UTAH DIVISION OF AIR QUALITY

White Paper: VOC Emissions Projection Methodology for the Uinta Basin

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Table of Contents

1.0 Introduction 3

1.1 Methodology 4

1.1.2 Proof of Concept 4

2.0 Estimating Growth in Production 5

2.1 Background 5

2.2 Data 5

2.3 Future Projections 6

2.3.1 EIA Growth 6

2.3.2 Shift-Share Analysis 7

2.3.3 Uinta Basin Extrapolation 7

2.4 Spuds 8

3.0 Decline Curve Analysis 9

3.1 Impact of Existing Wells 9

3.2 The Decline Curve 9

3.2.1 Determining the Rate of Decline 11

3.2.2 Applying the Decline Rate 12

3.3 Calculating VOC Emissions from Production 13

3.3.1 Oil Tanks 14

3.3.2 Additional Sources 15

3.4 Emission Controls 15

3.4.1 Oil Tanks Emission Controls 16

3.4.1.3 Additional Source Controls 17

3.5 Emissions Reductions 17

4.0 Summary 18

1.0 Introduction

Utah's permitting rule R307-401 contains the requirement for new or modified air pollution sources to obtain an approval order prior to commencing construction. The Director of the Utah Division of Air Quality (DAQ) may issue an approval order only if the requirements listed in R307-401-8 are met, including the national ambient air quality standards (NAAQS). DAQ uses different mechanisms, to determine if a new or modified source will cause or contribute to an ozone violation. These mechanisms can vary depending on the pollutant, the size of the source, and the background concentration of the pollutant.

For some pollutants, such as particulate matter or nitrogen dioxide, dispersion models can be used to determine the impact of a new or modified source on nearby ambient air quality concentrations. R307-410 requires modeling for sources with emission levels above the thresholds specified in R307-410. DAQ uses generic screening models or engineering judgment to assess the impact of sources with emission levels below the thresholds specified in R307-410. Other pollutants, such as ozone, are secondary pollutants that are formed through chemical reactions and are much more difficult to model. Ozone tends to cause impacts over a large regional area rather than being localized in a small area where the pollutant can be attributed to a single source or small group of sources. Regional models are developed for state implementation plans in ozone nonattainment areas, but these complex models take years to develop and are not appropriate for modeling individual permit applications. For this reason, DAQ has relied on a combination of monitoring data and stringent pollution control technology requirements to demonstrate attainment of the ozone standard

In recent years DAQ has monitored high ozone values in the Uinta Basin. The collection of data is not yet complete enough to determine whether the area violates the ozone standard, but monitored values are high enough during certain winter episodes to warrant a more in-depth evaluation of the impact of new or modified emission sources in the area. Based on extensive research that has been conducted in the Uinta Basin over the last several winters, VOC emissions appear to be the limiting ozone precursor in the area; therefore, any increase in VOC emissions must be evaluated.

When evaluating the impact of new or modified sources of VOC in the Uinta Basin through the permitting process, DAQ ensures that new sources are not making the ozone problem worse. Utah's Ozone Advance program is addressing the underlying problem caused by emissions from existing sources that do not have modern VOC emission controls. This approach leads to overall air quality benefits because new sources have state-of-the-art air pollution controls, are often more efficient, and are better attuned to the business needs of the area than older, outdated equipment.

The purpose of this analysis is to evaluate the expected growth of the oil and gas industry in Duchesne and Uintah Counties between 2013 and 2018 and to determine whether new sources will cause or contribute to a violation of the ozone standard. The analysis is focused on oil production in areas of the Uinta Basin that are under State jurisdiction because this information is most relevant to the permitting decisions that must be made by DAQ. This type of analysis could be expanded to include the entire Uinta Basin if other jurisdictions, such as the Ute Tribe, needed to address the impact of growth in their jurisdiction.

1.1 Methodology

In order to create a realistic scenario of how emissions from volatile organic compounds (VOC) would be affected by the permitting requirements from DAQ and EPA, an analytical approach was developed by DAQ. The working hypothesis for this approach assumes that production will increase due to newly permitted sources and production from existing sources will decrease due to well decline. The question that DAQ seeks to answer is this: While the number of barrels of oil produced in the Uinta Basin could increase, will overall emissions actually decrease over the same time horizon? In other words, as new production comes online subject to EPA's recently promulgated New Source Performance Standards (NSPS), would the increase in emissions from new development be offset by the decline in production from older, uncontrolled wells?

1.1.2 Proof of Concept

Since this analysis is not a standard regulatory approach, DAQ set out to test its hypothesis by bounding the problem in two specific ways. First, the analysis focuses only on oil production and only on lands in the Basin that fall under DAQ permitting jurisdiction. Second, the results only account for VOC emissions from storage tanks. This approach relies on three separate, but linked data sets:

- A future year projection of new oil production in the Uinta Basin
- A future year decline in the production of existing wells starting from a base-year
- A VOC emission factor to estimate the emissions based on annual production

Each of these inputs has its own level of uncertainty associated with it. Because of the different estimation techniques in each category it is important to evaluate whether the data sets are congruent with each other and are properly used in context. Over the past several months DAQ has tested alternate data sets including Energy Information Agency (EIA) projections, straight historical growth extrapolation, and an econometric model called Shift-share analysis. In addition, a variety of curve fitting techniques were used to obtain a logically consistent production decline curve. The final implementation of the analysis accounts for VOC emissions from oil storage tanks using the following assumptions:

- The majority of the tanks in use during the base year is uncontrolled
- As production at a site declines year-by-year over the analysis period, emissions decrease relative to the decrease in production
- The emissions from new production that comes on line after the EPA's NSPS regulations are in force for new storage tanks are 95% lower than the baseline emissions
- As new production comes online each year, VOC emissions are highly controlled while increasing the overall production in the basin
- Because production from high-emitting sources is declining and new sources are low-emitting, production increases but emissions are likely to decrease

2.0 Estimating Growth in Production

2.1 Background

To determine whether new permits for oil wells can be issued within state jurisdiction without a negative effect on VOC emissions requires an analysis of production and well growth over time, decline of well production over time, and emissions estimates of new and old wells. It is also necessary to take into consideration new wells having much stricter emissions controls than older wells.

