions come from the latter group.

Exceedances of the 8-hour ozone NAAQS have been recorded during January and February 2010, 2013 and 2014 in these counties. Surrounding counties have not recorded such wintertime exceedances.

UDAQ estimates that the non-road mobile sector comprises about 10% of the total oil and gas inventory. The exception to this is that PM10 and PM2.5 fugitive dust from paved and unpaved roads in the oil and gas fields contribute over 99% of PM from all oil and gas sources in the Basin.

ACKNOWLEDGEMENTS

The author wishes to thank staff at ENVIRON International Corporation (Novato, CA office) for their assistance in explaining details of their methodology report "Oil and Gas Mobile Sources Pilot Study" (Final, July 2011) for the Piceance Oil and Gas Basin, Colorado. Without their assistance, this inventory could never have been completed.

In particular, thanks to Amnon Bar-Ilan and John Grant for their assistance and interpretation of the methodology in their report through discussions by phone and via e-mail. Thanks also to the co-authors of the ENVIRON report, Rajashi Parikh and Ralph Morris.

Finally, thanks to staff at the Utah Division of Oil, Gas and Mining—in particular, Don Staley and Vicky Dyson for their assistance in data retrieval; and Colorado Department of Health and Environment, Air Pollution Control Division (Dale Wells) for his assistance in discussions on methodology development.

May 6, 2014

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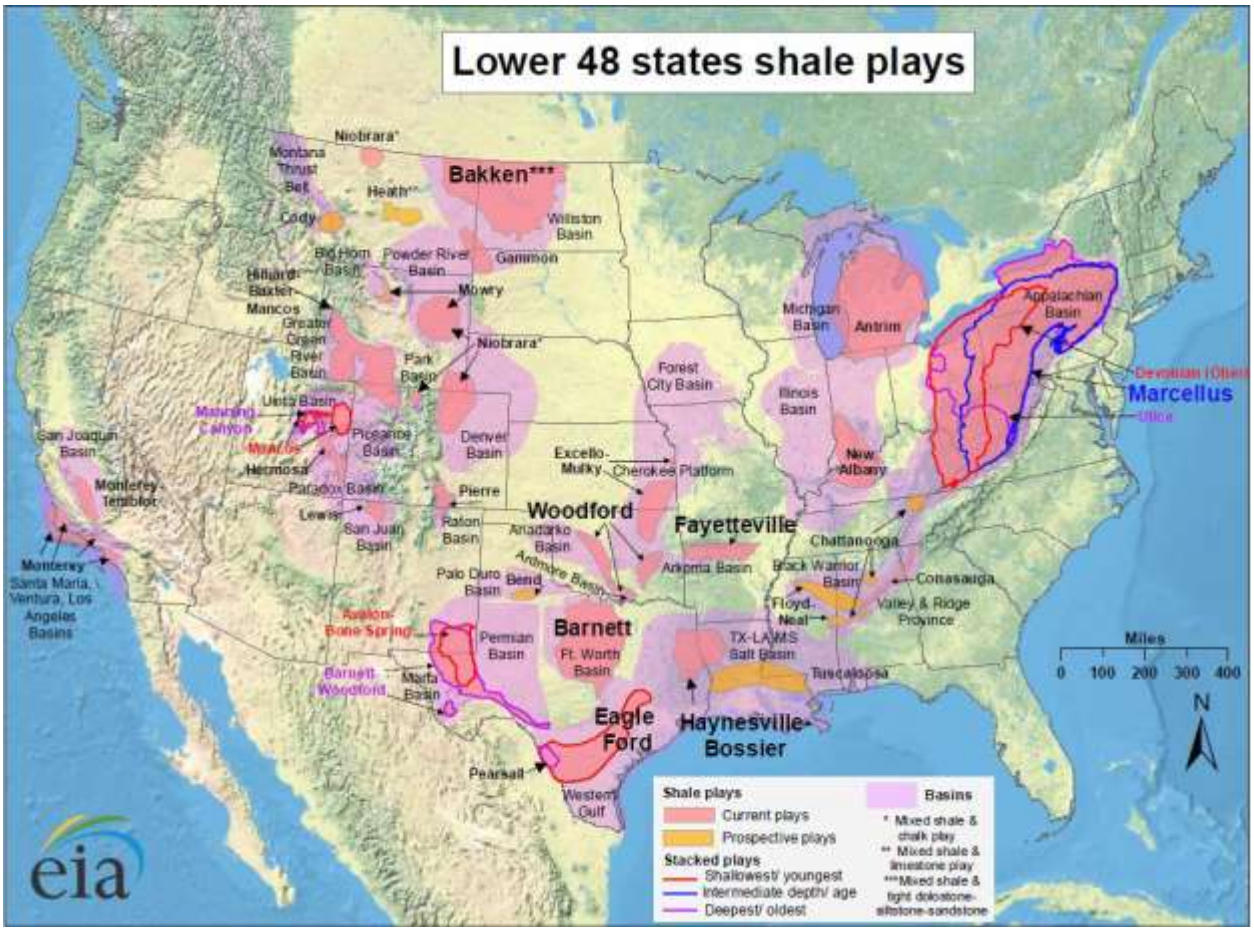

The map shows the major oil and gas fields in the U.S. (1)

Executive Summary

The Uinta Basin (Duchesne and Uintah Counties) have exceeded the eight-hour ozone NAAQS numerous times during January and February 2010, 2013 and 2014.

To date, no emission inventory of non-road mobile source equipment used in the Uinta Basin oil and gas fields has been created.

This report, prepared by the Utah Division of Air Quality (UDAQ), discusses a new emission inventory from non-road mobile sources (vehicles and non-road diesel equipment) used in the Uinta Basin oil and gas fields. The inventory covers Duchesne and Uintah Counties.

The base year for this inventory is 2013.

This inventory includes emissions from non-road mobile source equipment used in oil and natural gas extraction and production. Coal bed methane (CBM) activity is not included in this inventory, nor is condensate. Coal bed methane is primarily extracted in south-central Carbon County and northwest Emery County. (2)

New "unconventional fuels" such as oil shale and tar sands have not been mined to date. However, on April 11, 2014, the Utah Division of Water Quality issued its first permit to allow extraction of oil from oil shale in the Uinta Basin. Red Leaf Resources said it expects mining operations to begin in the spring [2014]. (3)

This inventory does not discuss emissions from new unconventional sources (oil shale and tar sands).

A summary of non-road mobile source emissions from oil and gas activity in the Uinta Basin is shown below:

SUMMARY OF NON-ROAD MOBILE SOURCE EMISSIONS FROM OIL AND GAS ACTIVITY IN UINTA BASIN

COMBINED DUCHESNE AND UINTAH COUNTIES
TONS PER YEAR

Cal Year	Counties	CO	NOx	PM10 Exh	PM10 Brake	PM10 Tire	PM10 Fug Dust Paved Roads	PM10 Fug Dust Unpaved Roads	
2013	DU + UI								
		493.3	1,148.	69.08	1.217	0.1985	3,390.9	6,171.5	
Cal Year	Counties	PM2.5 Exh	PM2.5 Brake	PM2.5 Tire	PM2.5 Fug Dust Paved Roads	PM2.5 Fug Dust Unpaved Roads	SOx	VOC Exh	VOC Evap
2013	DU + UI								
		67.00	0.3184	0.0475	793.3	1,451.2	21.01	90.88	2.123

About 75.4% of the Utah total of oil and gas production in calendar year 2012 came from Duchesne and Uintah Counties, according to the Utah Division of Oil, Gas and Mining. (4,5)

Future inventories might expand the area of coverage to include nearby counties such as Carbon, Grand and San Juan.

The methodology to create this inventory was reported in "Oil and Gas Mobile Sources Pilot Study" by ENVIRON International Corporation, July 2011. The ENVIRON report discusses non-road mobile source emissions from oil and gas activity in the Piceance Basin in northwest Colorado. (2)

The non-road mobile source inventory consists of two parts:

VMT-based activity; and
Non-road diesel equipment activity

The non-road mobile source inventory is based on a very general method that involves two main parameters:

1) count of active wells, regardless of the date of well construction; and
2) count of "spuds" (drilling events) that took place during the base year.

Emissions in the above report are grouped by activity. For each activity, emission factors for the various pollutants are given, in units of pounds (lbs) pollutant per well or spud. A "spud" is a drilling event.

Examples of some activities and emission factors are shown below:

Activity	NOX Emissions (lb/activity)
Pipeline Construction Traffic	0.15 (lb per spud)
Well Completion Traffic	51.67 (lb per spud)
Production Traffic	1.65 (lb per well)
Maintenance Operation Eq. (diesel non-road equipment)	31.60 (lb per well)

Baseline Inventory

The method used creates an inventory with units of tons per year in 2013. The Technical Analysis section will use the SMOKE pre-processor to perform a temporal allocation on the annual inventory to convert it to a winter weekday or winter weekend day inventory.

