

WRAP Oil & Gas:

2002/2005 and 2018 Area Source Controls Evaluation



**WRAP
SSJF Oil and Gas
Work Group Members
and Other Interested Parties**

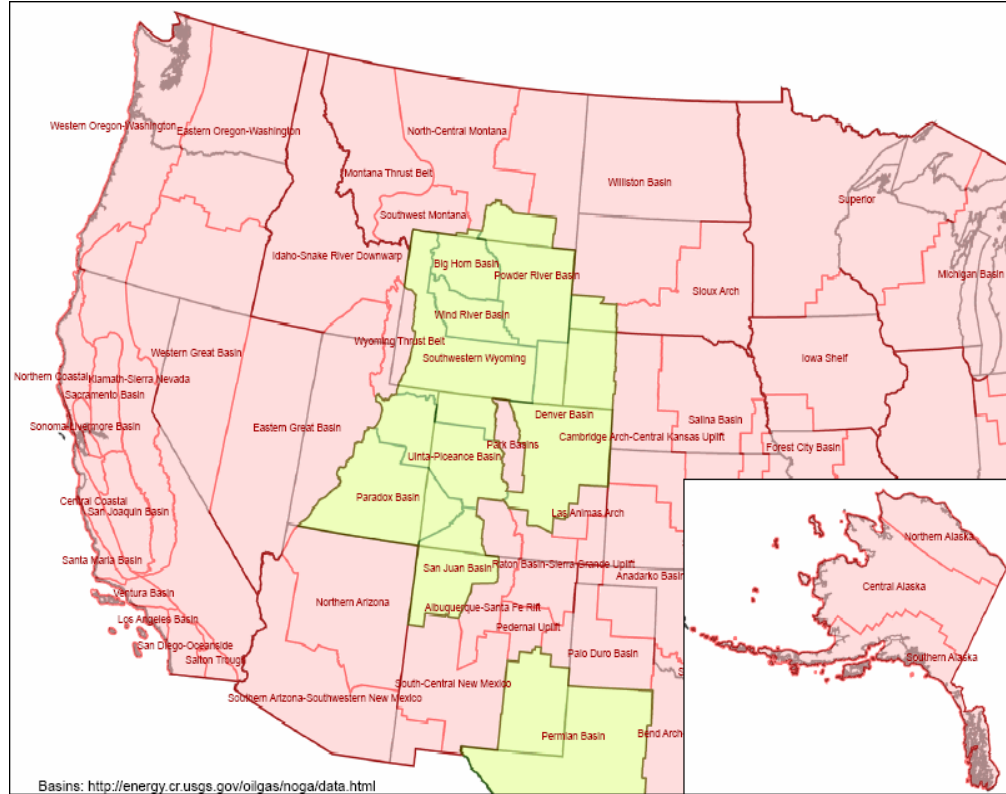
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WRAP Phase II Project Overview

- Project is focused on developing an improved emissions inventory of oil and exploration and production area sources in the WRAP region
- Area source categories include compressor engines, drilling rigs, heaters and other wellhead equipment
- Previous emission inventory (EI) efforts:
 - WRAP Phase I analysis, 2002 and 2018 (completed 2005)
 - NMED EI for San Juan and Rio Arriba counties (completed 2006)
- Specific objectives of the Phase II project:
 - Emissions inventory improvements for 2002
 - Current base year updates for 2005
 - 2018 growth factor projections improvements
 - Control technology evaluations and control strategies scenarios
 - 2018 point source SO₂ emissions improvements

Western States Oil & Gas Regions of Interest



Major basins of O&G activity in Phase II analysis:

Permian Basin (NM)

San Juan Basin North (CO)

Denver-Julesburg Basin (CO)

Green River Basin (WY)

Big Horn Basin (WY and MT)

San Juan Basin South (NM)

Uinta-Piceance Basin (CO and UT)