To be able to analyze future VOC emissions from oil wells within state jurisdiction requires an estimate of future oil production. Projecting production into the future has inherent uncertainties given that the future cannot fully be predicted. Given those uncertainties, it was determined to not rely on a single projection, but a range of projections. The Division of Air Quality focused on three different projections: a projection with smaller growth, a projection with mid-range growth, and a projection with larger growth.

These projections relied on two different oil and gas resources for background information. The first resource was the U.S. Energy Information Administration (EIA). The EIA issues official energy statistics for the U.S. government. Each year the EIA releases their *Annual Energy Outlook*. EIA's *Annual Energy Outlook 2013* presents yearly projections and analysis of energy topics. "The projections in the U.S. Energy Information Administration's (EIA's) Annual Energy Outlook 2013(AEO2013) focus on the factors that shape the U.S. energy system over the long term. Under the assumption that current laws and regulations remain unchanged throughout the projections, the AEO2013 Reference case provides the basis for examination and discussion of energy production, consumption, technology, and market trends and the direction they may take in the future (www.eia.gov)." Within the AEO2013, one can find crude oil projections out to the year 2040 for different regions around the U.S. Since Uintah and Duchesne County, UT are within the Rocky Mountain region, only projections from the Rocky Mountain region were analyzed. The Rocky Mountain model region consists of the following states: Arizona, Colorado, Idaho, Montana, North Dakota, the western half of New Mexico, Nevada, South Dakota, Utah, and Wyoming.

The second resource was the Utah Division of Oil, Gas, and Mining (DOGM). The DOGM oil and gas program keeps an updated (updated nightly) Data Research Center, which includes well data, well history data, and production data for the entire state of Utah. Within this database one can find production of oil wells within Uintah and Duchesne County, as well as the location of those wells. Spud (the commencement of drilling for a new well) data and their locations can also be found in the DOGM database.

2.2 Data

To be able to project production into the future one needs to have an idea of the past. Eleven years (2002-2012) of production data was pulled from DOGM's Data Research Center. DOGM does not explicitly note which airshed a well belongs to, so to determine jurisdiction ArcGIS software was employed. Each well has latitude and longitude coordinates assigned to it; these were used to place the wells in their appropriate location and to determine whether they were within state jurisdiction. Only oil well production that was within state jurisdiction was totaled for each year, as well as well counts and spud counts (Table 1).

Data was also gathered from the EIA. Crude oil was totaled over an eleven year time frame (2002-2012) for the entire EIA Rocky Mountain region (Table 1). Gathering actual production data at a regional scale allows one to determine how Uintah and Duchesne county oil production compares to the region as a whole. Crude oil projections were also gathered.

Table 1 Uintah and Duchesne County, and EIA Rocky Mountain Region oil production and total spuds. Uintah and Duchesne County totals are only from oil wells within state jurisdiction. Oil production is in barrels.

Year	EIA Rocky Mtn. Oil Production	Uintah + Duchesne Oil Production	Uintah + Duchesne Total Oil Spuds	Uintah + Duchesne Oil Wells
2002	141,679,095	2,940,738	13	553
2003	141,027,402	2,805,745	30	558
2004	149,775,243	3,276,753	48	598
2005	164,710,650	3,862,726	85	676
2006	176,212,675	3,768,506	112	759
2007	184,442,912	5,043,578	149	849
2008	203,787,385	5,699,654	117	935
2009	216,928,884	6,057,583	129	1033
2010	253,316,403	7,830,758	320	1259
2011	301,806,526	8,955,798	301	1475
2012	411,078,999	11,204,120	240	1680

2.3 Future Projections

As stated before, there are inherent uncertainties in projections given that the future cannot be fully predicted. Given those uncertainties, it was decided to not rely on a single projection, but a range of projections. The different projections are labeled: EIA growth (low growth), shift-share analysis (mid growth), and Uinta Basin Extrapolation (high growth). Future oil well production was estimated for years 2013-2018 (see Uinta_Basin_Projections.xlsx).

2.3.1 EIA Growth

EIA takes into consideration many different elements of the energy industry and is an estimate that merits analysis. EIA's Annual Energy Outlook 2013 contains projections for crude oil out to 2040 beginning with year 2010 for the entire United States including the Rocky Mountain region. Estimates are given in millions of barrels per day. To analyze yearly totals those estimates were then multiplied by 365 days to estimate millions of barrels of oil per year. From those estimates, growth rates from year to year (growth rate = latter year/previous year) were established. Year 2012 is the most current data for oil well production within state jurisdiction in Uintah and Duchesne County that can be gathered from the DOGM database and is the starting point for the projection. From year 2012 to 2013, the EIA growth rate for 2013 of 1.157 was applied to 2012's production to estimate 2013's production. This method was continued until 2018 utilizing each subsequent growth rate that the EIA estimated. From this projection, in year 2018, crude oil production for Uintah and Duchesne County in 2018 was estimated to be roughly 14.5 million barrels of oil. This projection produces the lowest estimates for oil production when compared to the shift share analysis and the Uinta Basin extrapolation (Table 2 and Figure 1).

2.3.2 Shift-Share Analysis

Shift-share is a tool that economists use for understanding trends in employment. It is a standard regional analysis method that attempts to determine how much of regional job growth can be attributed to national trends and how much growth is due to unique regional factors. The Shift-share approach is also used for projections of employment. Although Shift-share analysis is generally not applied to crude oil production, it can also be used in that application. A Shift-share projection analysis was applied to crude oil production in Uintah and Duchesne County to determine projection estimates that are a combination of regional and local effects. For this analysis the Rocky Mountain regional production numbers were used in place of national production numbers and Uintah and Duchesne production numbers were the local production numbers.