The inventory in units of tons per year is as follows:

NON-ROAD MOBILE SOURCE INVENTORY FROM OIL AND GAS ACTIVITY
(Uinta Basin—Includes Duchesne and Uintah Counties only)

BY-COUNTY SUMMARY OF NON-ROAD MOBILE SOURCE EMISSIONS FROM OIL AND GAS ACTIVITY IN UINTA BASIN

DUCHESNE COUNTY
TONS PER YEAR

Cal Year 2013	County	CO	NOx	PM10 Exh	PM10 Brake	PM10 Tire	PM10 Fug Dust Paved Roads	PM10 Fug Dust Unpaved Roads	
	Duchesne	151.0	356.4	21.11	0.4036	0.0646	983.1	1,790.7	
Cal Year 2013	County	PM2.5 Exh	PM2.5 Brake	PM2.5 Tire	PM2.5 Fug Dust Paved Roads	PM2.5 Fug Dust Unpaved Roads	SOx	VOC Exh	VOC Evap
	Duchesne	20.48	0.1056	0.0155	229.2	419.4	6.480	27.91	0.6722

UINTAH COUNTY
TONS PER YEAR

Cal Year 2013	County	CO	NOX	PM10 Exh	PM10 Brake	PM10 Tire	PM10 Fug Dust Paved Roads	PM10 Fug Dust Unpaved Roads	
	Uintah	342.3	791.4	47.97	0.8133	0.1339	2,407.8	4,380.8	
Cal Year 2013	County	PM2.5 Exh	PM2.5 Brake	PM2.5 Tire	PM2.5 Fug Dust Paved Roads	PM2.5 Fug Dust Unpaved Roads	SOx	VOC Exh	VOC Evap
2013	Uintah	46.53	0.2128	0.0320	564.1	1,031.7	14.53	62.97	1.451

This inventory should be considered a first estimate of emissions. As more tools and data become available, the accuracy of the inventory may be improved. In addition, the domain may be expanded to include nearby counties where exceedances of the 8-hour ozone and/or the 24-hour PM2.5 NAAQS occur.

Lastly, this inventory *adds to* the non-road mobile source inventories developed for SIP work and the statewide National Emissions Inventory (NEI). Non-road SIP and NEI inventories developed to date use the EPA NONROAD model. The NONROAD model includes only miscellaneous oil and gas equipment, and does not include the vehicles and equipment found in this oil and gas inventory.

Introduction

Oil and gas activity in the "Uinta Basin", which may include other petroleum products such as coal bed methane and condensate (liquid hydrocarbon byproducts from gas wells), has been expanding rapidly since 2000.

The charts below show how oil and gas production have increased since 1970. Data for years 1970 through 2007 are historical. For years 2008 to 2012, data was projected. (7)

DUCHESNE COUNTY

Gas Production – Gas production in Duchesne County has been plotted for the years 1970 – 2007 below in Figure 12, including projections to 2012.

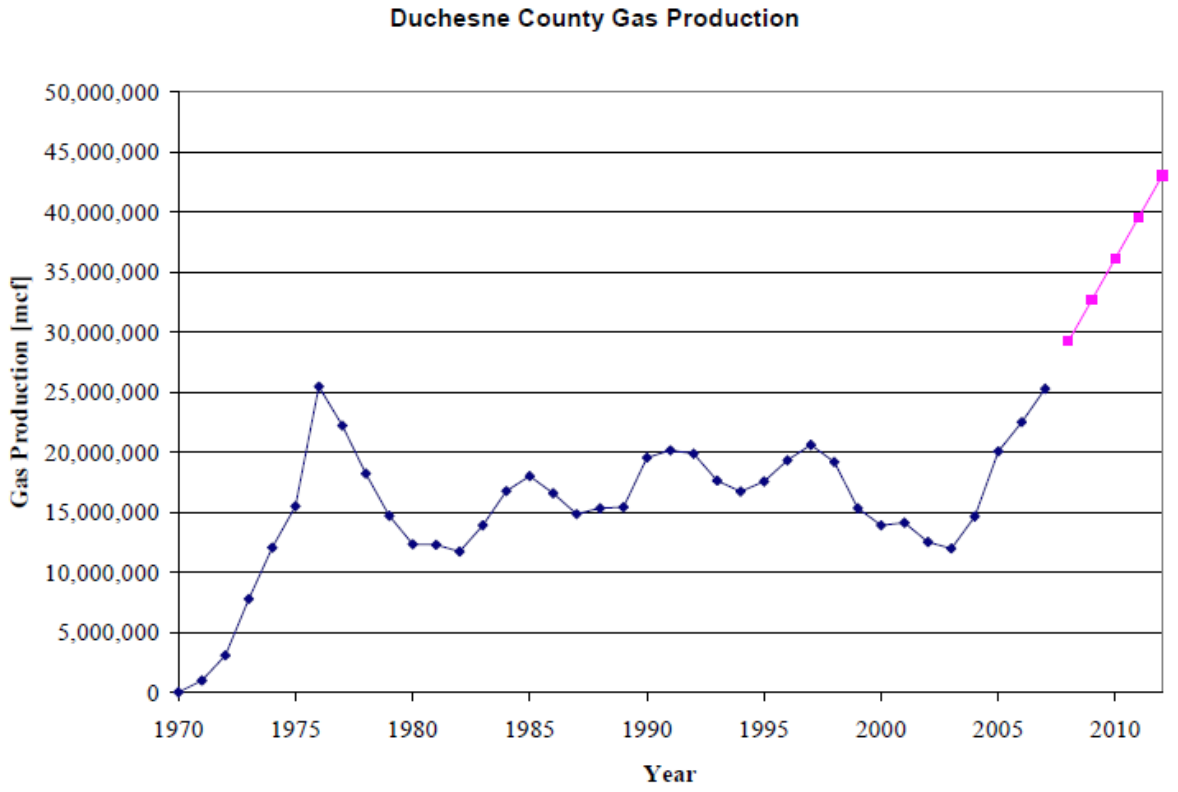

Figure 12. Gas production historical data (from the IHS database) for Duchesne County and projections to 2012. [11]

Oil Production – Oil production in Duchesne County has been plotted for the years 1970 – 2007 below in Figure 14 including projections to 2012.

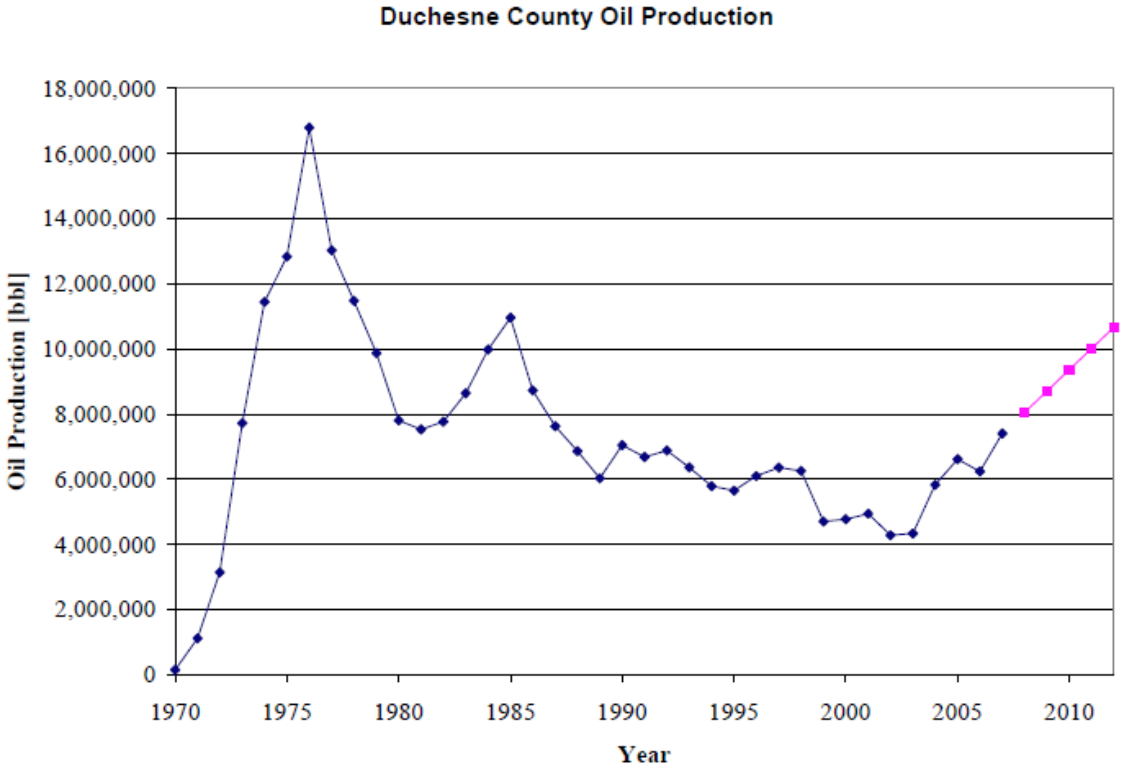

Figure 14. Oil production historical data (from the IHS database) for Duchesne County and projections to 2012. [13]

UINTAH COUNTY

Total Gas Production – Conventional gas production in Uintah County has been plotted for the years 1970 – 2007 below in Figure 30, including projections to 2012. As noted above, CBM gas production in Uintah County is negligible and was assumed to be conventional gas production for purposes of this analysis.

