International Emissions Inventory Conference

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Integrating State Data & the National Oil and Gas Emissions Inventory Tool: The Oklahoma Experience

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OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

Acknowledgments

Support from OKDEQ, including the hard work of the following staff:

- Mark Gibbs, Louise Esjornson, Tom Richardson, Lindsay Ross, Shelby Willeby, Carrie Schroeder, Cecelia Kleman, Cooper Garbe, Justin Milton, Jay Laughlin, Shannon Hill, Hanna Bentley

Help from ERG and Ramboll-Environ:

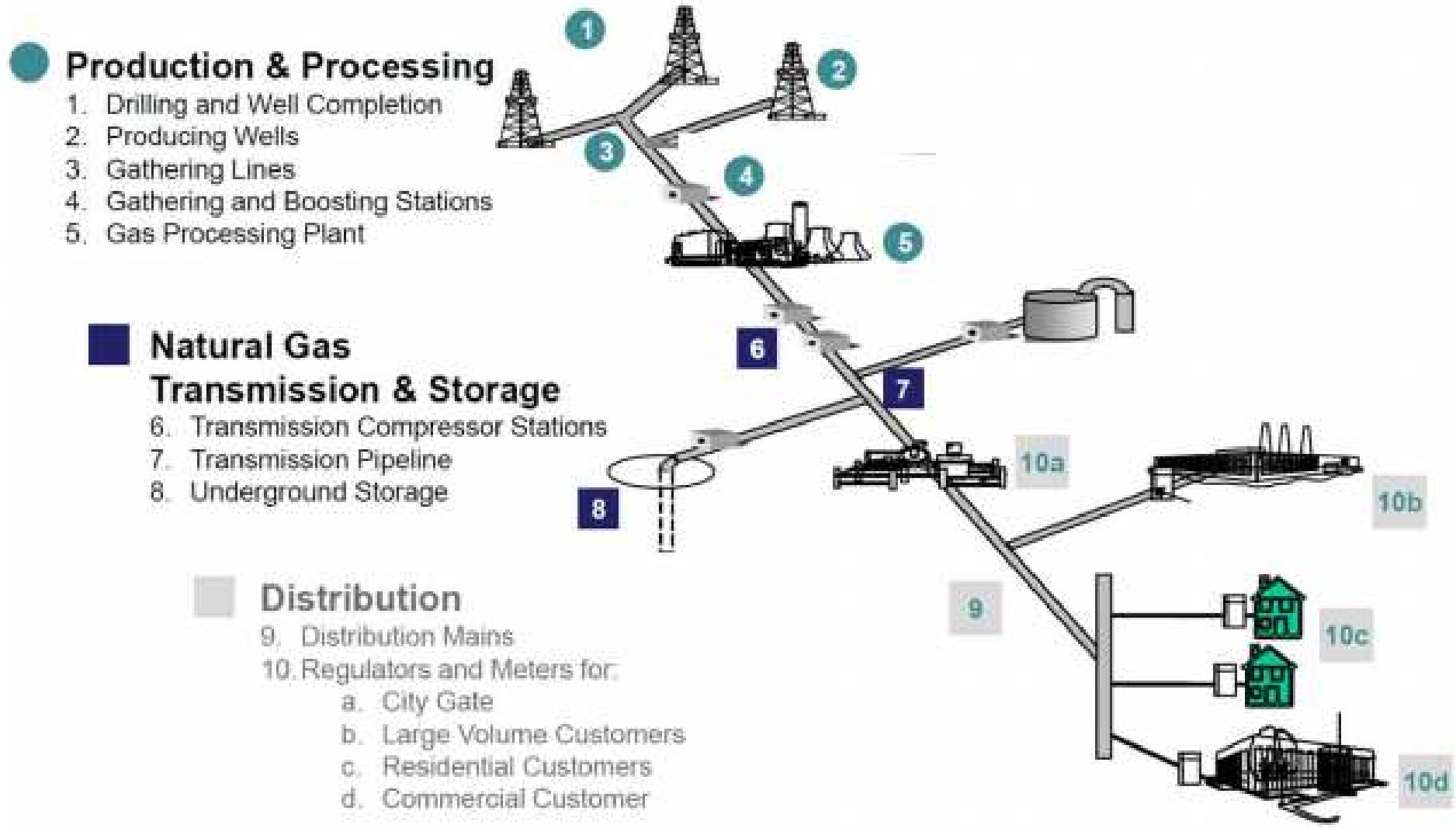
- Regi Oommen, Mike Pring
- John Grant, Amnon Bar-Ilan

Assistance from EPA:

- Jennifer Snyder

Oklahoma Oil & Gas NEI Submission History

	Before 2008	2008 NEI	2011 NEI	2014 NEI
Wellhead	Not Inventoried	CENRAP Study	Oil & Gas Tool	Oil & Gas Tool + Aggregated Permitted Wells
Midstream	Minor Facilities Not Reported	Aggregated Midstream Emissions	Point Source Midstream Emissions	Point Source Midstream Emissions
Major Point Sources	Type A & B Actuals	Type A & B Actuals	Type A & B Potential	Type A & B Potential



Source: (EPA 2014a)

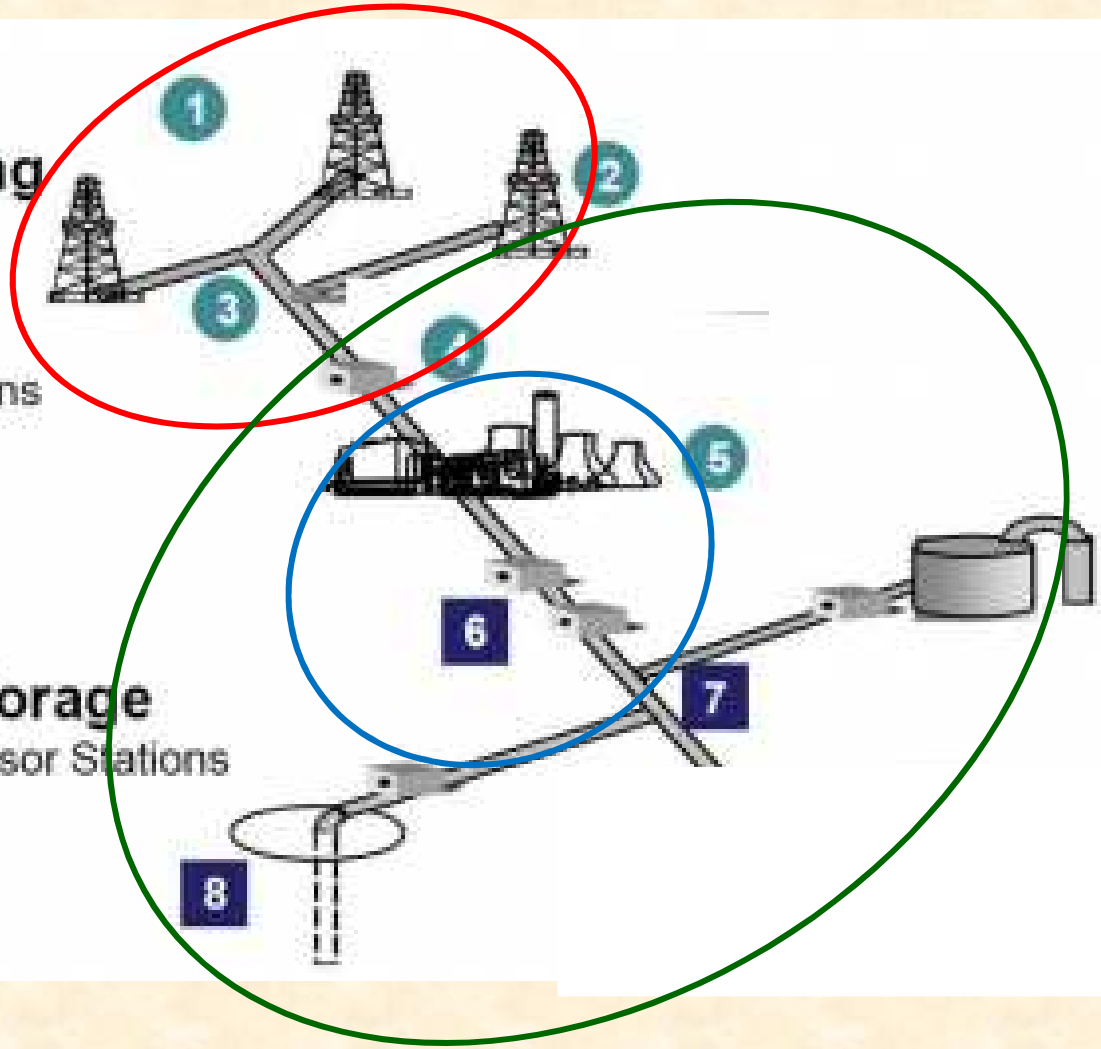
- **Oil and Gas Tool + Aggregated Permitted Wells**
- **Point Source Midstream Emissions**
- **Type A & B Potential Point Sources**