To perform this analysis EIA's Rocky Mountain region actual yearly production from 2002-2012 and future yearly production from 2013-2018 were utilized. Uintah and Duchesne county state jurisdiction oil production values for 2002-2012 were also utilized. To determine Uintah and Duchesne's "share" of the EIA Rocky Mountain region, production from Uintah and Duchesne County were divided by Rocky Mountain production actuals for 2002-2012. A linear trend line was fitted to the "share" (using the method of least squares) and then continued into the future for the years 2013-2018. The trend line value was then multiplied by the Rocky Mountain region actuals and projection oil production numbers to return the number of barrels of oil production per year for the Uinta Basin. The Shift-share technique forecasts nearly 20 million barrels of oil for the 2018 year.

This technique gives us an idea of what the future may hold as a combination of regional and local effects. The Shift-share analysis projection lies in-between the EIA growth and Uinta Basin Extrapolation and is considered a mid-growth projection for the Uinta Basin (Table 2 and Figure 1).

2.3.3 Uinta Basin Extrapolation

The Uinta Basin Extrapolation projects historical Uintah and Duchesne oil production within state jurisdiction for the last eleven years into the future. From 2002-2012 a growth rate was established for each year and was then averaged over the eleven year period. The average growth rate from 2002-2012 was determined to be 1.15. That growth rate was applied to all years beginning in 2013 and ending in 2018. Utilizing that growth rate, in 2018, oil production is close to 26 million barrels (Table 2 and Figure 1). The Uinta Basin extrapolation is considered to the most conservative approach and is also considered to be the high growth projection for the Uinta Basin. The Uinta Basin extrapolation is the projection that will be used for this analysis.

Table 2 EIA Rocky Mountain Region and state jurisdiction Uintah and Duchesne oil well production values for historical data (2002-2012) and projection data (2013-2018). Projection values for the EIA, shift share analysis, and Uinta Basin extrapolation projections are shown in color. Values are barrels of oil per year.

Year	Rocky Mtn. Region	State Uintah + Duchesne	EIA Growth	Shift-Share Analysis	Uinta Basin Extrapolation
2002	141,679,095	2,940,738			
2003	141,027,402	2,805,745			
2004	149,775,243	3,276,753			
2005	164,710,650	3,862,726			
2006	176,212,675	3,768,506			
2007	184,442,912	5,043,578			
2008	203,787,385	5,699,654			
2009	216,928,884	6,057,583			
2010	253,316,403	7,830,758			
2011	301,806,526	8,955,798			
2012	411,078,999	11,204,120			
2013	**478,150,000**		**12,963,167**	**15,083,184**	**12,879,213**
2014	**496,363,135**		**13,455,767**	**16,173,231**	**14,804,743**
2015	**508,236,585**		**13,778,706**	**17,087,956**	**17,018,154**
2016	**517,760,165**		**14,040,501**	**17,945,897**	**19,562,485**
2017	**529,049,980**		**14,349,392**	**18,886,673**	**22,487,210**
2018	**541,076,365**		**14,679,428**	**19,877,960**	**25,849,202**

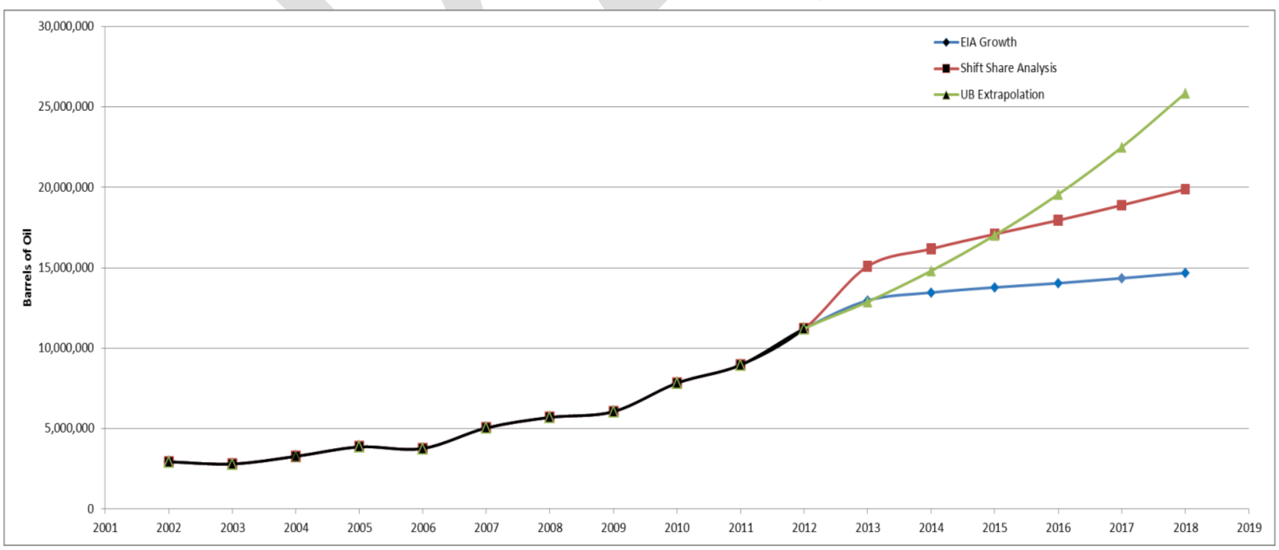

Figure 1 EIA (blue line), shift share analysis (red line), and Uinta Basin extrapolation (green line) projection values displayed graphically. Years 2002-2012 are historical data and are displayed in black. Values for the projections are barrels of oil per year.