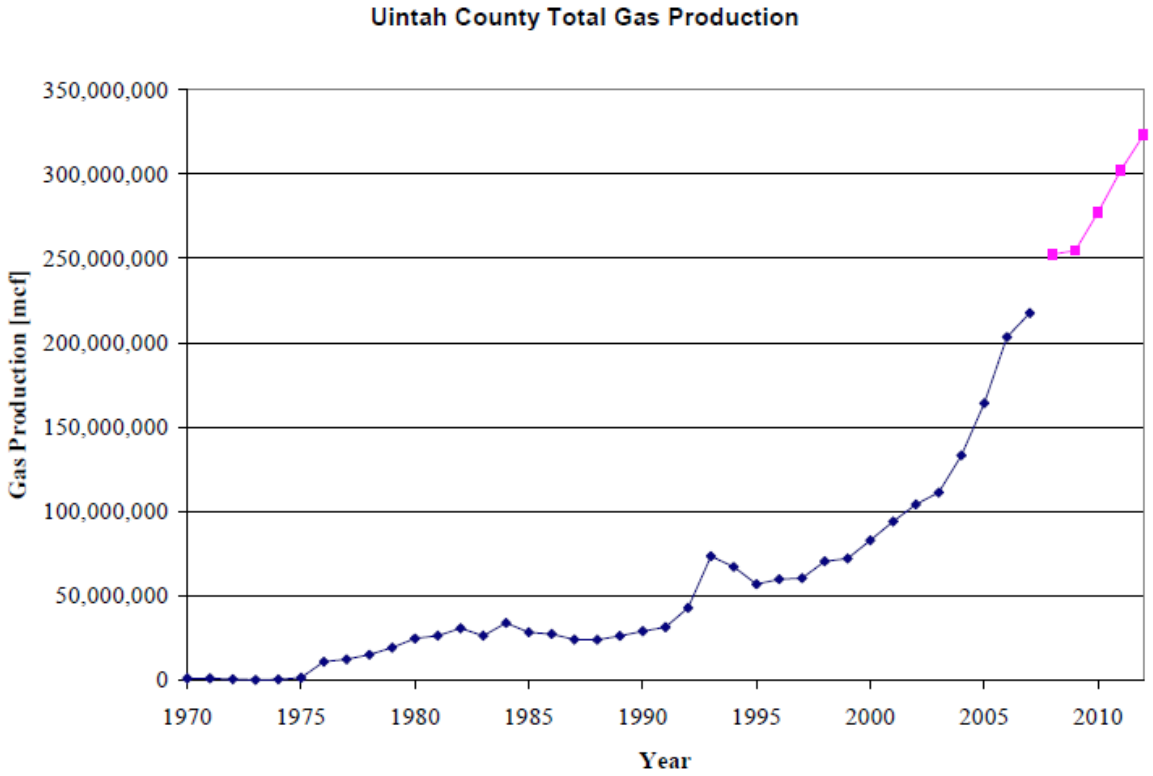

Figure 30. Total gas production historical data (from the IHS database) for Uintah County and projections to 2012.[29]

Oil Production – Oil production in Uintah County has been plotted for the years 1970 – 2006 below in Figure 33, including projections to 2012.

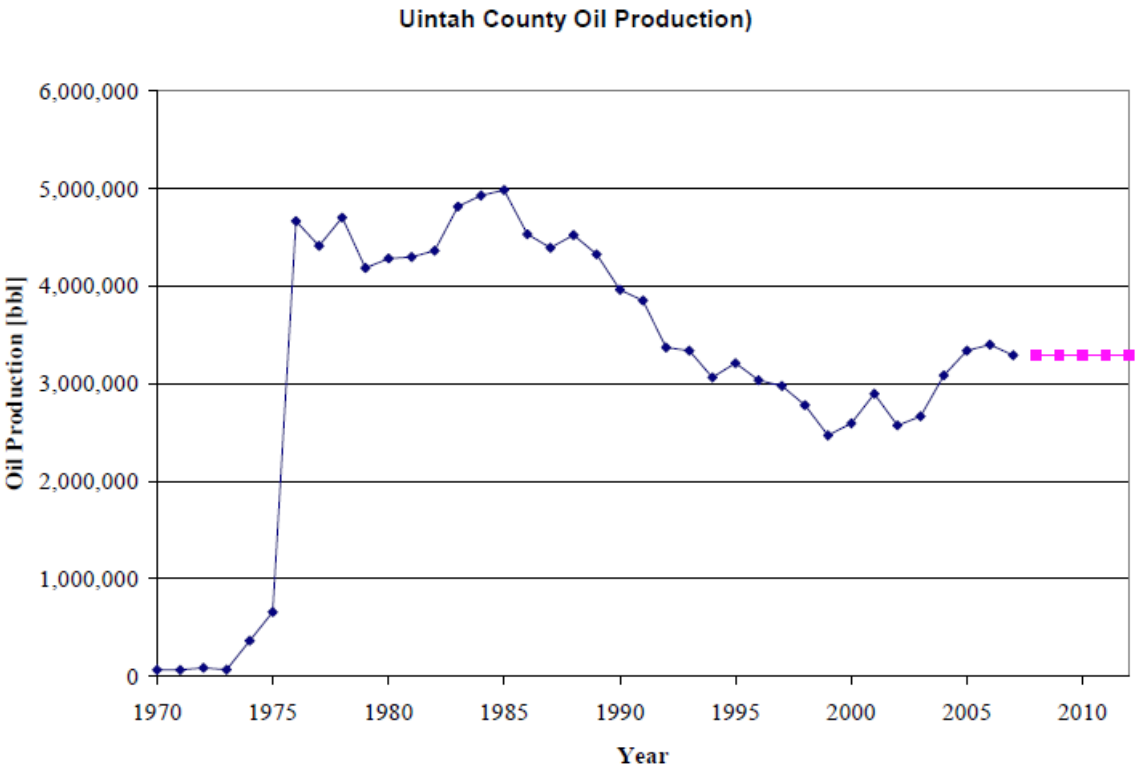

Figure 33. Oil production historical data (from the IHS database) for Uintah County and projections to 2012. [31]

Production data is in good agreement between the Division of Oil, Gas and Mining and the Utah Geological Survey.

Production of oil and gas in the Uinta Basin current to 2010 are as follows:

County	Calendar Year	Oil (4) (bbls/year)	Natural Gas (4) (ft3/year)
Duchesne	2010	11,000,000	33 billion
Uintah	2010	6,619,000	283 billion

As a check, oil and gas production in 2010 was reported in a 2011 document authored by the UT Department of Natural Resources, Utah Geological Survey (Mike D. Vanden Berg) as:

County	Calendar Year	Oil (6) (bbls/Year)	Natural Gas (6) (ft3/Year)
Duchesne	2010	10,911,000	33 billion
Uintah	2010	6,610,000	283 billion

Expansion of the oil and gas industry has brought a large increase in truck traffic and operation of non-road diesel equipment in the oil and gas fields, privately-owned paved and unpaved roads, and on nearby public roads. (8,9,10)

Winter Ozone Data

The Uinta Basin experienced high 8-hour ozone readings during January – March 2010 at the monitors in Ouray and Redwash. (10) During January and February 2013, monitors in Duchesne, Roosevelt and Vernal each showed numerous exceedances of the 8-hour ozone NAAQS.

The Air Monitoring Center website does not show any exceedances of the 8-hour ozone NAAQS in Duchesne and Uintah Counties during the months of January and February in 2011 and 2012. (11)

Ozone data for January and February 2014 has not been quality-assured to date. (11)

If ozone exceedances are recorded in nearby areas, the inventory domain may be expanded to include Carbon, Grand, San Juan and possibly other counties.

Oil and Gas Mobile Source Inventory as Share of Total Oil and Gas Inventory

The ENVIRON report on the Piceance Basin, Colorado estimates that, although small compared to the point and area source oil and gas inventories, the non-road mobile source inventory contributes about 10% of the total emissions inventory for oil and gas. We expect a similar contribution to the total oil and gas inventory in the Uinta Basin from non-road mobile sources. (2)

One large component of the non-road mobile source oil and gas inventory is PM10 and PM2.5 fugitive dust from activity on paved and unpaved roads. Thus non-road mobile sources are expected to constitute the majority of PM10 and PM2.5 emissions if fugitive dust is included. (2)

Non-road Mobile Sources in the Oil and Gas Industry

The non-road mobile source inventory for oil and gas activity is different from a typical non-road mobile source inventory, such as one prepared for the PM2.5 SIP or the triennial statewide inventory (National Emissions Inventory, or NEI).

The non-road mobile source inventory for oil and gas (NR O&G) is distinct from the point, area or non-point, and on-road mobile source inventory.

The NR O&G inventory consists of all mobile activity in the oil and gas fields per se. There are two parts to this NR inventory:

VMT-Based Activity: This part of the inventory is comprised of emissions from light- and heavy-duty diesel and gasoline trucks traveling on paved and unpaved roads in the oil and gas fields per se. These roads are NOT included in an on-road mobile source inventory, where VMT comes from the Federal Highway Administration (FHWA) or UDOT Highway Performance Monitoring System (HPMS) or from travel demand models operated by Metropolitan Planning Organizations (MPOs).