Production & Processing

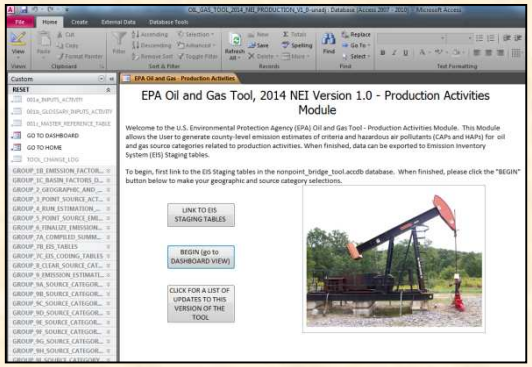
1. Drilling and Well Completion
2. Producing Wells
3. Gathering Lines
4. Gathering and Boosting Stations
5. Gas Processing Plant

Natural Gas Transmission & Storage

6. Transmission Compressor Stations
7. Transmission Pipeline
8. Underground Storage



Oklahoma Area Source Oil & Gas Production Emissions



2014 O&G Production Tool

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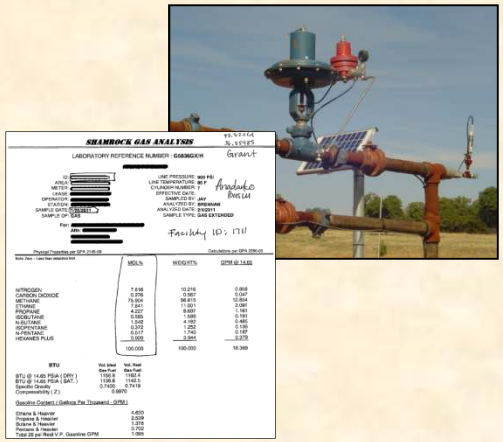

Oklahoma Changes

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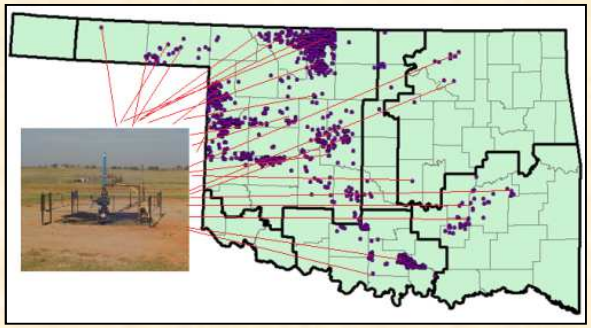

Point Source Inventories from Permitted Wellheads

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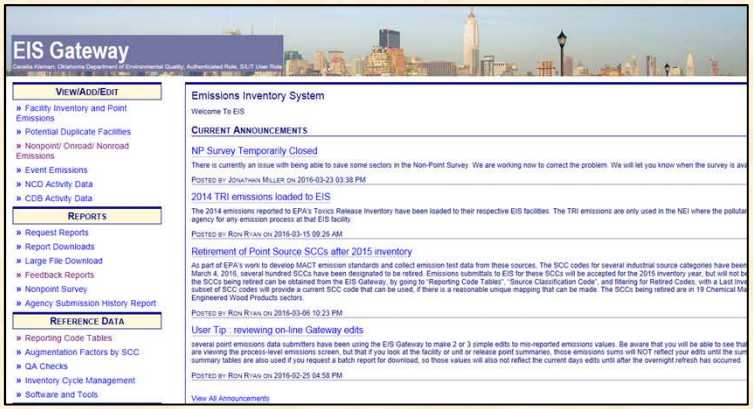


2014 NEI Area Oil and Gas Submission to EIS

Oklahoma Modifications: What is Different?

- **OKDEQ Gas Composition**: We used gas composition data for the 15 counties where we had sufficiently representative data
- **Pneumatic Devices**: We incorporated the results of an Oklahoma Independent Petroleum Association (OIPA) study on pneumatic devices performed in Oklahoma (normal operations + malfunctions)
- **Wellhead Point Source Inventory Data**: We incorporated point source inventory data from over 4,000 oil and gas wellheads into our area source submission
  - This number of wells and their associated activity was removed from the Tool

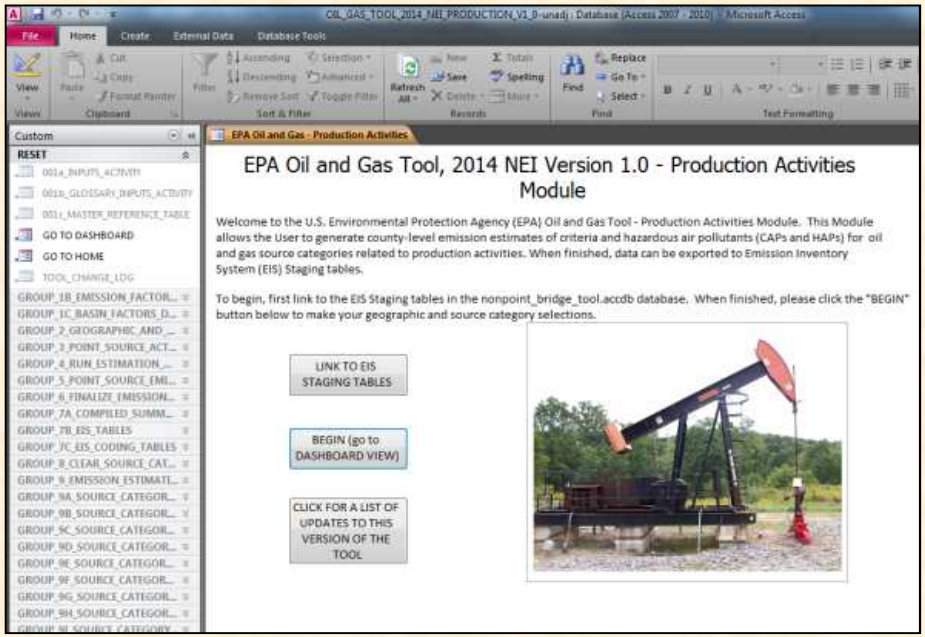
Area Oil & Gas Emissions Estimation Tool