2.4 Spuds

A spud is the commencement of drilling for a new well. Spuds were also projected out into the future following the Uinta Basin extrapolation method of growth and increase each year by a growth rate of

1.15. Well counts for the same years are the sum of the previous year's well count and the spuds for the future year (see Uinta_Basin_Projections.xlsx). Spud and well counts are provided for 2002-2018 (Table 3).

Table 3 Uintah and Duchesne state jurisdiction historical and projected oil production, oil spuds, and oil well counts for the Uinta Basin extrapolation projection method. Projections are shown in blue

Year	Uintah + Duchesne Oil Production (barrels)	Uintah + Duchesne Spuds	Uintah + Duchesne Oil Wells
2002	2,940,738	13	553
2003	2,805,745	30	558
2004	3,276,753	48	598
2005	3,862,726	85	676
2006	3,768,506	112	759
2007	5,043,578	149	849
2008	5,699,654	117	935
2009	6,057,583	129	1033
2010	7,830,758	320	1259
2011	8,955,798	301	1475
2012	11,204,120	240	1680
2013	**12,879,213**	**276**	**1956**
2014	**14,804,743**	**317**	**2273**
2015	**17,018,154**	**365**	**2638**
2016	**19,562,485**	**419**	**3057**
2017	**22,487,210**	**482**	**3538**
2018	**25,849,202**	**554**	**4092**

3.0 Decline Curve Analysis

3.1 Impact of Existing Wells

The analysis in this paper will focus on the growth projection determined only from historic Uinta Basin production data. This method compared to the Shift-share method or EIA method, is much more conservative in that it assumes no decline in the rate of production in the basin. While the Shift-share method likely provides a more accurate representation of future production growth in the region, the historic Uinta Basin method provides the highest production scenario for the region and thus the highest emissions scenario for the region. Future analyses will include the additional growth projections, and are likely to predict even lower future production and emissions levels than we currently estimate.

3.2 The Decline Curve

In examining how the oil and gas industry presence in the Uinta Basin may change over the next several years, it is important to look at the existing infrastructure and predict how it may evolve. One of the most substantial changes that will occur in the basin is a change in the amount of production coming from existing wells. In addition to impacting the cumulative production from the region, this change also impacts the amount and type of equipment needed in the region. Emissions related to oil and gas production can either be directly correlated to the amount of oil or gas production, or be dependent on actual equipment counts. Thus predicting how production and equipment sums for existing sources are changing is one of the best ways to determine how future emissions from these sources is likely to change.

It is beneficial for several reasons to determine what future production at a well may be, and also to estimate the likely life of the well. The standard method for determining these facts is decline curve analysis. An inherent feature of oil and gas wells is that their production naturally decreases as a function of time, see 2. Decline curve analysis relies on historical production data from a well. A plot of production versus time is developed, and a line is then fit to the performance history. This line trend is then extrapolated out in time, making the assumption that future production performance will continue to follow a similar trend. Historically these decline trends have been characterized according to the "Arps equations", developed by J.J. Arps in 1944. The "Arps equations" are a set of three types of equations: hyperbolic, harmonic, and exponential, see 3. Depending on the specific behavior of the well or group of wells being analyzed, one of the three equations will fit better than the others. For instance in cases where the well pressure is proportional to the amount of remaining oil, and where production rates are always proportional to the reservoir pressure, exponential decline would be the best fitting model. However, in cases where pressures seem to decline at a gradually slower rate as the amount of oil diminishes, and the productivity declines as the reservoir is depleted, harmonic decline would be the best fitting model. Utilizing one of these three equation types along with historic production data, the decline rate for a specific well or group of wells can be determined.

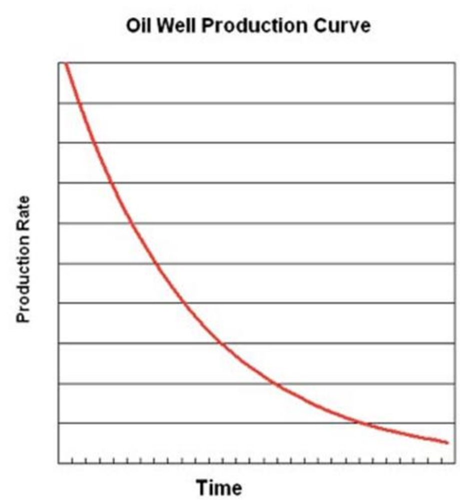

Figure 2 Example of oil well production decline curve.

In analyzing how the production from existing wells in the Uinta Basin is likely to change over the next several years, we focused on development within Uintah and Duchesne counties on state jurisdiction. The vast majority of the energy development that is occurring on state jurisdiction is oil production, for this reason this initial analysis is focused only on oil production.

3.2.1 Determining the Rate of Decline

Oil well data for our analysis was obtained from the Utah Division of Oil, Gas, and Mining (DOGM). The data that was gathered included basic information about each well within the state, as well as production data for each of those wells. A query of this data was performed to select only oil wells within Uintah and Duchesne counties. We used an eleven year production period, 2002 to 2012 for our analysis, and only utilized wells that reported at least one day of production for each year within this period. We also removed any wells with zero production in the initial year (2002). The well selection was additionally refined using GIS processing to select only wells located within state jurisdiction. This final set of wells including their cumulative yearly production, and cumulative days of production for years 2002 to 2012, were then analyzed with each of the three "Arps equations", see Note Adapted from "Analysis of Decline Curves" by J.J. Arps, 1944, Trans. *AIME,* 160, 228-247.