In other words, vehicle traffic on paved and unpaved roads located in the oil and gas fields *per se* are included in this inventory. Traffic on paved roads open to the public are NOT included in this inventory, because emissions from such roads have already been captured in the on-road inventory using the EPA MOVES2010a emissions model.

Non-road Diesel Equipment Activity This part of the inventory is comprised of mostly heavy-duty diesel working equipment (for example, backhoes, cranes, graders, etc.) that carry out operations involved in preparation, drilling, fracking and maintenance of oil and gas wells.

The non-road inventory does not include emissions from stationary or more-or-less stationary sources and equipment, such as those reported in area source inventories from many states with oil and gas fields. Some of the equipment that is NOT reported under non-road mobile includes:

Compressor Engines
Condensate Tanks
Dehydrators
Drilling Rigs
Heaters
Loaders (to transfer, load and/or transport products)
Oil Tanks
Pneumatic Devices

Care has been taken to compare vehicles and equipment in the non-road inventory with those in the other sectors of the inventory (point, area or non-point and on-road mobile sources) to insure that no double-counting has occurred.

Methodology

Emissions from non-road diesel equipment is typically estimated using variables such as engine horsepower (hp), hours of operation (hr), load factor of engine (LF), and emission factors in units of grams per horsepower-hour (gm/hp-hr). (13) However, UDAQ does not have staff time to survey actual equipment operating in the Basin.

The NR O&G inventory cannot be computed using the EPA NONROAD model. The EPA NONROAD model does not include oil and gas as a source category.

Instead, UDAQ performed a literature search to find reports about methodologies that might be used to estimate the inventory.

An on-line literature search to find a useable methodology to estimate mobile source emissions from the oil and gas industry found there is extremely limited information available.

ENVIRON International Corporation created a methodology to estimate the non-road mobile source oil and gas emissions inventory. The method can be applied to any oil and gas basin so long as the following data sets are available:

Number of active wells in the study area, regardless of when well became active; and
Number of spuds ("drilling events") that took place in the study area during the base year.

The ENVIRON report that outlines the methodology is "Oil and Gas Mobile Pilot Study, Final Report" [for the Piceance Basin, Colorado], dated July 2011. (2) UDAQ used the methodology outlined in the ENVIRON report to estimate the inventory.

In addition, staff found incomplete discussions of methodologies drafted by state air quality staff in Colorado, Texas, Utah and Wyoming, and from the Bureau of Land Management (Utah State Office) and the Western Regional Air Partnership (WRAP) "Emissions" website at http://www.wrapair2.org/emissions.aspx. (12)

Typical non-road vehicles and equipment used in O & G activity are discussed in detail in an inventory for the Eagle Ford Oil and Gas Basin in southeast Texas. This document also discusses other major oil and gas fields in the U.S., including the Marcellus shale gas field in western New York, eastern Ohio, Pennsylvania and West Virginia. However, this report does not provide a complete methodology to estimate mobile source emissions from oil and gas activity. (12)

Pollutants

The inventory includes emissions and emission factors (EF) for CO, NOx, PM10, PM2.5 and SOx. In addition, emissions of subcomponents are estimated:

VOC exhaust and evaporatives
PM10 and PM2.5 exhaust, brake wear, tire wear, fugitive dust (from paved and unpaved roads)

As mentioned above, an estimate of the non-road inventory can be created if one knows the number of spuds drilling in the study area during the base year or period, and the number of active wells in the study area, regardless of when the well was completed.

A "spud" is a well-drilling event. The surrogate "spuds drilled in current year" are spuds drilled during calendar year 2012 because the episode days for the inventory begin on January 1, 2013. Only those spuds (wells drilled) in calendar year 2012 are included in the spud surrogate count.

The surrogate "total well count" includes all active and producing wells regardless of the year that well began production. All these types of wells generate mobile source traffic or activity. Active and/or producing well types in the Uintah Basin include:

Active gas injection well
Active test well
Active water disposal well
Active water injection well
Producing gas well
Producing oil well
Shut-in gas well

Well types NOT counted for emissions include:

Gas or oil well with approved permit but not yet drilled ("spudded")
Well with drilling operations suspended
Well with drilling location abandoned
Well with new permit but not yet approved

Plugged and/or abandoned well
Returned APD (unapproved, no permit issued)
Well with drilling commenced but not yet completed
Temporarily abandoned well

UDAQ consulted with the UT Division of Oil, Gas and Mining (OGM) to determine which well types should be considered active. The inclusion of certain well types is somewhat arbitrary. The recommendation of OGM was that "shut-in" wells should be included. These are closed for only a few days a year. "Temporarily abandoned wells" should not be counted, because these are shut down for extended periods.

Well and Spud (Drilling Event) Counts

Active well and spud (drilling event) counts were obtained current to January 1, 2013 from the Utah Department of Natural Resources, Division of Oil, Gas and Mining website. (4) Well and spud counts for Duchesne and Uintah Counties are shown below:

Number of Active Wells in Uinta Basin During Base Year

County	FIPs	Number of Active Wells Current to Jan 1, 2013	Number of Shut-In Wells Current to Jan, 1, 2013	Total Number of Wells
Duchesne	49013	2,841	256	3,097
Uintah	49047	7,055	599	7,654
SUM		9,886	855	10,751

Number of Spuds (Drilling Events) in Calendar Year 2012

County	FIPs	Number of Spuds Drilled in 2012
Duchesne	49013	420
Uintah	49047	636
SUM		1,056

Non-road Mobile Source Activity

As discussed above, there are two main groups of non-road mobile source activity in an oil and gas basin that generate emissions: (1)

VMT-Based Vehicles
These include light-duty diesel and gasoline trucks and heavy-duty diesel trucks driving on paved and unpaved roads in the oil and gas fields per se.

Non-road Diesel Working Equipment
These include mobile non-road equipment used in oil and gas operations such as well pad construction, pipeline construction, fracking and refracking, and maintenance operations.

Mobile source emissions from each type of activity involved in the oil and gas industry are tied to either the annual spud count or the total well count. Spud and well counts are called "inventory surrogates".

Emission factors are expressed in units of "lb/activity". "Lbs/Activity" means emissions in pounds (lb) (for a specific pollutant) per spud or well count.

The first group, VMT-based activity, is further broken down into nine activity types:

Activity Type	Description	Activity Surrogate
Construction Traffic (Running + Idle)	Well pad	Spuds drilled in current year
Construction Traffic (Running + Idle)	Pipeline	Spuds drilled in current year
Construction Traffic (Running + Idle)	Drilling	"
Completion Traffic (")	Spud	"
Recompletion Traffic (")	General	Total well count
Production Traffic (")	"	Total well count
Maint Operation Traffic (")	"	"
Ancillary Traffic (")	"	"
Employee Commuting Traffic (")	"	"

The second group, non-road diesel working equipment activity, is further broken down into six activity types:

Activity Type	Description	Surrogate
Well Pad Const Equipment	NR Diesel Trucks & Equip	Spuds drilled in current year
Pipeline Const Eq	NR Diesel Trucks & Equip	"
Fracking Eq	"	"
Refracking Eq	"	Well count
Other Relocatable Eq	"	"
Maint Operation Eq	"	"

Mobile Source Emissions per Well and/or Spud Count by Activity Type

Each active or producing well is estimated to produce a specific mass of mobile source emissions.

For each mobile source activity category, the Piceance Basin report includes emissions of pollutants in units of pounds per spud count or pounds per well count:

VMT-Based Activity Types, Activity Surrogates, and Emissions by Activity

The following are activity source categories that comprise VMT-based activity in the oil and gas fields per se:

County	Source Category	Description	Activity Surrogate	Surrogate Count	Lbs per Spud or Well CO	NOx	PM10	PM2.5	SOx	VOC
DU, UI	Const. Traffic Running Emissions	Well Pad Const.	Spud Count	1,056	1.02	1.08	3.87	0.48	0.00	0.13
	Const. Traffic Idle Emissions	Well Pad Const.	Spud Count	1,056	0.21	0.35	0.02	0.02	0.00	0.04

County	Source Category	Description	Activity Surrogate	Surrogate Count	Lbs per Spud or Well CO	NOx	PM10	PM2.5	SOx	VOC
DU, UI	Const. Traffic Running Emis.	Pipeline Const.	Spud Count	1,056	0.28	0.15	0.65	0.08	0.00	0.03
	Const. Traffic Idle Emis.	Pipeline Const.	Spud Count	1,056	0.05	0.05	0.00	0.00	0.00	0.01
	Const. Traffic Running Emis.	Drilling	Spud Count	1,056	31.10	38.67	134.95	17.28	0.16	4.36
	Const. Traffic Idle Emis.	Drilling	Spud Count	1,056	11.75	24.93	1.38	1.34	0.09	2.65
	Completion Traffic Running	Well Pad Const.	Spud Count	1,056	27.71	51.67	199.60	23.87	0.21	4.42
	Completion Traffic Idle Emis.	Well Pad	Spud	1,056	21.52	58.99	3.14	3.05	0.22	5.38
	Recompletion Traffic Running	Well Pad Const.	Well Count	10,751	0.05	0.10	0.37	0.05	0.00	0.01
	Recompletion Traffic Idle	Well Pad Const.	Well Count	10,751	0.00	0.00	0.00	0.00	0.00	0.00
	Production Traffic Running	Oil Production	Well Count	10,751	2.91	1.65	8.48	0.95	0.01	0.35
	Production Traffic idle	Oil Production	Well Count	10,751	0.56	0.72	0.04	0.04	0.00	0.11
	Maint Operation Traffic Running	Well Maint	Well Count	10,751	0.51	0.50	1.70	0.22	0.00	0.07
	Ancillary Traffic Idle	Well Maint	Well Count	10,751	0.26	0.04	0.00	0.00	0.00	0.02
	Employee Commuter Traffic Running	All Activities	Well Count	10,751	17.63	6.71	1,728	410.4	0.04	1.41