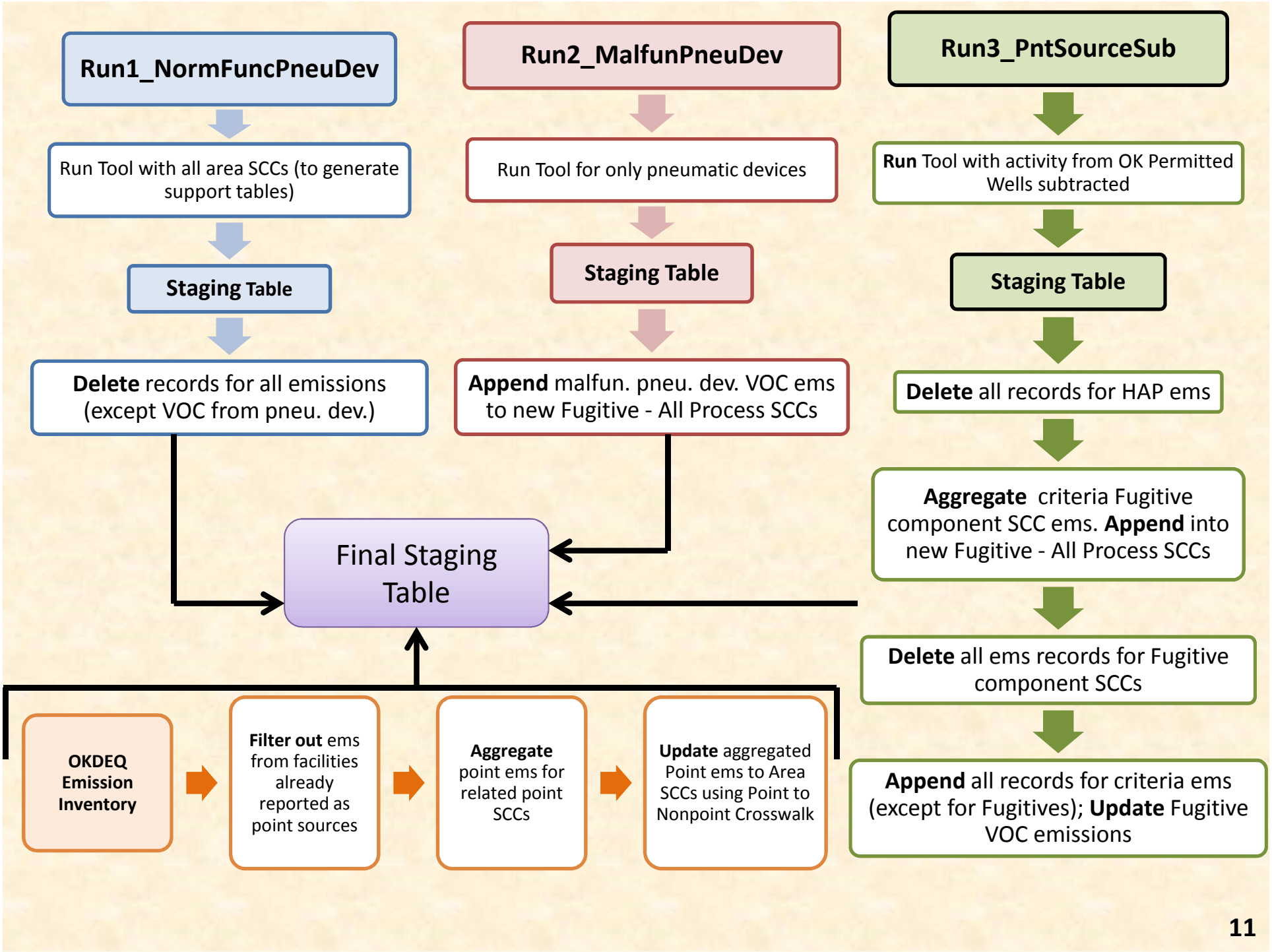
- **Goal:** To capture the best estimate of criteria pollutant and HAP emissions from the Production oil and gas sector across the state of Oklahoma
  - Involved many runs of the tool, and manipulation of the staging tables
  - **Main objective:** prioritize getting point source emissions into the final staging table over perfecting the point to nonpoint crosswalk (TONS matter more than SCCs)
  - EPA/ERG performed HAP augmentation to better characterize HAP emissions from OK point (and nonpoint) sources

Overview of Our Approach

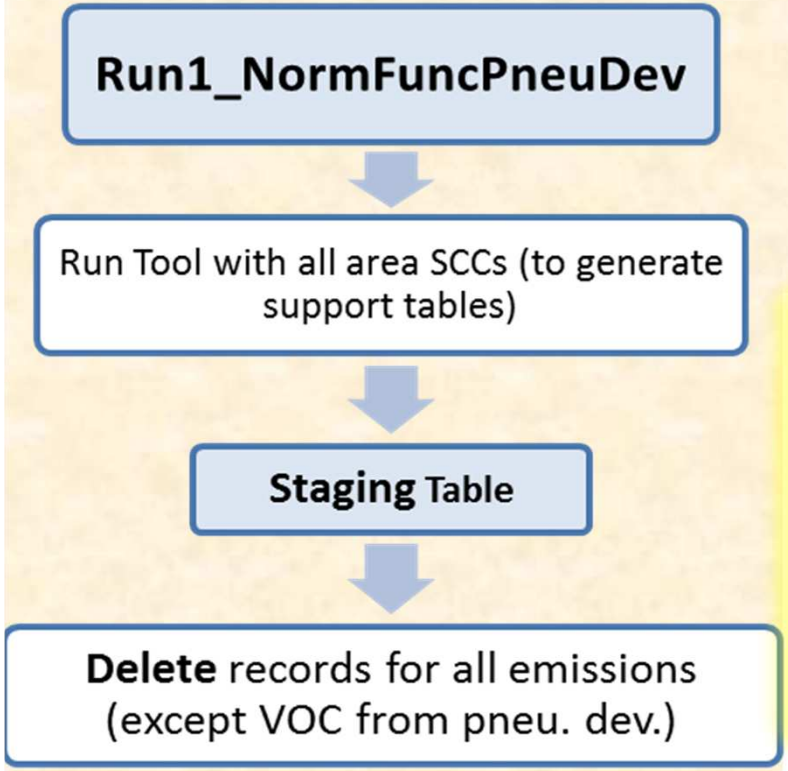
- **Tool Scenario Runs:** Running the O&G tool with different source categories, basin factors, speciation profiles, etc.
- **Procedures:** Adding emissions from the different scenario runs, and from the OKDEQ point emission inventory to the final staging tables
- **Analysis:** Examine VOC & NOx emission totals and the differences between permitted wells and unpermitted wells