Figure 3. To determine how well the data fit to each model, the coefficient of determinations (R^2) were calculated and evaluated. Plots of $\log(q)$ versus t and $\log(q)$ versus $\log(t)$ were examined to help identify the correct model, and estimated decline rates were also applied to the actual production data and compared to historic values. In examining the fit of the hyperbolic model, it was determined that the estimated decline rate did not accurately reflect the historic data, therefore this method was deemed an unsuitable model for our analysis. By examining the linear-log and log-log plots from the data and R^2 values, the exponential model rather than the harmonic model, was determined to be the most suitable model. One drawback with the decline curve analysis method is that it is most accurate when applied to wells in which production conditions are relatively stable. Wells in which new technologies such as water injections, or fracking have begun to be utilized, even though they may have previously reached their steady decline period, may suddenly see production increases and production fluctuations. As a result, these wells are not good candidates for the application decline curve analysis. For this reason any wells within our dataset that did not experience a decrease in production over the 10 year period from 2002 to 2012 were not included in our analysis. For the remaining set of wells, an average decline rate of D = 0.0002329/day was calculated using the exponential model (see Decline_Curve_Analysis.xls).

Decline Curve Analysis Equations			
General governing decline rate equation:		$\frac{1}{q}\frac{dq}{dt} = -bq^d$	
	Hyperbolic Model	**Exponential Model**	**Harmonic Model**
Decline Exponent (b)	0 < b < 1	b = 0	b = 1
Flow Rate Relations	$q(t) = \frac{q_i}{[1 + bD_i t]^{\frac{1}{b}}}$	$q(t) = q_i e^{-D_i t}$	$q(t) = \frac{q_i}{[1 + D_i t]}$

Cumulative Production Relations	$N_p \;\; t \; = \frac{q_i}{D_i}[1 - e^{\,-D_i t}\,]$ **or** $N_p \;\; t \; = \frac{1}{D_i}[q_i - q(t)]$	$N_p \;\; t$ $= \frac{q_i}{(1-b)D_i}[1 - (1 + bD_i t)^{1-1/b}]$ **or** $N_p \;\; t \; = \frac{q_i}{(1-b)D_i}[1 - (\frac{q(t)}{q_i})^{1-b}]$	$N_p \;\; t \; = \frac{q_i}{D_i}\ln(1 + D_i t)$ **or** $N_p \;\; t \; = \frac{q_i}{D_i}\ln(\frac{q_i}{q(t)})$ $= -\frac{q_i}{D_i}\ln(\frac{q(t)}{q_i})$

Note Adapted from "Analysis of Decline Curves" by J.J. Arps, 1944, Trans. *AIME,* 160, 228-247.

Figure 3 Traditional Decline Curve Analysis: Governing Equations ("Arps equations")

3.2.2 Applying the Decline Rate

3.2.2.1 Base Year

From the DOGM database, the most recent year with a complete set of reported production data for oil and gas wells is 2012. For this reason in our analysis 2012 is used as the base year. All oil and gas wells and their production data for 2012 were obtained from the DOGM database. A query and subsequent GIS processing were again performed to select only producing oil wells within Uintah and Duchesne counties on state jurisdiction. For 2012, it was determined that there were 1,680 producing oil wells within state jurisdiction in Uintah and Duchesne counties producing 11,204,120 barrels of oil. The decline rate that was determined using historic production data mentioned above was then applied to the 2012 base year production value to determine how much the production from wells existing in 2012 was likely to decline in the future. Because there is some inherent uncertainty in any predictive model, and because this uncertainty increases the further out the model projects, we decided to only carry our model out 5 years from present, to the year 2018. For all producing wells in 2012 the decline rate was applied to the cumulative production from those wells and the future production from those wells in 2013 was estimated. Similarly, for all of those wells now producing in 2013, the decline rate was applied to their 2013 cumulative production and their future production for 2014 was estimated. This same method was employed for each subsequent year out to 2018 (see Application_of_Decline_Rate.xls).

3.2.2.2 Future Years

In addition to the existing wells in the basin as of our base year, 2012, there are also new wells coming online each year out to 2018. The estimated number of new wells coming online each year was determined in our future projections analysis, specifically the Uinta Basin Extrapolation, (see Uinta_Basin_Projections.xls). Additionally, the cumulative oil production for the Uinta Basin region (including production from existing and new wells) was also determined in that same analysis. However, the proportion of the cumulative production associated with either existing or new wells still needed to be determined. For our analysis we utilized both the projected cumulative oil production for each future year, 2013 to 2018, as well as our estimated future production from 2012 existing wells, taking into account their production decline. For 2013 the difference of the cumulative oil production for the region and the production just from 2012 wells, gives the amount of the total production that is associated with new 2013 wells. Similar to how existing 2012 wells declined from 2012 to 2013 and then again in each subsequent year, wells that are new in 2013 are also going to begin to age. Their production will decline from 2013 to 2014 and then again in each subsequent year. This will be true for all new wells that come online in each year; they will decline in subsequent years at the same decline rate we determined previously. For each future year the amount of the cumulative production associated with new wells will be the cumulative production minus the production associated with all of the previous year's wells, see Figure 4 and Figure 5. Using this method, the proportion of cumulative production associated with each set of wells was determined for each year from 2013 to 2018 (see Application_of_Decline_Rate.xls). In general we estimate that an overall increase in oil production in the Uinta Basin will occur. We also estimate that the proportion of the total production associated with existing wells will begin to decline, and an increasing proportion of production will be associated with the new wells that commence production each year.

Estimated 2016 Production Determination
$P_{2016} = P_{Cumulative} - (P_{d2012} + P_{d2013} + P_{d2014} + P_{d2015})$
where $P_{d2012} = P_{2012}e^{-Dt}$; $P_{d2013} = P_{2013}e^{-Dt}$; $P_{d2014} = P_{2014}e^{-Dt}$; $P_{d2015} = P_{2015}e^{-Dt}$

Figure 4 Example of determination of the proportion of total cumulative production associated with new wells. Table shows equation for estimating production associated with new wells that came on line in 2016.