County	Source Category	Descrip-tion	Activity Surrogate	Surrogate Count	Lbs per Spud or Well CO	NOx	PM10	PM2.5	SOx	VOC
DU, UI	Employer Commuter Traffic Idle	All Activ-ities	Well Count	10,751	1.75	1.66	0.11	0.11	0.01	0.33

Non-road Diesel Working Equipment, Activity Surrogates, and Emissions by Activity

The following are activity source categories that comprise non-road diesel working equipment activity in the oil and gas fields per se:

County	Source Category	Descrip-tion	Activity Surrogate	Surrogate Count	Lbs per Spud or Well CO	NOx	PM10	PM2.5	SOx	VOC
DU, UI	Well Pad Const. Equip.	NR Diesel Trucks & Equip.	Spud Count	1,056	4.94	12.49	0.79	0.77	0.26	0.83
	Pipeline Const Eq	NR Diesel Trucks & Equip.	Spud Count	1,056	5.62	14.29	1.08	1.05	0.32	1.27
	Fracking Equip.	NR Diesel Trucks & Equip.	Spud Count	1,056	49.14	249.68	9.11	8.84	6.15	11.85
	Refrack-ing Eq.	NR Diesel Trucks & Equip.	Well Count	10,751	3.40	13.32	0.58	0.56	0.25	0.85
	Other Relocat-able Eq.	NR Diesel Trucks & Equip.	Well Count	10,751	38.39	113.31	6.33	6.14	2.38	8.73
	Maint Operation Equip.	NR Diesel Trucks & Equip.	Well Count	10,751	10.38	31.60	7.80	5.69	0.49	2.33

Emissions by Source Classification Code (SCC)

The oil and gas emission inventories (point, area/non-point and on- and non-road mobile sources) will be reported in SMOKE format for input into an air dispersion model operated by the UDAQ Technical Analysis Section. The SMOKE format requires emissions to be reported by SCC.

The O & G report on the Piceance Basin, Colorado identifies general vehicle types used in the oil and gas fields. However, the specific vehicle type is not identified. Vehicle types given include:

Light-duty Gasoline Truck
Light-duty Diesel Truck
Heavy-duty Diesel Truck

UDAQ will assign SCC codes to these vehicles as follows:

Vehicle Type (M5)	MOBILE5 Code	SCC Code	GVWR (lb)
Light-Duty Gasoline Truck	LDGT I	2201020099	0 < G ≤ 6,000
Light-Duty Gasoline Truck	LDGT II	2201040099	6,000 < G ≤ 8,500
Light-Duty Diesel Truck	LDDT	2230060099	0 < G ≤ 8,500
Heavy-Duty Diesel Truck	HDDT	2230070099	G > 8,500

We assume that light-duty gasoline truck (LDGT I and LDGT II) emissions are split 50/50 because we do not have specific data for this.

We also do not know the GVWR's for the heavy-duty diesel trucks, so we will use the generic SCC code shown above for all diesel trucks.

Specific Non-road Diesel Equipment Used

The Piceance Basin report includes a list of typical non-road mobile diesel equipment used in the oil and gas industry. However, specific counts and specifications for each type of diesel equipment are not reported.

UDAQ, in its literature search, identified the major oil and gas field in the U.S. UDAQ obtained a report on non-road mobile sources operating in a large oil and gas field in southeast Texas—the Eagle Ford Shale Play, an area covering parts of 25 counties, in which over 200 oil and gas companies operate. The report on Eagle Ford identified specific non-road mobile diesel equipment used in its oil and gas fields, including equipment populations, horsepower, activity and load factors. (1,13)

For each activity type, the following non-road diesel equipment was used:

Process Type	Equipment	SCC	Avg Pop	Avg HP	Activity (hr/well pad)	Load Factor	Product of Factors	Units	Relative Activity
Well Pad Constr. Equip.	Scraper	2270002018	2.0	667	61	0.40	32,711	hp*hr	0.577
	Grader	2270002048	1.0	205	76	0.40	6,249	hp*hr	0.110
	Dozer	2270002063	1.7	292	69	0.41	14,318	hp*hr	0.253
	Backhoe	2270002066	1.0	100	85	0.40	3,392	hp*hr	0.060
Pipeline Const. Equip.	Excavator	2270002036	1.0	160	36	0.50	2,880	hp*hr	0.144
	Grader	2270002048	1.0	205	76	0.40	6,232	hp*hr	0.311
	Backhoe/ Loader/ Tractor	2270002066	1.0	100	85	0.40	3,400	hp*hr	0.170
	Dumper/ Tender **Equip.**	2270002078	1.0	330	57	0.40	7,524	hp*hr	0.376
Fracking Equip.	Crane (lg)	2270002045	1.0	500	54	0.59	15,930	hp*hr	0.025
	Crane (sm)	2270002045	1.0	250	54	0.59	7,965	hp*hr	0.013
	Forklift	2270002057	1.0	100	54	0.59	3,186	hp*hr	0.005
	Bulldozer	2270002063	1.0	100	54	0.59	3,186	hp*hr	0.005
	Backhoe	2270002066	1.0	90	54	0.59	2,867	hp*hr	0.005
	Generator (small)	2270006005	1.0	50	54	0.59	1,593	hp*hr	0.003

Process Type	Equipment	SCC	Avg Pop	Avg HP	Activity (hr/well pad)	Load Factor	Product of Factors	Units	Relative Activity
Fracking Eq. (cont.)	Blender Truck	2270002051	1.0	650	54	0.43	15,930	hp*hr	0.024
	Generator (med)	2270006005	5.0	90	54	0.59	14,337	hp*hr	0.023
	Plug & Perforating Pump Truck	2270006010	2.0	2,250	54	0.30	72,900	hp*hr	0.115
	Pump Engine	2270006010	12.0	2,250	54	0.30	437,400	hp*hr	0.691
	Water Pump	2270006010	5.0	400	54	0.43	46,440	hp*hr	0.073
	Blowout Control System	2270010010	1.0	15	54	0.43	348	hp*hr	0.001
	Sand King	2270010010	3.0	100	54	0.43	6,966	hp*hr	0.011
Refracking Equip.	Crane (lg)	2270002045	1.0	500	36	0.59	10,620	hp*hr	0.025
	Crane (sm)	2270002045	1.0	250	36	0.59	5,310	hp*hr	0.013
	Blender Truck	2270002051	1.0	650	36	0.43	10,062	hp*hr	0.024
	Forklift	2270002057	1.0	100	36	0.59	2,124	hp*hr	0.005
	Bulldozer	2270002063	1.0	100	36	0.59	2,125	hp*hr	0.005
	Backhoe	2270002066	1.0	90	36	0.59	1,912	hp*hr	0.005
	Generator (small)	2270006005	1.0	50	36	0.59	1,062	hp*hr	0.003
	Generator (medium)	2270006005	5.0	90	36	0.59	9,558	hp*hr	0.023
	Plug & Perforating Pump Truck	2270006010	2.0	2,250	36	0.30	48,600	hp*hr	0.115
	Pump Engine	2270006010	12.0	2,250	36	0.30	291,600	hp*hr	0.691
	Water Pump **Equip.**	2260006010	5.0	400	36	0.43	30,960	hp*hr	0.073
	Blowout Control System	2270010010	1.0	15	36	0.43	232	hp*hr	0.001
	High-Pressure Water Cannon	2270010010	1.0	200	36	0.43	3,096	hp*hr	0.007

Process Type	Equipment	SCC	Avg Pop	Avg HP	Activity (hr/well pad)	Load Factor	Product of Factors	Units	Relative Activity
Refracking Eq. (cont.)	Sand King	2270000010	3.0	100	35	0.43	4,644	hp*hr	0.011
Other Relocatable Eq.	Diesel Off-Hwy Truck	2270002051	60.	450	54	0.59	860,220	hp*hr	0.350
	Diesel Snow-blower (comm.)	2270004036	60.	137.5	54	0.43	191,565	hp*hr	0.078
	Diesel Snow-blower (comm.)	2270004036	60.	237.5	54	0.43	330,885	hp*hr	0.135
	Generator (small)	2270006005	20	50.	54	0.59	31,860	hp*hr	0.013
	Generator (medium)	2270006005	40	50.	54	0.59	114,696	hp*hr	0.047
	Water Pump	2270006010	100	400.	54	0.43	928,800	hp*hr	0.378
Maintenance Operation Eq.	Grader	2270002048	6.	205	500	0.40	246,000	hp*hr	0.1,056
	Diesel Off-Hwy Truck	2270002051	6.	137.5	500	0.59	243,375	hp*hr	0.415
	Diesel Other Oil Field Equip.	2270010010	5.	75.	500	0.43	96,750	hp*hr	0.165

Results

The final inventory is reported in units of tons per year.