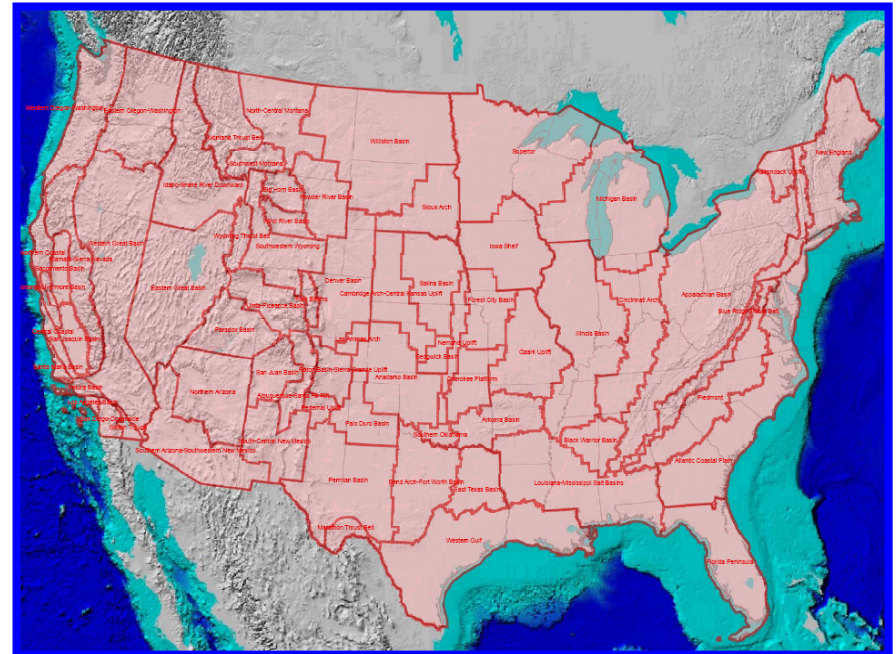
Paradox Basin (UT)

Wind River Basin (WY)

Powder River Basin (WY and MT)

2002 Emissions Inventory Improvements

- New methodology estimated 2002 emissions on a basin-wide average basis for all basins in the WRAP region, focusing on those basins where major O&G activities are occurring and detailed producer information was provided
- In basins where significant activity was not occurring, or producer information was unavailable, used Phase I estimates



Brief Overview of Methods

- Basin-specific emissions estimates were made using activity and equipment information provided directly by the producers
 - Previous Phase I work used available data from limited areas and generalized to WRAP region
- For Phase II EI improvements, focus was on well-head compressors and drilling rigs as area sources
- Focused basin list only – these are the areas where major oil and gas activity is occurring or expected to occur
- Updated baseline emissions year from 2002 to 2005
- Revised 2018 projections using most recent planning information available and producer data where available

2018 Emissions

- Emissions included updated growth projections from Resource Management Plans, Alaska Oil & Gas Report, and National Energy Forecast released by the Energy Information Administration (EIA)
- State controls evaluated:
 - Wyoming BACT requirements for permitted sources
 - Colorado controls requirements for point sources (ERG)
 - Utah BACT requirements for compressors
- Federal controls evaluated:
 - Federal nonroad engine standards
 - EPA nonroad diesel fuel sulfur content standards

2018 Emissions Projections

Drilling Rigs - TPY

	NOx		SOx		VOC	
	2005	2018	2005	2018	2005	2018
Alaska	835	452	62	1	0	0
Arizona	0	0	0	0	0	0
Colorado	8,000	4,413	350	11	308	155
Montana	3,007	2,821	640	6	3	10
Nevada	37	21	1	0	0	0
New Mexico	8,640	5,343	362	3	111	68
North Dakota	3,055	1,655	688	4	0	0
Oregon	0	0	0	0	0	0
South Dakota	203	118	43	0	0	0
Utah	2,888	944	149	1	106	31
Wyoming	15,783	9,883	541	3	714	407
WRAP Total	42,448	25,652	2,835	29	1,242	671

2018 Emissions Projections

Compressor Engines - TPY

	NOx		SOx		VOC	
	2005	2018	2005	2018	2005	2018
Alaska	0	0	0	0	0	0
Arizona	6	8	0	0	0	0
Colorado	3,302	4,006	0	0	1,225	1,485
Montana	2,267	3,946	0	0	10	421
Nevada	33	40	0	0	0	0
New Mexico	35,345	47,599	1	1	3,542	4,879
North Dakota	2,799	18,399	0	0	0	0
Oregon	51	37	0	0	0	0
South Dakota	305	368	0	0	0	0
Utah	996	164	0	0	64	91
Wyoming	3,288	655	0	0	459	464
WRAP Total	48,393	76,399	1	1	5,300	7,340

Controls Evaluated

- Developed a series of white papers on control technologies for drill rigs and compressors and some VOC sources
- White papers include only those technologies deemed technically feasible now
- List of control technologies includes:
 - Engine modifications (e.g., lean-burn engines, ignition timing)
 - Aftertreatment control devices (e.g., catalysts, exhaust gas recirculation)
 - Engine replacement/repowering
 - VOC controls (e.g., dehydrators, pneumatics)

White Papers

- Control effectiveness
- Capital and Operating Cost
- Potential emissions reduction
- Cost-effectiveness (\$/ton)

Sources of Information

- ENVIRON Field Tests
 - Pilot Project to Assess the Effectiveness of an Emission Control System for Gas Compressor Engines in Northeast Texas – 2006
- Selected Studies and Sources of Information
 - Technology Demonstration Report – Selective Catalytic Reduction and Bi-Fuels Implementation on Drill Rig Engines, prepared for Shell Rocky Mountain Production LLC and Ultra Petroleum Inc., Pinedale, WY, June 2006.
 - Manufacturers of Emissions Control Association, Stationary Engine Emission Control, May 2002
 - Personal Communications with Emission Control Equipment Manufacturers
- 4 Corners Air Quality Task Force (AQTF)
 - Draft Report of Mitigation Options, Version 5, January 10, 2007 (update this)
 - Conference Calls with the Mitigation Options Workgroup