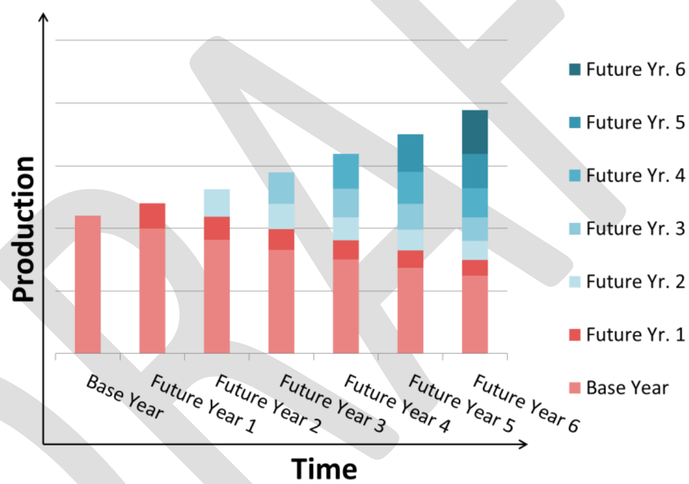

Figure 5 Example of the resulting production proportions after application of an estimated decline factor.

3.3 Calculating VOC Emissions from Production

In 2006, Environ (sponsored by the Independent Petroleum Association of Mountain States (IPAMS) and the Western Regional Air Partnership (WRAP)) conducted a study to compile baseline emissions estimates from the oil and gas industry for Utah's Uinta Basin, including Uintah, Duchesne, Carbon, Emery, and Grand County. Emissions estimates for NO_x, VOCs, CO, SO_x, and PM10 were inventoried through examining various processes of the oil and gas extraction and production cycle. Spud counts were also included to estimate the total emissions from drilling processes (http://www.wrapair2.org/emissions.aspx).

In 2009 Environ was tasked with projecting the 2006 baseline emissions to 2012. Production, well, and spud count values were analyzed and then extrapolated to the year 2012. Once values were obtained for production, well, and spud counts, a simple equation (Equation 1) could be used to create a growth (scaling) factor to be applied to the 2006 baseline emissions.

Equation (1): $F = C_2/C_1$

where:

F is the growth (scaling) factor
C_2 is the count or value for various production, well, and spud counts for the year interested in
C_1 is the count or value for various production, well, and spud counts for 2006

The 2012 emissions estimated were the product of the 2006 baseline emissions and the growth factor. To determine the appropriate growth factor for the various processes in the Uinta Basin for oil and gas, scaling parameters were used based on the well count, spud count, gas well production, oil well production, and gas well condensate. In the case of oil tanks, the scaling parameter is oil production and was the only scaling parameter currently used for this analysis.

DAQ created an emissions inventory based on the same method that Environ employed. An emissions inventory was generated for the year 2012 in which production, well, and spud values were already completed and available in the DOGM database. Production counts for Uintah and Duchesne County for the years 2006 and 2012 for oil production, producing wells, and spuds were obtained from the aforementioned database.

Production values for the year 2006 varied slightly from Environ's Phase III report, which is most likely due to amendments made by the oil and gas companies in the Uinta Basin after the report was completed in 2007. Even though values were different from the Environ report, the new totals had to be used to ensure that the growth factors were accurate for 2012. Emission estimates were then totaled for the oil production and oil well spud counts for Uintah and Duchesne County.

Since VOCs appear to be the limiting factor for ozone creation in the Uinta Basin, presently only a VOC emissions factor for tanks has been calculated. To calculate the emissions factor for oil tanks, total VOC emissions (tons per year) was divided by oil production. The factor that was used for our analysis is 0.0014745 tons per barrel of oil production. This emissions factor is applied later in our analysis to determine the change in VOC emissions over time based on the change in oil production from legacy and new wells (see Emissions_Inventory.xlsx).

Although emissions estimates were calculated only using the oil production scaling parameter to assess an emission factor for oil tanks, eventually in the future other production and scaling parameters (gas and condensate) will be calculated to look into emission factors from other elements of the energy development in the Uinta Basin. An example of using all production and scaling parameters can be found on UDAQ's website in the Uinta Basin page in the "Other Resources" section under the heading "2011 Uinta Basin Oil and Gas Emissions Estimates Technical Document". This is a project that scales 2006 WRAP emissions to 2011 for the entire Uinta Basin including state and other jurisdictions for Uintah, Duchesne, Carbon, Emery, and Grand counties (http://www.deq.utah.gov/locations/uintahbasin/index.htm).

3.3.1 Oil Tanks

According to 2012 projections from the 2006 WRAP Phase III emissions inventory, oil tanks were responsible for approximately 64% of oil related VOC emissions in Uintah and Duchesne counties. Because oil tanks represent such a large portion of the total VOC emissions in the region, for our initial analysis we focused just on the VOC emissions associated with this source. The determination of an emissions factor for oil tanks mentioned earlier provides an estimate of the amount of VOC emissions associated with each barrel (bbl) of produced oil associated with oil tanks. This emissions factor can then be multiplied by the total amount of oil production each year from 2012 to 2018. This calculation gives us an estimate of the total amount of emissions associated with oil tanks for each of those years. The emissions information determined from 2012 provides a baseline value of the current level of the emissions in the region from oil tanks. The subsequent emissions totals that we calculated for 2013 to 2018 provide a glimpse of how oil tank emissions are likely to change over the next several years in correlation to changes in production.

3.3.2 Additional Sources

As mentioned previously oil tanks are the largest contributing source of oil related VOC emissions in Uintah and Duchesne counties. Other sources also contribute to the overall oil related VOC emissions in the region. The three main sources are oil tanks, pneumatic controllers, and pneumatic pumps. These three sources are estimated to contribute a total of approximately 90% of oil related VOC emissions in the region. While this initial analysis did not incorporate any sources other than tanks, future analysis will investigate these additional contributing sources.