VMT-Based Emissions

VMT-based activity includes traffic generated by light-duty diesel and gasoline trucks and heavy-duty diesel trucks driving on paved and unpaved roads in the oil and gas fields per se:

DUCHESNE COUNTY
VMT-Based Emissions
TONS PER YEAR

Cal Year	County	CO	NOx	PM10 Exh	PM10 Brake	PM10 Tire	PM10 Fug Dust Paved Roads	PM10 Fug Dust Unpaved Roads
2013	**Duchesne**	57.66	54.96	2.927	0.4036	0.0646	983.1	1,783.8

Cal Year	County	PM2.5 Exh	PM2.5 Brake	PM2.5 Tire	PM2.5 Fug Dust Paved Roads	PM2.5 Fug Dust Unpaved Roads	SOx	VOC Exh	VOC Evap
2013	**Duchesne**	2.846	0.1056	0.0155	229.2	415.6	0.2357	6.541	0.6722

UINTAH COUNTY
VMT-Based Emissions
TONS PER YEAR

Cal Year	County	CO	NOx	PM10 Exh	PM10 Brake	PM10 Tire	PM10 Fug Dust Paved Roads	PM10 Fug Dust Unpaved Roads
2013	**Uintah**	123.7	100.5	5.234	0.8133	0.1339	2,407.8	4,363.7

Cal Year	County	PM2.5 Exh	PM2.5 Brake	PM2.5 Tire	PM2.5 Fug Dust Paved Roads	PM2.5 Fug Dust Unpaved Roads	SOx	VOC Exh	VOC Evap
2013	**Uintah**	5.093	0.2128	0.0320	564.1	1,022.3	0.4459	12.95	1.451

Non-road Diesel Equipment Emissions

Non-road diesel equipment emissions come from non-road working equipment and trucks, such as a backhoe, bulldozer, forklift, grader, small generator, etc.

DUCHESNE COUNTY
Non-road Diesel Equipment Emissions
TONS PER YEAR

Cal Year	County	CO	NOX	PM10 Exh	PM10 Brake	PM10 Tire	PM10 Fug Dust Paved Roads	PM10 Fug Dust Unpaved Roads
2013	Duchesne	93.32	301.4	18.18	0.0000	0.0000	0.0000	6.901

Cal Year	County	PM2.5 Exh	PM2.5 Brake	PM2.5 Tire	PM2.5 Fug Dust Paved Roads	PM2.5 Fug Dust Unpaved Roads	SOx Exh	VOC Evap	VOC **Exh**
2013	Duchesne	17.63	0.0000	0.0000	0.0000	3.793	6.245	0.0000	21.37

UINTAH COUNTY
Non-road Diesel Equipment Emissions
TONS PER YEAR

Cal Year	County	CO	NOX	PM10 Exh	PM10 Brake	PM10 Tire	PM10 Fug Dust Paved Roads	PM10 Fug Dust Unpaved Roads
2013	Uintah	218.6	690.9	42.73	0.0000	0.0000	0.0000	17.06

Cal Year	County	PM2.5 Exh	PM2.5 Brake	PM2.5 Tire	PM2.5 Fug Dust Paved Roads	PM2.5 Fug Dust Unpaved Roads	SOx	VOC Exh	VOC Evap
2013	Uintah	41.43	0.0000	0.0000	0.0000	9.374	14.08	50.02	0.0000

Discussion

For CO, NOx and VOC, about 75% of non-road mobile emissions come from non-road diesel equipment (as opposed to light- and heavy-duty truck traffic).

Emissions from gasoline-powered non-road equipment are insignificant.

VMT-Based Emissions

VMT-based emissions are mostly from light-duty diesel and gasoline trucks. About 60% of the light-duty traffic in the oil basin per se is from employee commuting traffic on non-public roads, traveling to well pads or assisting in bringing miscellaneous equipment for well drilling and completion, maintenance, pipeline construction and other activities. In this methodology, worker traffic for construction of compressor stations or gas plants is not included.

In addition, heavy-duty diesel trucks drive on mostly unpaved roads for similar purposes. This driving is also part of "VMT-based" emissions.

Non-Road Diesel Equipment Emissions

About 63%, 86%, 97% and 77% of CO, NOx, SOx and VOC respectively of Uinta Basin non-road mobile O & G emissions come from non-road diesel working equipment, such as backhoes/loaders, tractors, cranes, bulldozers, graders, excavators and dumpers/tenders.

The mobile source oil and gas report on the Piceance Basin, Colorado states that mobile source activity is estimated to contribute 10% or less to the total oil and gas inventory from point, area (non-point), on- and non-road mobile sources.

The exception to this is that over 99% of the PM10 and PM2.5 fugitive dust in an oil and gas inventory comes from mobile sources, specifically employee commuter travel on paved and unpaved roads.

Relationship to Statewide National Emissions Inventory (2011) and PM2.5 SIP Inventories

The non-road mobile source inventory for winter 2014 shows only 5 tons per year NOx from oil and gas equipment in Duchesne County, a truly insignificant contribution. The statewide National Emissions Inventory also shows an insignificant contribution. The reason for this is that the EPA NONROAD model includes only miscellaneous oil and gas equipment. Therefore, this oil and gas inventory should be considered an "add-on" to the non-road inventories.

Emission Projections

This report does not cover emissions projections.

However, emissions in future years are expected to increase rapidly, based on the slopes of the production curves and well and spud count curves. This is particularly true for natural gas.

The report "Final Report: Uinta Basin Energy and Transportation Study" estimates that, under the "constrained output forecast", the dollar value (in 2012 dollars) of natural gas and oil

products will increase from about $2.5 to 4.5 billion from 2013 to 2020, an annual increase of about 8.76%. (10)

This estimate assumes that all roadway projects in the UDOT Long Range Plan through 2020 under the "build" scenario will be completed, and that oil and gas pipeline capacity will grow 3% per year from 2011 to 2020.

Comparison of Uinta Basin and Piceance Basin, Colorado Oil and Gas Activity

The number of active and producing oil and gas wells in the Piceance and Uinta Basins are somewhat similar current to the beginning of 2013:

Basin	Counties Included	No. of Oil and Gas Wells	Current to
Piceance, Colorado	Delta, Garfield, Gunnison, Mesa, Moffat, Rio Blanco, Routt	9,578 (projection)	June 2012
Uinta, Utah	Duchesne, Uintah	10,751 (actual)	Jan 1, 2013

Basin	Counties Included	No. of Spud Events (Wells Drilled in 2012)	Current to
Piceance, Colorado	Delta, Garfield, Gunnison, Mesa, Moffat, Rio Blanco, Routt	2009 = 893 (P. rept) 2012 = 104 (projection)	June 2012
Uinta, Utah	Duchesne, Uintah	1,056 (actual)	Jan 1, 2013

Accuracy of Inventory

This non-road inventory is only a first attempt at estimating emissions. Accuracy could be improved if surveys of actual equipment and vehicles were obtained.

Conclusions

1. In the Uinta Basin, non-road mobile source emissions of CO, NOx, SOx and VOC from oil and gas activity are expected to contribute about 10% of the total oil and gas inventory from point, area, non- and on-road mobile sources.

The exception to this is that non-road mobile PM10 and PM2.5 fugitive dust from paved and unpaved roads comprises over 99% of total PM10 and PM2.5 in the oil and gas inventory.

2. Non-road mobile oil and gas emissions are split about 70/30 between Uintah and Duchesne Counties.

3. Projections of non-road mobile source emissions from oil and gas activity are expected to increase as the oil and gas industry grows.

However, it is difficult to estimate the increase because production volumes depend in part on transportation network and pipeline expansion. In addition, the effect of controls on emissions is unknown.

Appendix

1. Duchesne County Spud Counts (1970 – 2012)
2. Duchesne County Well Counts (1970 – 2012)
3. Uintah County Spud Counts (1970 – 2012)
4. Uintah County Well Counts (1970 – 2012)
5. Article from Salt Lake Tribune (April 14, 2014): Oil Shale Mining in Utah

Duchesne County

Spud Counts – Spud counts in Duchesne County have been plotted for the years 1970 – 2007 below in Figure 10, including projections to 2012.