Sources of Information (continued)

- EPA Natural Gas Star Program
 - Lessons Learned from Best Management Practices
 - Technology Reports on Best Management Practices
- U.S. EPA Control Technology Guidelines
 - Stationary Reciprocating Internal Combustion Engines, Alternative Control Techniques Document, EPA-453/R-93-032
 - Final Regulatory Support Document: Control of Emissions from New Marine Compression-Ignition Engines Above 30 Liters Per Cylinder EPA-420-R-03-004
- California Air Resources Board RACT/BARCT Determinations
 - Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Stationary Spark-Ignited Internal Combustion Engines - 2001
- NESCAUM Studies
 - Stationary Diesel Engines in the Northeast: An Initial Assessment of the Regional Population, Control Technology Options, and Air Quality Policy Issues – 2003
 - Status Report on NO_x Controls for Gas Turbines, Cement Kilns, Industrial Boilers, Internal Combustion Engines, Technologies and Cost Effectiveness, Northeast States for Coordinated Air Use Management, December 2000.

Summary of Control Options Under Consideration: Compressor Engines

Measure No.	Category	Control Measure Name ¹	Pollutant	Control Efficiency (%)
CE-1	Compressor Engines-Rich Burn	NSCR	NOx	90 to 98
			HC	50
CE-2	Compressor Engines, SI and CI	AFR	NOx	10 to 40
CE-3	Compressor Engines, SI and CI	ITR	NOx	15 to 30
CE-4	Compressor Engines, SI and CI	AFR + ITR	NOx	10 to 40
CE-5	Compressor Engines, Rich Burn	PSC	NOx	80
CE-6	Compressor Engines, SI	L-E	NOx	80
CE-7	Compressor Engines, Lean Burn	SCR	NOx	80
CE-8	Compressor Engines, All	Replace Engine	NOx	60 to 100
CE-9	Compressor Engines, All	Fuel Switching	NOx	30

¹ NSCR - Non-selectic catalytic reduction AFR - Air Fuel Ratio Control, ITR - Ignition Timing Retard, PSC - Prestratified Charge, L-E - Low Emission Engine, SCR - Selective Catalytic R, eduction, EGR - Exhaust Gas Recirculation, CEC - Crankcase Emission Control, DPF - Diesel Particulate Filter, DOC - Diesel Oxidation Catalyst, LNC - Lean NOx Catalyst, NG - Natural Gas, VRU - Vapor Recovery Unit

Summary of Control Options Under Consideration: Drilling Rigs

Measure No.	Category	Control Measure Name ¹	Pollutant	Control Efficiency %
DER-1	Drilling Rig Engines	ITR	NOx	15 to 30
DER-2	Drilling Rig Engines	SCR	NOx	80 to 95
DER-3	Drilling Rig Engines	EGR	NOx	40
DER-4	Drilling Rig Engines	CEC	PM	6 to 23
DER-5	Drilling Rig Engines	DPF	PM	85
			HC	90
DER-6	Drilling Rig Engines	DOC	PM	25
			HC	90
DER-7	Drilling Rig Engines	LNC	NOx	10 to 20
DER-8	Drilling Rig Engines	Low S	PM	14
		NG	NOx	85 to 90
			PM	50 to 80
		Emulsion	NOx	20
			PM	17

¹ NSCR - Non-selectic catalytic reduction AFR - Air Fuel Ratio Control, ITR - Ignition Timing Retard, PSC - Prestratified Charge, L-E - Low Emission Engine, SCR - Selective Catalytic R, eduction, EGR - Exhaust Gas Recirculation, CEC - Crankcase Emission Control, DPF - Diesel Particulate Filter, DOC - Diesel Oxidation Catalyst, LNC - Lean NOx Catalyst, NG - Natural Gas, VRU - Vapor Recovery Unit

Summary of Control Options Under Consideration: Other Wellhead Sources

Measure No.	Category	Control Measure Name ¹	Pollutant	Control Efficiency %
EAP-1	Glycol Dehydration	Optimize Circulation	VOC	33 to 67
		Electric Pump	VOC	67
		Flash Tank	VOC	10 to 40
		Desiccant	VOC	99
EAP-2	Pneumatic Controls	Instrument Air	VOC	98
		Non-Bleed	VOC	98
EAP-3	Completion Venting and Flaring	Flaring	VOC	62 to 84
		Green Completion	VOC	70
EAP-4	Tanks	VRU	VOC	95
		Water Blanket	VOC	TBD