3.4 Emission Controls

A number of new emissions regulatory measures are beginning to become effective over the next several years. This includes federal regulations such as the NSPS and NESHAP for the oil and gas industry, potential state regulations to reduce emissions from existing sources such as pneumatic controllers and truck filling, and the ongoing permitting requirements for new and modified sources established in approval orders (AO) or general approval orders (GAO). The most important point to note about these incoming controls is that they will impact new equipment and wells, but not really have much impact on existing equipment and wells. As a result of the shift in the proportion of production associated with existing versus new wells and equipment, an increasing number of wells and equipment will begin to be impacted by these new stricter controls. This impact will be evident when looking at the emissions associated with these production values. This is similar to the familiar scenario of mobile emissions. Several years ago existing vehicles on the road did not have very strict emission controls. As these existing autos aged, more and more new vehicles with strong emissions controls were beginning to hit the road. They were replacing many of the older vehicles that were being retired. The number of new vehicles and the total number of vehicles on the road was increasing year over year, but the number of older vehicles was actually declining. Because of this, a larger percentage of the total number of vehicles on the road were impacted by the newer stricter emissions controls. The result of this was that even though there were more vehicles on the road overall, mobile emissions actually declined as a result of the implementation of new emissions controls on new vehicles. We expected to see similar results, such as those shown in Figure 6, with our analysis of the VOC emissions related to oil production in Uintah and Duchesne counties.

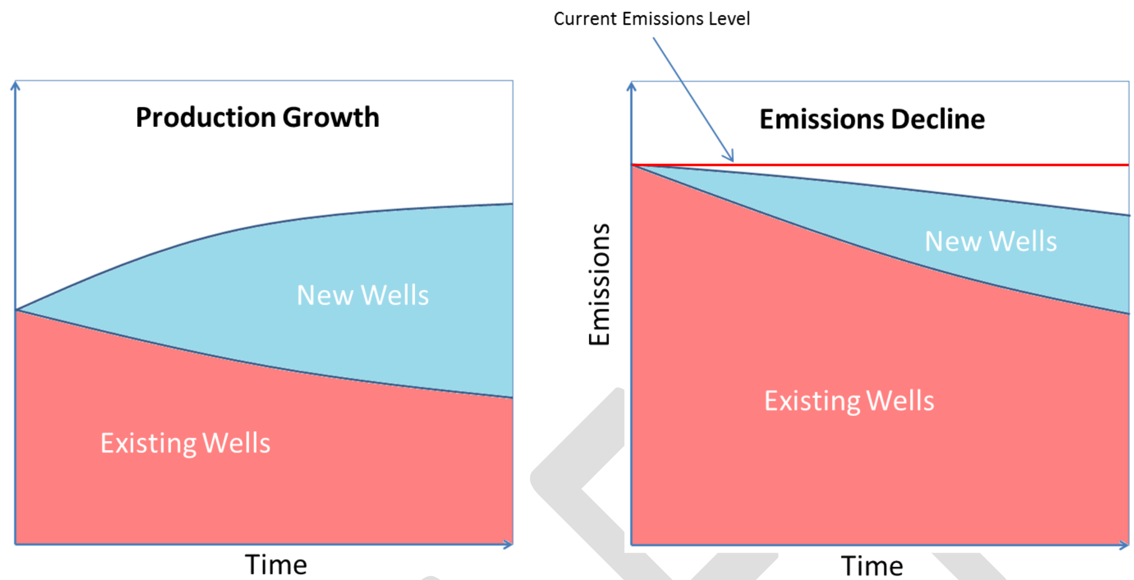

Figure 6 Shows an example of the theoretical future production growth in the Uinta Basin region and the distribution of production among existing versus new wells. The figure also shows an example of theoretical future emissions in the basin which is associated with either the production from existing or new wells. A red line denotes the theoretical current emissions level in the basin.

3.4.1 Oil Tanks Emission Controls

3.4.1.1 Existing Controls

In order to estimate the level of VOC emission reductions gained from the implementation of new controls an accurate base VOC emissions level, taking into account controls that are already in place, needed to be determined. Non-de minimis (≥ 5 TPY VOC) sources are currently required to acquire an AO and meet the necessary AO control requirements, at least best available control technology (BACT). All of the wells included in our analysis were compared to a database of existing AOs for the Uinta Basin region to determine which sources had existing permits. The percentage of cumulative production associated with permitted and controlled sources was determined to be 10%. We applied an oil tanks control level of 95%, to the VOC emissions associated with this portion of the production total. This quantity of controlled VOC emissions combined with the remaining uncontrolled VOC emissions, gives the total current VOC emissions level for oil tanks in Uintah and Duchesne counties, 14,951 TPY VOC (see Emissions_Reductions.xls).

3.4.1.2 NSPS Subpart OOOO

Oil storage tanks associated with oil and natural gas production having VOC emissions ≥ 6 TPY are subject to EPA's 2012 NSPS. The NSPS requires tanks subject to the rule to control VOC emissions by 95%, or to demonstrate that emissions from the tank have dropped to ≤ 4 TPY VOC without emission controls. The rule impacts tanks constructed after August 23, 2011. The rule includes a phased in compliance deadline. Tanks that come online after April 12, 2013 must meet the compliance deadline of

April 15, 2014, or 60 days after startup, whichever is later. Tanks that were constructed between August 23, 2011 and April 12, 2013 must meet the compliance deadline of April 15, 2015.