Tool Scenario Runs

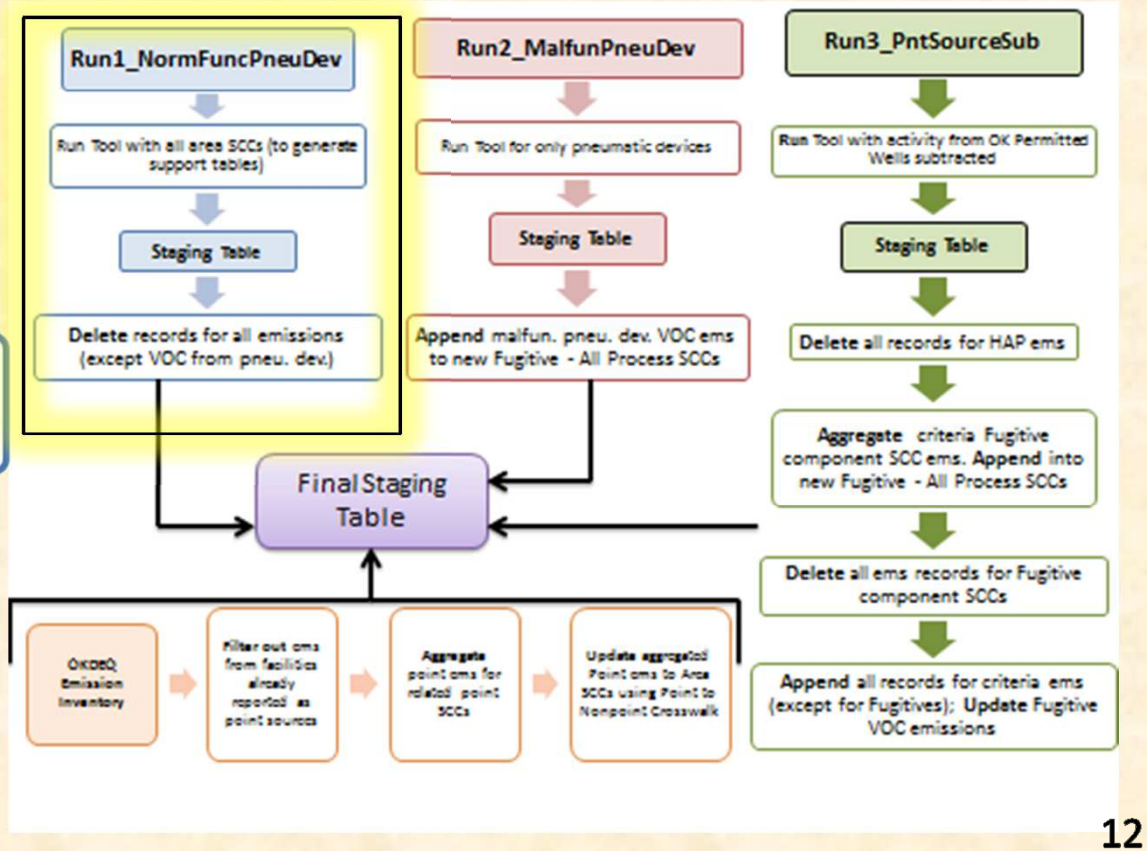



Run1_NormFuncPneuDev
Run Tool with all area SCCs (to generate support tables)
Staging Table
Delete records for all emissions (except VOC from pneu. dev.)
Run2_MalfunPneuDev
Run Tool for only pneumatic devices
Staging Table
Append malfun. pneu. dev. VOC ems to new Fugitive - All Process SCCs
Run3_PntSourceSub
Run Tool with activity from OK Permitted Wells subtracted
Staging Table
Delete all records for HAP ems
Aggregate criteria Fugitive component SCC ems. Append into new Fugitive - All Process SCCs
Delete all ems records for Fugitive component SCCs
Append all records for criteria ems (except for Fugitives); Update Fugitive VOC emissions
Final Staging Table
OKDEQ Emission Inventory
Filter out ems from facilities already reported as point sources
Aggregate point ems for related point SCCs
Update aggregated Point ems to Area SCCs using Point to Nonpoint Crosswalk

Run1_NormFuncPneuDev



STEP 1: Produce VOC emissions from normally-functioning pneumatic devices



Run1_NormFuncPneuDev

- Run of the tool that generates emissions from **normally functioning pneumatic devices**
- Includes:
  - OKDEQ local gas composition data (speciation profiles for pneumatic devices)
  - Pneumatic device basin factor data for normally functioning pneumatic devices (OIPA, 2014)
  - Running all area SCCs to generate support tables; only emissions from normally functioning pneumatics are kept

Run1_NormFuncPneuDev

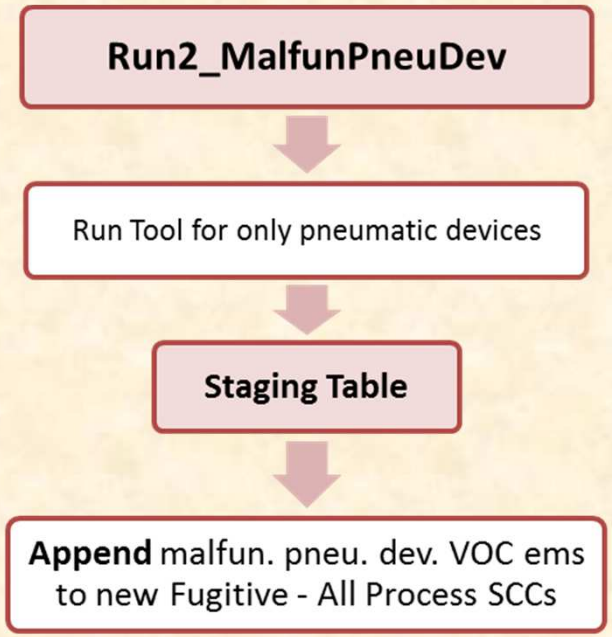
BASIN FACTOR - DATA_CATEGORY	CURRENT_VALUE	CURRENT_REFERENCE
Number of No Bleed devices (COUNT)		OIPA_STUDY_2014
Bleed rate, No Bleed devices (SCF/HR/DEVICE)		OIPA_STUDY_2014
Number of Low Bleed devices (COUNT)		OIPA_STUDY_2014
Bleed rate, Low Bleed devices (SCF/HR/DEVICE)		OIPA_STUDY_2014
Number of High Bleed devices (COUNT)		OIPA_STUDY_2014
Bleed rate, High Bleed devices (SCF/HR/DEVICE)		OIPA_STUDY_2014
Number of Intermittent Bleed devices (COUNT)	3.6	OIPA_STUDY_2014
Bleed rate, Intermittent Bleed devices (SCF/HR/DEVICE)	1.05	OIPA_STUDY_2014

OIPA Basin Factors: for **normally** functioning pneumatic devices.

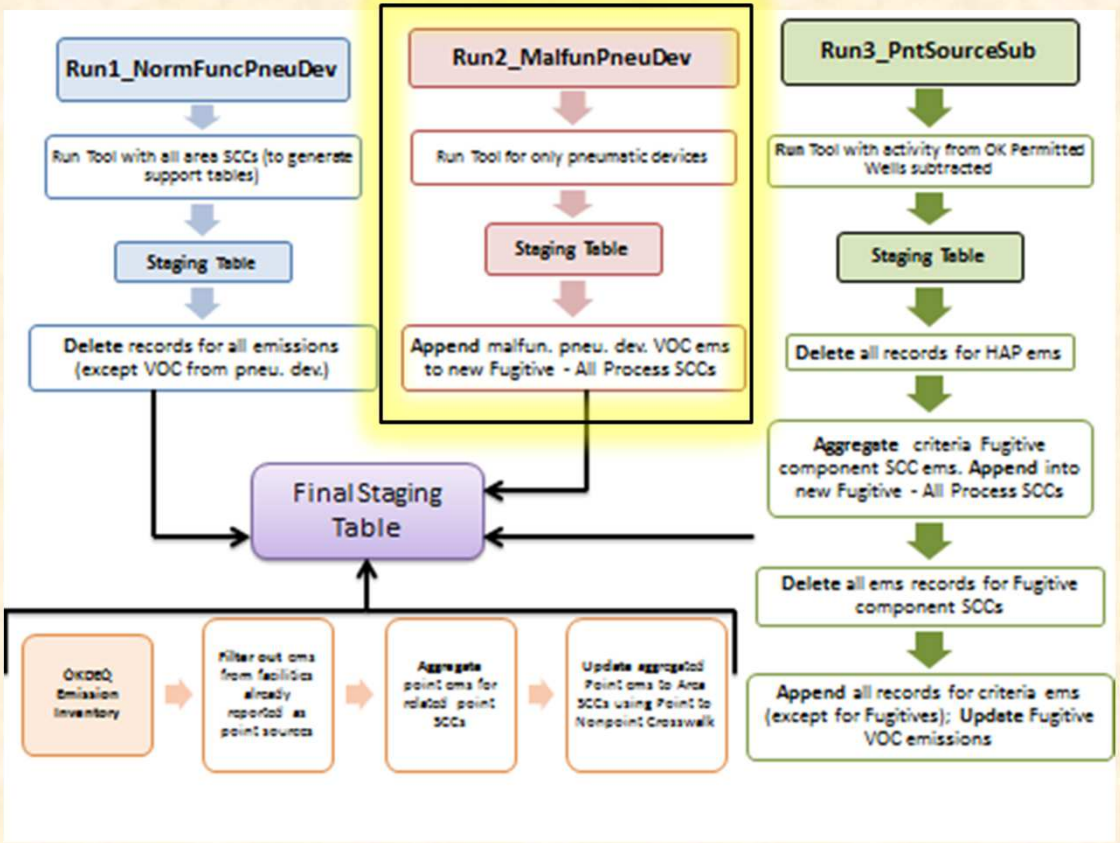
OKDEQ Speciation Profiles: calculated only for counties with at least 10 unique sales gas composition analyses