¹ NSCR - Non-selective catalytic reduction, AFR - Air Fuel Ratio Control, ITR - Ignition Timing Retard, PSC - Prestratified Charge, L-E - Low Emission Engine, SCR - Selective Catalytic Reduction, EGR - Exhaust Gas Recirculation, CEC - Crankcase Emission Control, DPF - Diesel Particulate Filter, DOC - Diesel Oxidation Catalyst, LNC - Lean NOx Catalyst, NG - Natural Gas, VRU - Vapor Recovery Unit

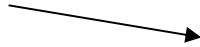
Controls Analysis

- Compressor Engines
 - Cost-effectiveness and NOx reduction potential estimated for range of compressor engines across WRAP region
 - Engine size ranged from 50 hp – 300+ hp
- Drilling Rigs
 - Cost-effectiveness and NOx reduction potential estimated for range of drilling rigs across WRAP region
 - If multiple engines are present on a single rig, control is applied to all engines and the overall “rig” cost-effectiveness and NOx reduction potential reported
 - Drilling rig engines sizes vary from 200 hp – 1500 hp
 - Drilling rig engines vary widely in activity

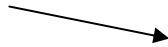
Controls Analysis – Example Calculation: Drilling Rigs

	CATERPILLAR D398	
	Baseline	SCR
Operating Fraction (%/yr)	0.75	0.75
Annual usage (hr/yr)	6,570	6,570
Annualized Capital Cost		\$142,645
Useful Life (years)	10.0	10.0
NOx Emission Factor (g/bhp-hr)	8.94	1.12
VOC Emission Factor (g/bhp-hr)	0.11	0.11
Engine Size (bhp)	967	967
Avg. Load	0.68	0.68
NOx g/hr	5879	735
VOC g/hr	72	72
NOx tons/year	42.57	5.32
VOC tons/year	0.52	0.52
NOx Reduction tons/year		37.25
VOC Reduction tons/year		0.00
Annualized Cost-Effectiveness (NOx Only)		\$3,829
Annualized Cost-Effectiveness (VOC Only)		N/A

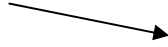
Varies with geographic area, average is based on available data from producers



Varies by basin, calculation conducted for each basin



No anticipated VOC reduction for this example control measure



Summary of Emissions Reductions and Cost-Effectiveness: Drill Rigs

Measure No.	Control Measure Name	Control Efficiency %	NOx Reduction [tpy]	Cost-Effectiveness [\$ /ton]
DRE-1	ITR	15 to 30	6.6 to 17.2	1,000 to 2,200
DRE-2	SCR	80 to 95	25.8 to 66.8	3,000 to 7,700
DRE-3	EGR	40	11.8 to 30.6	800 to 2,000
DRE-7	LNC	10 to 20	4.4 to 11.5	1,400 to 3,400
DRE-8	Low S Diesel	14	TBD	TBD
DRE-8	NG	85 to 91	TBD	TBD
DRE-8	Emulsified Diesel	20	5.9 to 15.3	4,500 to 11,600
DRE-9	Tier 2 to Tier 4 Replacement	43 to 93	7.8 to 33.6	900 to 2,400
DRE-9	Tier 3 to Tier 4 Replacement	43 to 89	4.7 to 20.1	900 to 2,000

Summary of Emissions Reductions and Cost-Effectiveness: Compressor Engines

Measure No.	Control Measure Name	Control Efficiency %	NOx Reduction [tpy]	Cost-Effectiveness [\$ /ton]
CE-1	NSCR	90 to 98	1.0 to 45.3	200 to 7,900
CE-2	AFR	10 to 40	0.3 to 12.1	100 to 2,500
CE-3	ITR	15 to 30	0.3 to 10.8	100 to 1,200
CE-4	AFR + ITR	10 to 40	0.3 to 12.1	100 to 3,600
CE-5	PSC	80	0.9 to 38.5	100 to 3,000
CE-6	L-E	80	0.9 to 38.5	100 to 2,600
CE-7	SCR	80	0.9 to 38.5	900 to 31,000
CE-8	Replace Engine	60 to 100	0.9 to 38.5	100 to 4,700

Control Options: Summary

- For drill rigs most controls fall within the \$750/ton-NO_x - \$2000/ton-NO_x range
 - Exceptions for emulsified fuel, SCR systems which have higher cost-effectiveness
- For compressor engines most controls have C-E values \$1000/ton-NO_x or below except SCR/NSCR
- Further information needed on bi-fuel engines and cost – NG cost, infrastructure, piping, etc.

2018 Emissions Control Scenarios Planned To be completed

- For each viable control technology, will estimate emissions reduction potential for O&G area sources in each state
- Analysis will focus on compressors and drill rigs only
- Scenarios will show emissions reductions for a range of
 - Growth projections
 - Control technology penetration rates
- Estimated costs will be provided for each scenario