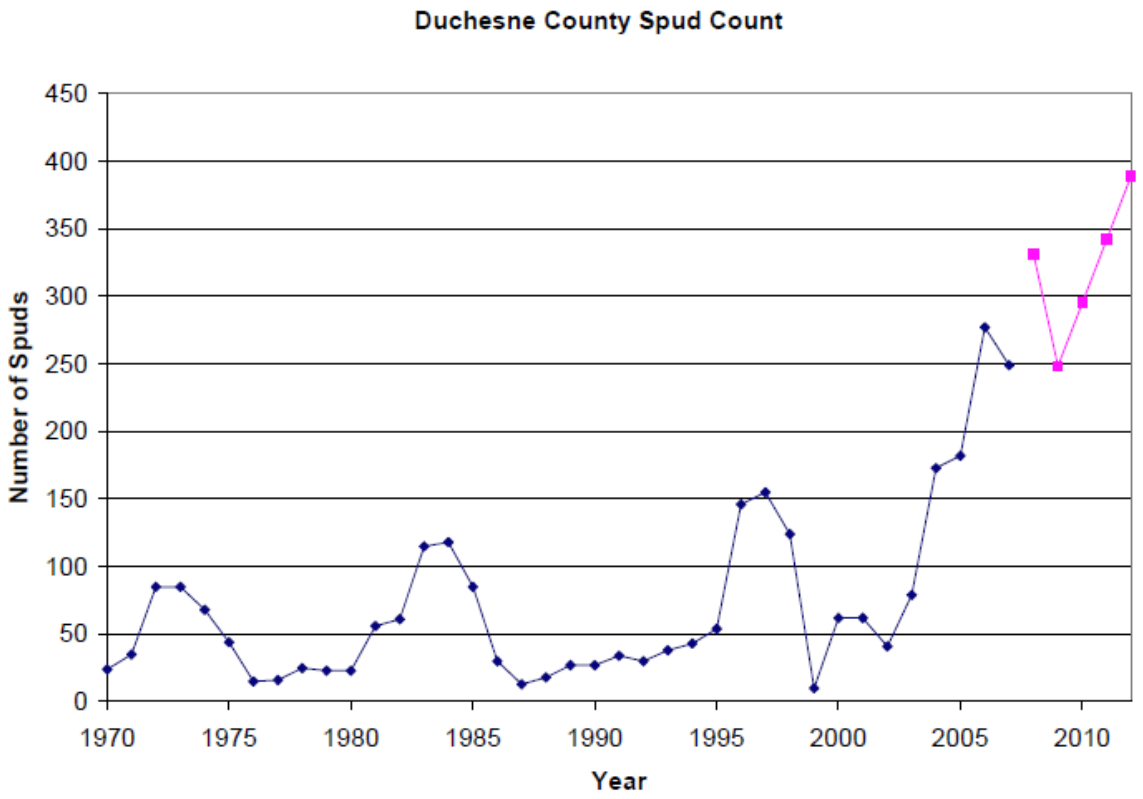

Figure 10. Spud count historical data (from the IHS database) for Duchesne County and projections to 2012. [9]

Total Well Counts – Total well counts in Duchesne County have been plotted for the years 1970 – 2007 below in Figure 11, including projections to 2012.

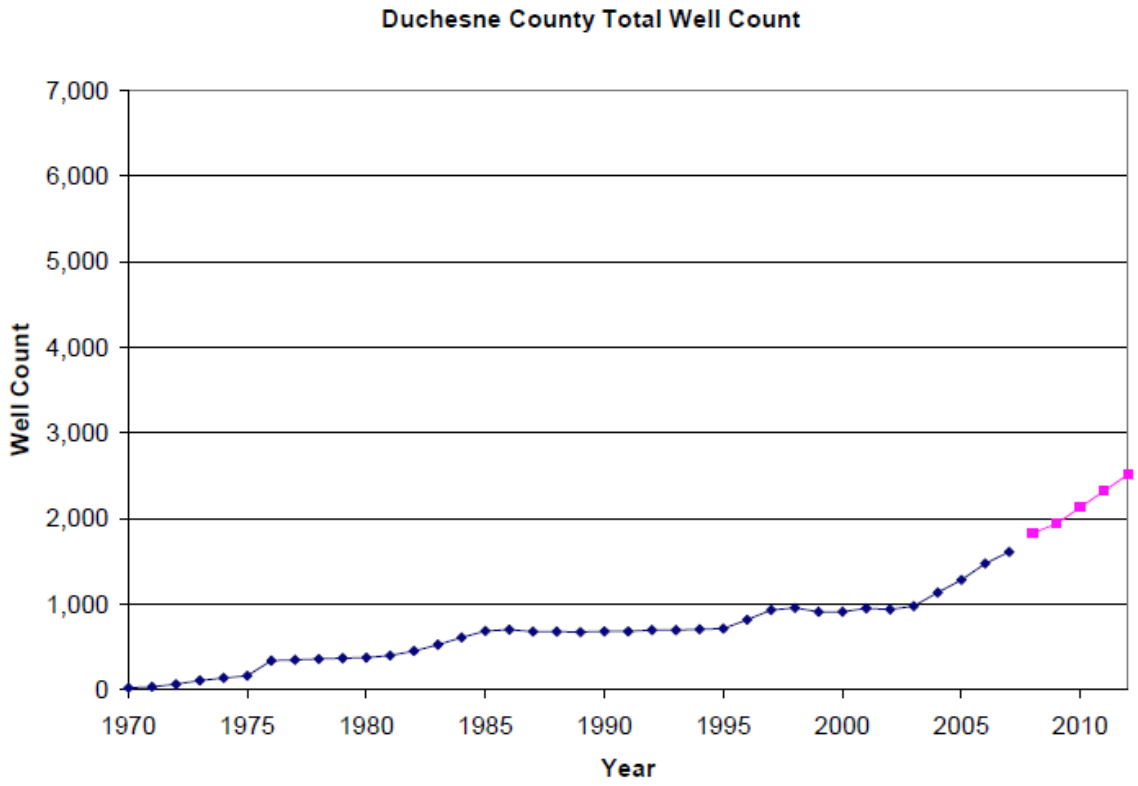

Figure 11. Total well count historical data (from the IHS database) for Duchesne County and projections to 2012. [10]

Uintah County

Spud Counts – Spud counts in Uintah County have been plotted for the years 1970 – 2006 below in Figure 28, including projections to 2012.

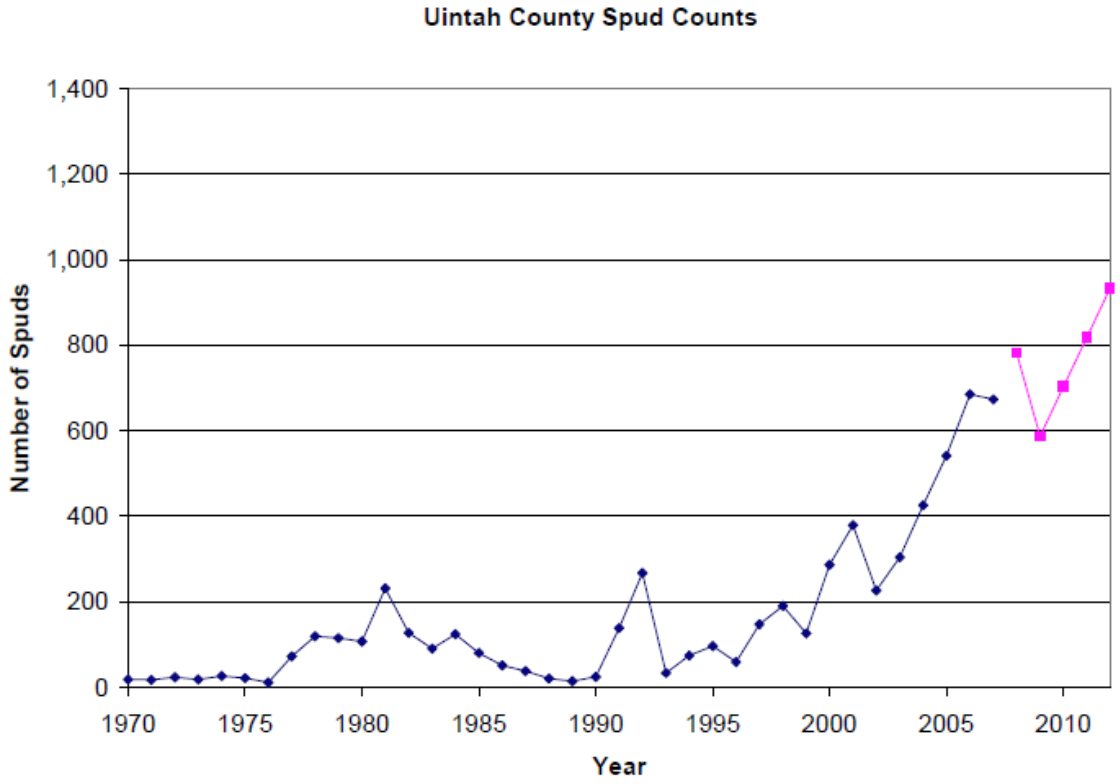

Figure 28. Spud count historical data (from the IHS database) for Uintah County and projections to 2012. [27]

Total Well Counts – Total well counts in Uintah County have been plotted for the years 1970 – 2006 below in Figure 29, including projections to 2012.