County	Reference	Alfalfa
MW of vented gas (G/MOL)	OKDEQ_STUDY_2015	19.87562
Wt Frac VOC	OKDEQ_STUDY_2015	0.17202
Wt Frac H2S	OKDEQ_STUDY_2015	0.00000
Wt Frac CO2	OKDEQ_STUDY_2015	0.01119
Wt Frac CH4	OKDEQ_STUDY_2015	0.68427
Wt Frac Benzene/VOC	OKDEQ_STUDY_2015	0.00000
Wt Frac E-Benzene/VOC	OKDEQ_STUDY_2015	0.00000
Wt Frac Toluene/VOC	OKDEQ_STUDY_2015	0.00000
Wt Frac Xylene/VOC	OKDEQ_STUDY_2015	0.00000
Wt Frac CH4/VOC	OKDEQ_STUDY_2015	4.21549
Wt Frac H2S/VOC	OKDEQ_STUDY_2015	0.00000

Run2_MalfunPneuDev



STEP 2: Add VOC emissions from malfunctioning pneumatic devices to Fugitives: All Process SCCs



Run2_MalfunPneuDev

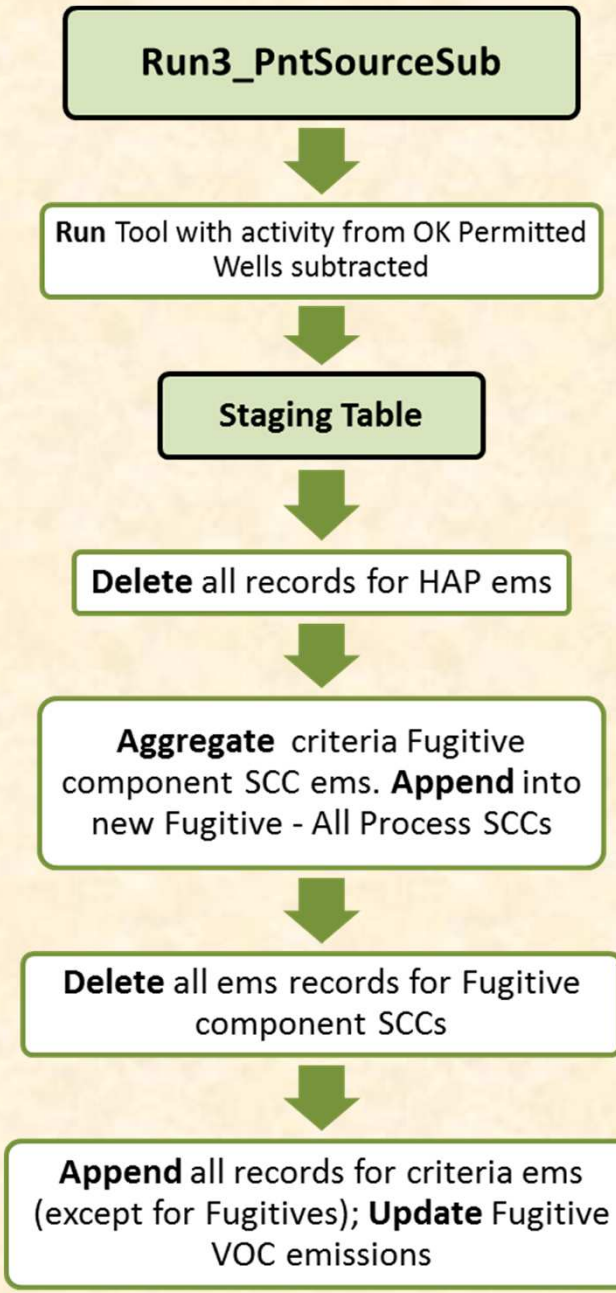
- Run of the tool that generates emissions from **malfunctioning pneumatic devices**
- The emissions are aggregated to fugitive SCCs and added to the final staging table
- Includes:
  - ONLY pneumatic device SCCs
  - Pneumatic device basin factor data for malfunctioning pneumatic devices (OIPA, 2014)

Run2_MalfunPneuDev

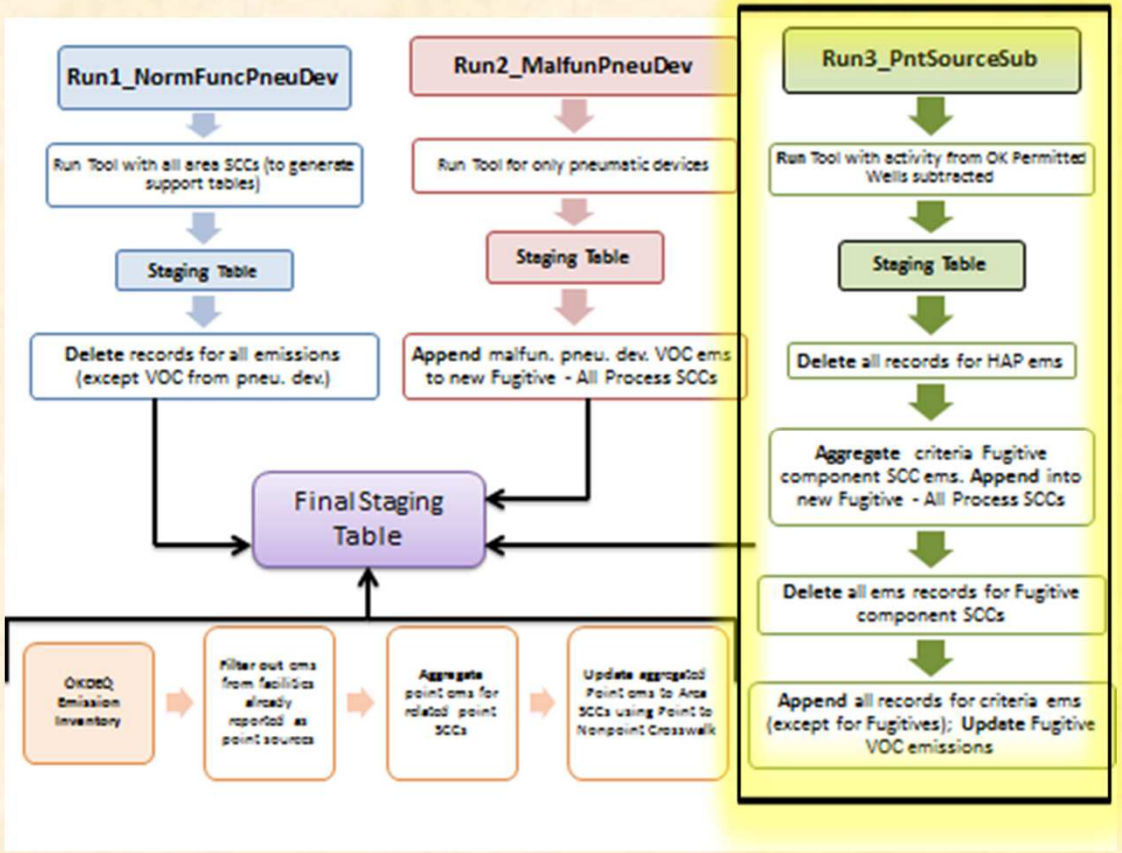
BASIN FACTOR - DATA_CATEGORY	CURRENT_VALUE	CURRENT_REFERENCE
Number of No Bleed devices (COUNT)		OIPA_STUDY_2014
Bleed rate, No Bleed devices (SCF/HR/DEVICE)		OIPA_STUDY_2014
Number of Low Bleed devices (COUNT)		OIPA_STUDY_2014
Bleed rate, Low Bleed devices (SCF/HR/DEVICE)		OIPA_STUDY_2014
Number of High Bleed devices (COUNT)		OIPA_STUDY_2014
Bleed rate, High Bleed devices (SCF/HR/DEVICE)		OIPA_STUDY_2014
Number of Intermittent Bleed devices (COUNT)	3.6	OIPA_STUDY_2014
Bleed rate, Intermittent Bleed devices (SCF/HR/DEVICE)	**2.0**	OIPA_STUDY_2014; Allen_Study_2014

OIPA Basin Factors: for **malfunctioning** pneumatic devices. (Emissions from normally operating pneumatic devices were generated from the previous run.)