Using 2012 base year production data and the previously determined basin-wide tanks emission factor, 0.0014745 TPY VOC per bbl of oil, it was estimated that 42.68% of the total oil wells on state jurisdiction in Uintah and Duchesne counties have VOC emissions ≥ 6 TPY, and account for 84.59% of the total oil production. For our analysis we assumed that in the future a similar proportion of wells would have ≥ 6 TPY VOC emissions and would be responsible for a similar percentage of production. An assumption was also made that new wells come online each year at a steady rate, for example 182 days into the year approximately half of the total wells expected to come online that year, have done so. For each projected year, 2013 to 2018, the total production was divided among the percentage of wells expected to have < 6 TPY VOC emissions and not requiring emission controls, and the percentage of wells expected to have ≥ 6 TPY VOC emissions and needing controls. The wells expected to have ≥ 6 TPY VOC were then further divided into those that would come online at a time requiring them to comply with the tanks NSPS (Aug 23, 2011 - April 12, 2013 or after April 12, 2013) and those that would come online at an early enough time to bypass said controls. Any production that was determined to be impacted by the tanks NSPS, had a 95% VOC control applied to its associated emissions (see Emissions_Reductions.xls).

3.4.1.3 Additional Source Controls

For this initial analysis we focused just on the NSPS requirements for tanks, which will soon implemented. Further analyses will focus on additional controls that will impact VOC emissions. Many of these were mentioned previously in this section. As the impact of regulations on oil production in the basin evolves our analyses will be updated to include those regulations as needed.

3.5 Emissions Reductions

After calculating the VOC emissions associated with declining existing wells, the growing number of new wells, and including the emissions impact of both existing and future VOC emissions control strategies, these estimate were combined to determine an estimate of cumulative VOC emissions for each year 2012 to 2018. The resulting cumulative emissions are shown below in Table 4. From 2012 to 2018 we estimate approximately a 130% increase in oil production from 11,204,120 bbls to 25,849,202 bbls. At the same time we estimate that if left uncontrolled emissions would also increase 130% over that same period. However, after accounting for declining emissions from existing wells, as a result of natural production decline, and accounting for the new NSPS requirements for tanks, which will begin to be implemented in April of 2014, we estimate approximately a 24% decrease in VOC emissions from 14,951 TPY VOC to 11,425 TPY VOC (see Emissions_Reductions.xls).

Table 4 Analysis result showing projected production, VOC emissions without controls, and VOC emissions with the implementation of controls.

Uintah and Duchesne Counties Future Oil Emissions Estimates (b2)																					
	2012	2012	2012	2013	2013	2013	2014	2014	2014	2015	2015	2015	2016	2016	2016	2017	2017	2017	2018	2018	2018
	Oil Prod	VOC	VOC	Oil Prod	VOC	VOC	Oil Prod	VOC	VOC	Oil Prod	VOC	VOC	Oil Prod	VOC	VOC	Oil Prod	VOC	VOC	Oil Prod	VOC	VOC
	(BBL)	(TPY)	(TPY)	(BBL)	(TPY)	(TPY)	(BBL)	(TPY)	(TPY)	(BBL)	(TPY)	(TPY)	(BBL)	(TPY)	(TPY)	(BBL)	(TPY)	(TPY)	(BBL)	(TPY)	(TPY)
		w/o cntrl	w/ cntrl		w/o cntrl	w/ cntrl		w/o cntrl	w/cntrl		w/o cntrl	w/cntrl		w/o cntrl	w/cntrl		w/o cntrl	w/cntrl		w/o cntrl	w/cntrl
Wells as of 2012	11,204,120	16,521	14,951	10,291,020	15,175	13,733	9,452,335	13,938	12,614	8,681,999	12,802	8,839	7,974,444	11,759	6,979	7,324,552	10,800	6,410	6,727,625	9,920	5,888
2013 New Wells				2,588,193	3,816	3,816	2,377,264	3,505	2,053	2,183,524	3,220	838	1,956,721	2,885	567	1,842,126	2,716	533	1,691,999	2,495	490
2014 New Wells							2,975,145	4,387	1,887	2,732,680	4,029	791	2,509,975	3,701	727	2,305,420	3,399	668	2,117,536	3,122	613
2015 New Wells										3,419,950	5,043	990	3,141,235	4,632	910	2,885,235	4,254	836	2,650,097	3,908	767
2016 New Wells													3,931,256	5,797	1,138	3,610,871	5,324	1,046	3,316,597	4,890	960
2017 New Wells																4,519,005	6,663	1,309	4,150,721	6,120	1,202
2018 New Wells																			5,194,628	7,660	1,504
TOTALS	**11,204,120**	**16,521**	**14,951**	**12,879,213**	**18,991**	**17,549**	**14,804,743**	**21,830**	**16,554**	**17,018,154**	**25,094**	**11,458**	**19,513,632**	**28,774**	**10,321**	**22,487,210**	**33,158**	**10,801**	**25,849,202**	**38,116**	**11,425**

4.0 Summary

When evaluating the impact of new or modified sources of VOC in the Uinta Basin through the permitting process, DAQ must ensure that new sources are not making the ozone problem that occurs during wintertime inversions worse. The purpose of this analysis is to evaluate the expected growth of the oil and gas industry in Duchesne and Uintah Counties between 2013 and 2018 and to determine whether new sources will cause or contribute to a violation of the ozone standard. The analysis shows that even with oil production increasing substantially in the Basin, overall VOC emissions will decline because well sites with new storage tanks that are subject to stringent control requirements are replacing production from existing well sites with uncontrolled storage tanks. Under conservative assumptions outlined in this analysis, DAQ projects that new permits will not increase the ozone burden during winter inversions.

DAQ believes that this method can serve as an effective screening tool to support the goal of evaluating the impact of additional permitting in the Basin while at the same time working to decrease the amount of pollution from continued oil and gas production. While there is uncertainty in any forecast, the method of extrapolation from historical data is a conservative estimate of growth; especially as compared to the EIA projection. There is also uncertainty in the overall emissions inventory and it is hoped that with a persistent effort to improve the inventory, this uncertainty will decrease over time.

DAQ makes no assumptions that other agencies with regulatory authority such as the Ute Tribe, EPA, BLM, or other federal agencies, would choose to use this method. However, it is DAQ’s intention to extend this approach if, after a full review of the method and results, other land managers see benefit to extending this analysis.

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