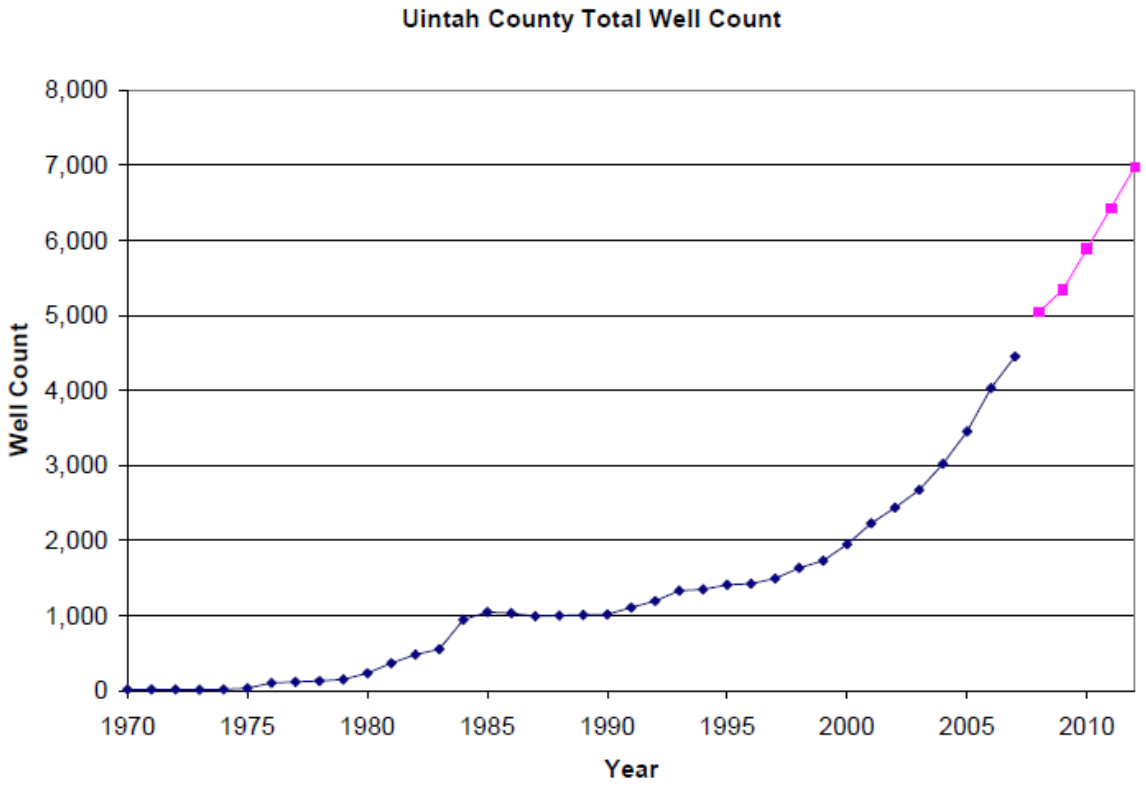

Figure 29. Total well count historical data (from the IHS database) for Uintah County and projections to 2012.[28]

Total Well Counts – Total well counts in Uintah County have been plotted for the years 1970 – 2006 below in Figure 29, including projections to 2012.

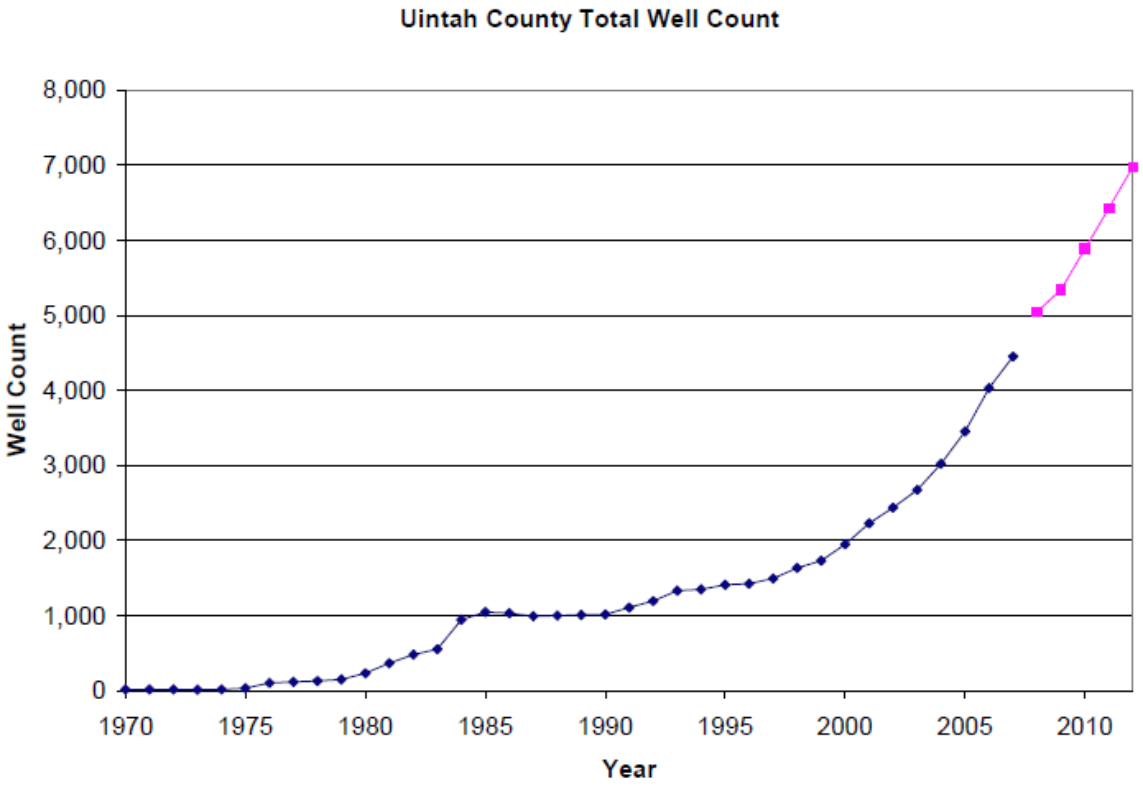

Figure 29. Total well count historical data (from the IHS database) for Uintah County and projections to 2012. [28]

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5. Salt Lake Tribune (Brian Maffly), Monday, April 14, 2014: "Utah Oks Nation's First Commercial Oil Shale Mine"
http://www.sltrib.com/sltrib/news/57291000-78/oil-shale-leaf-red.html.csp

Oil shale production can now move forward in Utah. Regulators on Friday issued a groundwater permit to Red Leaf Resources, a Utah company planning to develop a shale mine and below-grade ovens to heat ore mined from state land in the Uinta Basin.

A yuletide present to those championing Utah energy production, the permit issued by the Utah Division of Water Quality is the last big hurdle for North America's first commercial oil shale mine. Red Leaf said it expects mining operations to begin in the spring.

Kerogen-bearing shale exists in vast abundance under Utah, Colorado and Wyoming, but no one has figured out how to extract oil from it in commercial amounts. With 600 million barrels available under its Utah leasehold, Red Leaf hopes to be the first.

Its initial, small-scale demonstration project "will produce more than 300,000 barrels of oil and prove our clean oil shale technology works on a large scale," said CEO Adolph Lechtenberger in a news release.

But environmentalists are dubious. Groundwater disruption is just one of many environmental drawbacks posed by the proposed development of the Uinta Basin's rich oil shale and tar sands resources, according to activists. This is because ore is strip mined, and developers would consume more resources to convert hydrocarbon precursors, kerogen and bitumen, into liquid oil.

"They take the skin off the planet and are not putting it back. It's going to be a moonscape," said John Weisheit of Moab-based Living Rivers. "They are destroying the watershed, the near-surface aquifers. It's a water system that makes the ecosystem what it is."

But state regulators believe these lands don't have much groundwater, and they are requiring Red Leaf to maintain monitoring wells to see how the project affects the water that is there.

"'We based our permit decision on the absence of water in the extraction process, the lack of an aquifer and low permeability of the rocks underlying the test site," DWQ director Walt Baker said. "We plan to keep a close eye on the project to make sure the process works as promised."

Living Rivers has held up state approvals for a nearby tar sands mine, also on state land, with an appeal pending in the Utah Supreme Court. But because of the small scale of Red Leaf's initial project, environmentalists don't have much latitude to block it in the courts.

In Red Leaf's trademarked EcoShale process, operators dig pits lined with bentonite and clay, fill them with ore and heat it to 725 degrees for a few months. By contrast, Enefit American Oil, another developer proposing a mine nearby, plans to run ore through a processing facility that "retorts" or heats kerogen into oil in a matter of hours.

Red Leaf's process "extracts oil with lower energy consumption, lower emissions, lower water use and less environmental impact than any oil shale technology deployed in the world today," Lechtenberger said in his statement. "The EcoShaleTM process was specifically designed to address traditional environmental challenges of oil shale production."

But eco-activists say EcoShale is still hard on the earth. While Enefit would put spent ore back in the mine, Red Leaf would leave it where it was retorted, along with the infrastructure.

"'Their reclamation plan sucks," Weisheit said. "It allows them to keep the earth ovens in place and cover it with top soil. They are using bentonite, which is mined. It has to be trucked in. They leave all that pipe in there. They don't recycle it."

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