Run3_PntSourceSub



RUN 3: Subtract permitted wellhead activity; accounts for unpermitted wellhead emissions



Run3_PntSourceSub

- Subtraction of:
  - AERR type A &B point source activity
  - OKDEQ permitted/inventoried well activity that have matched API numbers in the HPDI database
- Emissions after the point source subtraction are added to the final staging table
- Includes:
  - All SCCs **EXCEPT** pneumatic devices
  - OKDEQ local gas composition data (speciation profiles for fugitives, gas-actuated pumps, and liquids unloading)

Run3_PntSourceSub
(Fugitive Components)

- Our point inventory contained inconsistent characterizations of fugitive SCCs. We felt it did not justify the level of granularity shown in the Tool.
- Aggregate fugitive component emissions by well type, then append into new Fugitives: All Process SCCs

	Gas Wells	CBM Wells	Oil Wells
Connectors	2310021501	2310023511	2310011501
Flanges	2310021502	2310023512	2310011502
Open Ended Lines	2310021503	2310023513	2310011503
Valves	2310021505	2310023515	2310011505
Other	2310021506	2310023516	N/A
↓	↓	↓	↓
All Process	2310021509	2310023509	2310011500

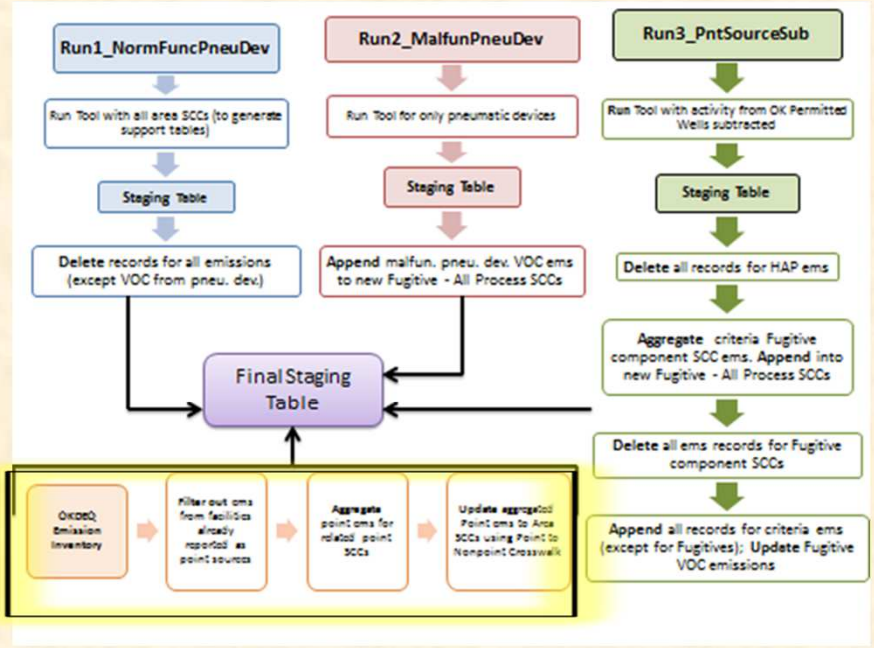
- Delete all fugitive component SCC records in the Emissions and EmissionsProcess table

Comparison: OKDEQ Point Source Activity Data

	OKDEQ Permitted Wells	TOTAL (HPDI)	% Point
Total Liquids (BBL)	55,901,885	117,319,665	48%
Total Gas (MCF)	713,638,549	2,162,187,694	33%
# Oil Wells	3,397	21,060	16%
# Gas Wells	843	31,395	2.7%
# CBM Wells	66	3,113	2.1%

- Note the range in coverage
- OKDEQ permitted wells capture:
  - Almost **50%** of the total liquids production, but only **16%** of oil wells
  - **33%** of the total gas production and less than **3%** of gas wells

Run4_OKPermitWellAgg



OKDEQ Emission Inventory

Filter out ems from facilities already reported as point sources

Aggregate point ems for related point SCCs

Update aggregated Point ems to Area SCCs using Point to Nonpoint Crosswalk

Run4_OKPermitWellAgg

- Not a run of the Tool, but the process of mapping our permitted wellhead emission data into the final staging table
  - After filtering out facilities in our inventory that had already reported as AERR Type A and B sources, we aggregated the remaining point emissions by SCC grouping, pollutant, and well type
  - Grouped point SCCs are cross-walked to area SCCs
  - Emissions are added to the final staging table

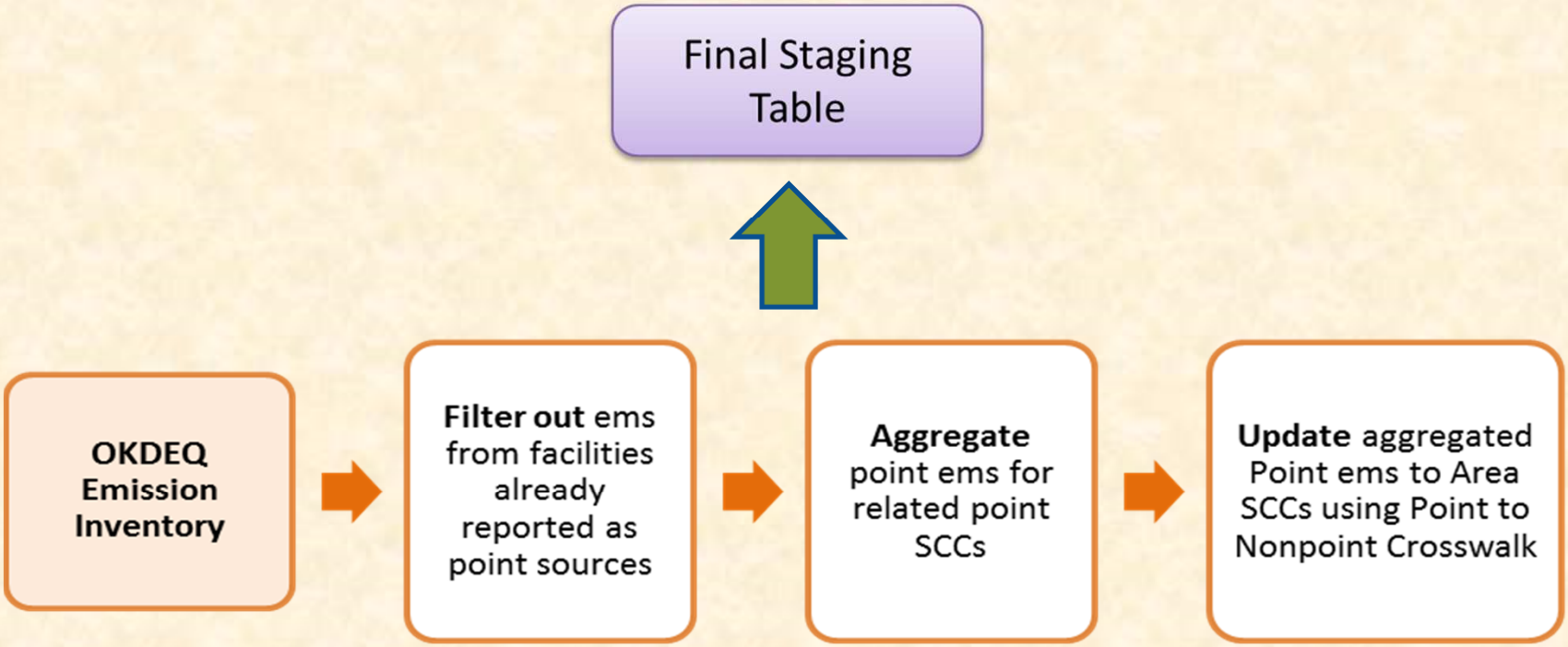
Step 4 Aggregate Point Emissions, Tanks

List of Point SCC emissions aggregated in preparation for mapping to tank area SCCs

Count	SumOfEms (TPY)	Point SCC	PointSCC_L4
7107	8811.321	40400311	Fixed Roof Tank, Condensate, working+breathing+flashing losses
1152	5684.968	40400300	Fixed Roof Tank: Flashing Loss
797	1217.975	40400312	Fixed Roof Tank, Crude Oil, working+breathing+flashing losses
1039	1160.008	40400302	Fixed Roof Tank: Working Loss
1191	938.866	40400301	Fixed Roof Tank: Breathing Loss
1304	818.29	31000205	Flares
256	143.975	31000160	Flares
341	16.352	31000215	Flares Combusting Gases : 1000 BTU/scf
11	16.215	30600903	Natural Gas

Run4_OKPermitWellAgg

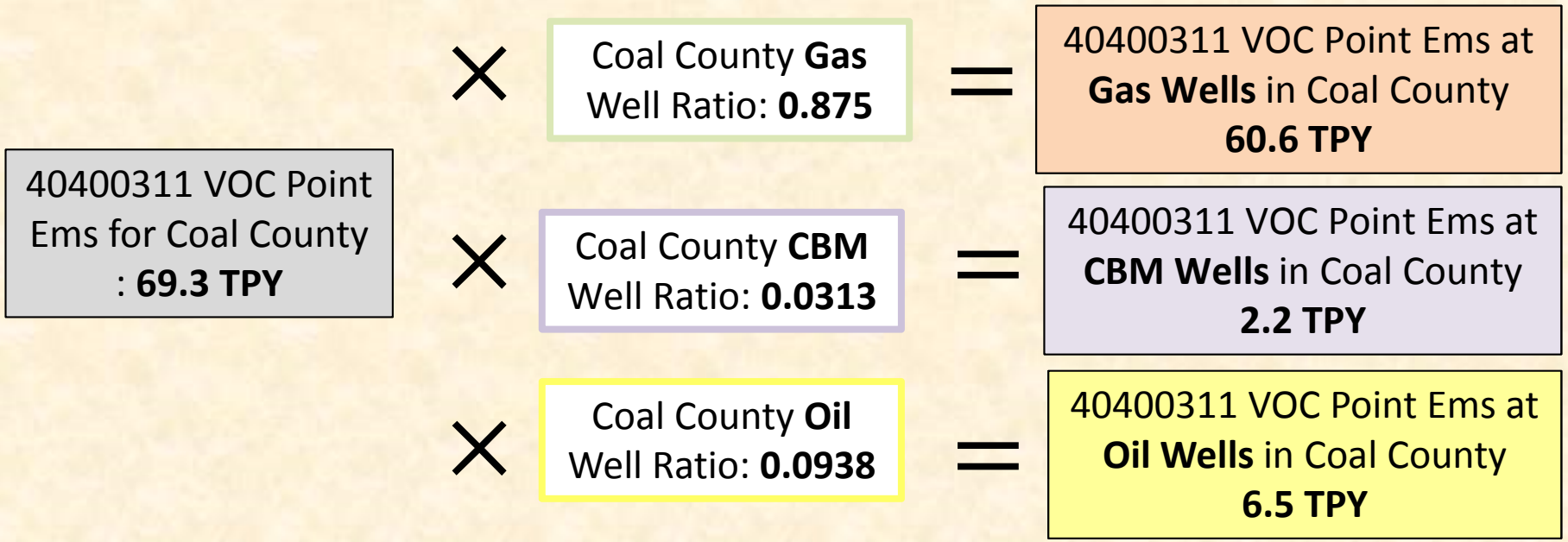
Once point emissions were aggregated into a chosen group, they were allocated to gas, oil, and CBM wells in each county using well-type ratios



Run4_OKPermitWellAgg

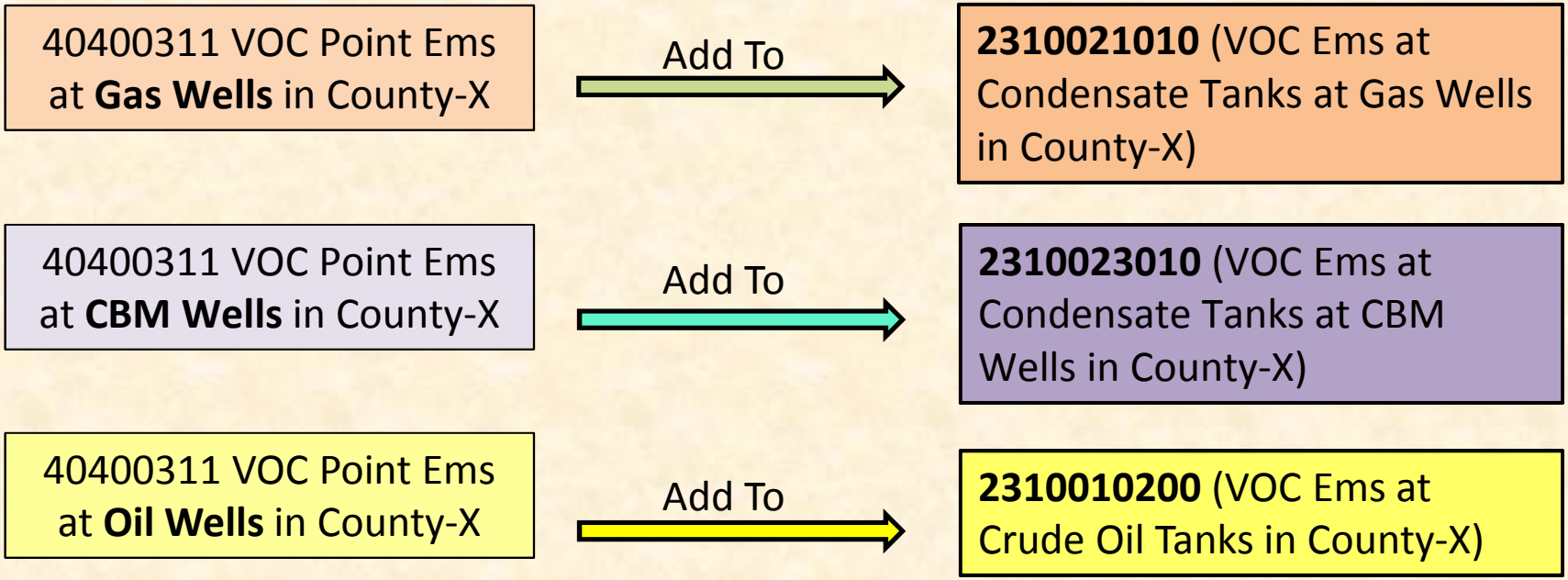
Allocate point emissions by well type using well type ratios (HPDI county averages for the permitted wellheads)

ex. 40400311 - Coal County



Run4_OKPermitWellAgg

Using a **point to nonpoint SCC crosswalk**, we added the well-type allocated point emissions to a related nonpoint SCC that was present in the Oil & Gas Tool



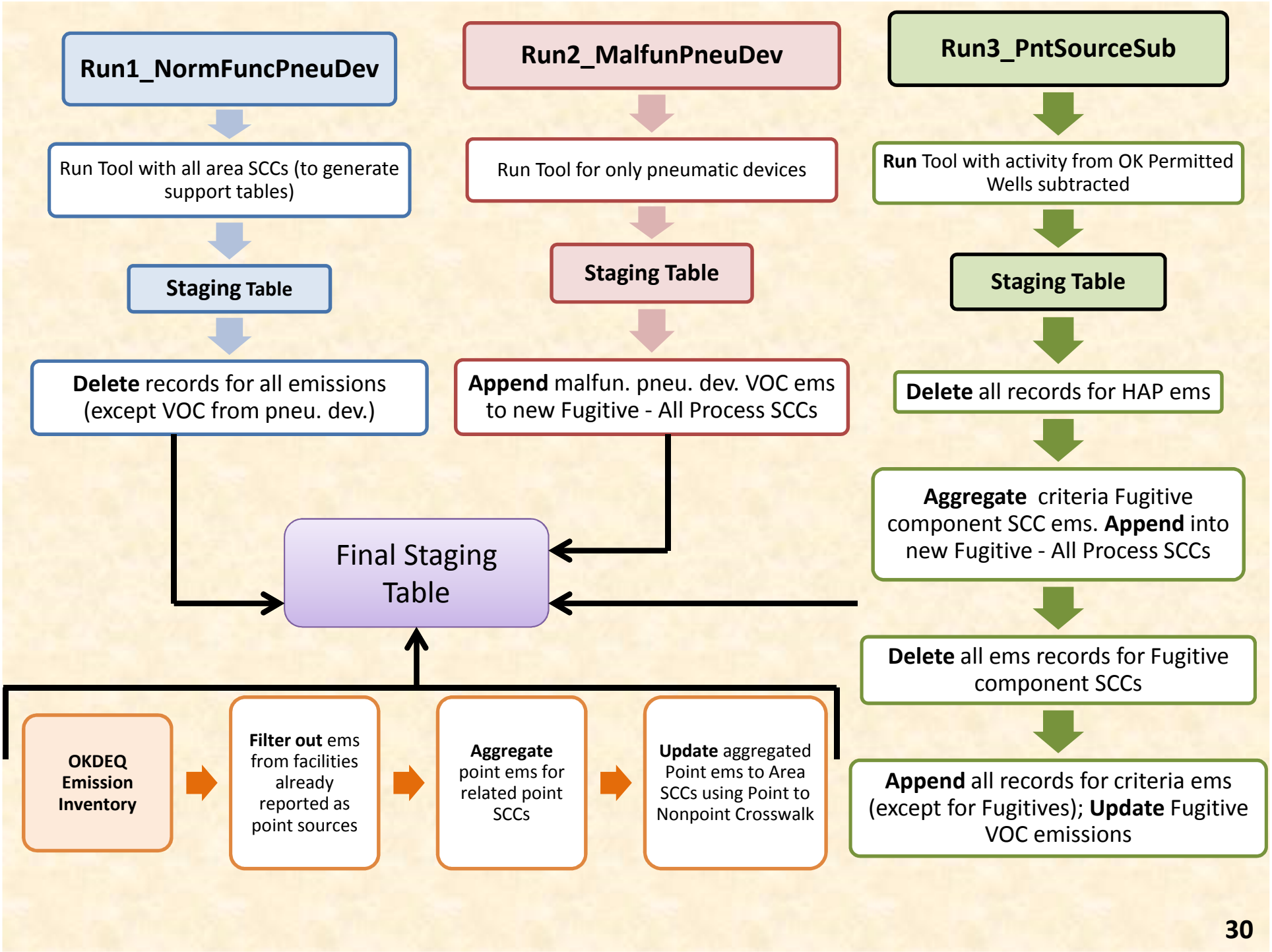
Point to Nonpoint Crosswalk

Point_SCC	Gas Wells, Nonpoint SCC	CBM Wells, Nonpoint SCC	Oil Wells, Nonpoint SCC	Other, Nonpoint SCC	Pollutants
40400311 Tanks & Flares	2310021010 Condensate Tanks	2310023010 Condensate Tanks	2310010200 Crude Oil Tanks	N/A	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$
20200253 4-Cycle Rich	2310021302 4-cycle Rich	2310023302 4-cycle Rich	2310000330 Artificial Lift	N/A	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$
20200254 4-cycle Lean	2310021202 4-cycle Lean	2310023202 4-cycle Lean	2310000330 Artificial Lift	N/A	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$
20200252 2-cycle Lean	2310021102 2-cycle Lean	2310023102 2-cycle Lean	2310000330 Artificial Lift	N/A	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$
20200202 Unspecified Engines	2310021302 4-cycle Rich	2310023302 4-cycle Rich	2310000330 Artificial Lift	N/A	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$
	2310023202 4-cycle Lean	2310023202 4-cycle Lean			

These are 50-499 HP Engine Area SCCs. In reality, some of the engines we inventory will have HP outside of this range.

Point to Nonpoint Crosswalk Cont.

Point_SCC	Gas Wells, Nonpoint SCC	CBM Wells, Nonpoint SCC	Oil Wells, Nonpoint SCC	Other, Nonpoint SCC	Pollutants
31000220 Fugitives	2310021509 Fugitives All Process	2310023509 Fugitives All Process	2310011500 Fugitives	N/A	VOC
40400250 Loading Racks	310021030 Tank Truck & Railcar Loading: Condensate	2310023030 Tank Truck & Railcar Loading: Condensate	2310011201 Tank Truck & Railcar Loading: Crude Oil	N/A	VOC
31000404 Process Heaters	2310021100 Gas Well Heaters	2310023100 CBM Well Heaters	2310010100 Heater Treaters	N/A	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$
40400315 Tanks, Produced Water	N/A	N/A	N/A	2310000550 Produced Water	VOC
31000227 Dehydrators	2310021400 Dehydrators	N/A	N/A	N/A	VOC, NO_x, CO, SO_x, PM_{10}, $PM_{2.5}$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Run Tool for only pneumatic devices
Staging Table
Append malfun. pneu. dev. VOC ems to new Fugitive - All Process SCCs
Run3_PntSourceSub
Run Tool with activity from OK Permitted Wells subtracted
Staging Table
Delete all records for HAP ems
Aggregate criteria Fugitive component SCC ems. Append into new Fugitive - All Process SCCs
Delete all ems records for Fugitive component SCCs
Append all records for criteria ems (except for Fugitives); Update Fugitive VOC emissions
Final Staging Table
OKDEQ Emission Inventory
Filter out ems from facilities already reported as point sources
Aggregate point ems for related point SCCs
Update aggregated Point ems to Area SCCs using Point to Nonpoint Crosswalk

Final Comparison Analysis

Pollutant	Run with EPA defaults – The Oil and Gas tool v2.1 without any point source subtraction or other alteration	Final Run - Total emissions from the final staging table of the flow chart procedures.
NOx (tons)	41,300	54,900
VOC (tons)	148,900	162,300

Comparison of Emissions per Well (Nonpoint vs. Point)

	2014 O&G Tool v1.0 w/o Modifications	Oklahoma Permitted Wells
Total Number of Wells (Oil, Gas, & CBM Combined)	55,568	4,306
Total Emissions		
NO_X (tons)	42,166	16,190
VOC (tons)	147,984	38,836
Per Well Emissions		
NO_X (tons/well)	0.759	3.760
VOC (tons/well)	2.663	9.019

Remaining Questions/Concerns

- Source Classification Code structure
  - Poor descriptions and missing codes
  - Crosswalk between point & nonpoint SCCs
- Definition of gas well vs. oil well
  - Reclassification of well types (affects where emissions are appearing and changes the emission factors in the tool)
  - Point source inventory mitigates this problem (e.g. 48% of liquids in OKDEQ point inventory)

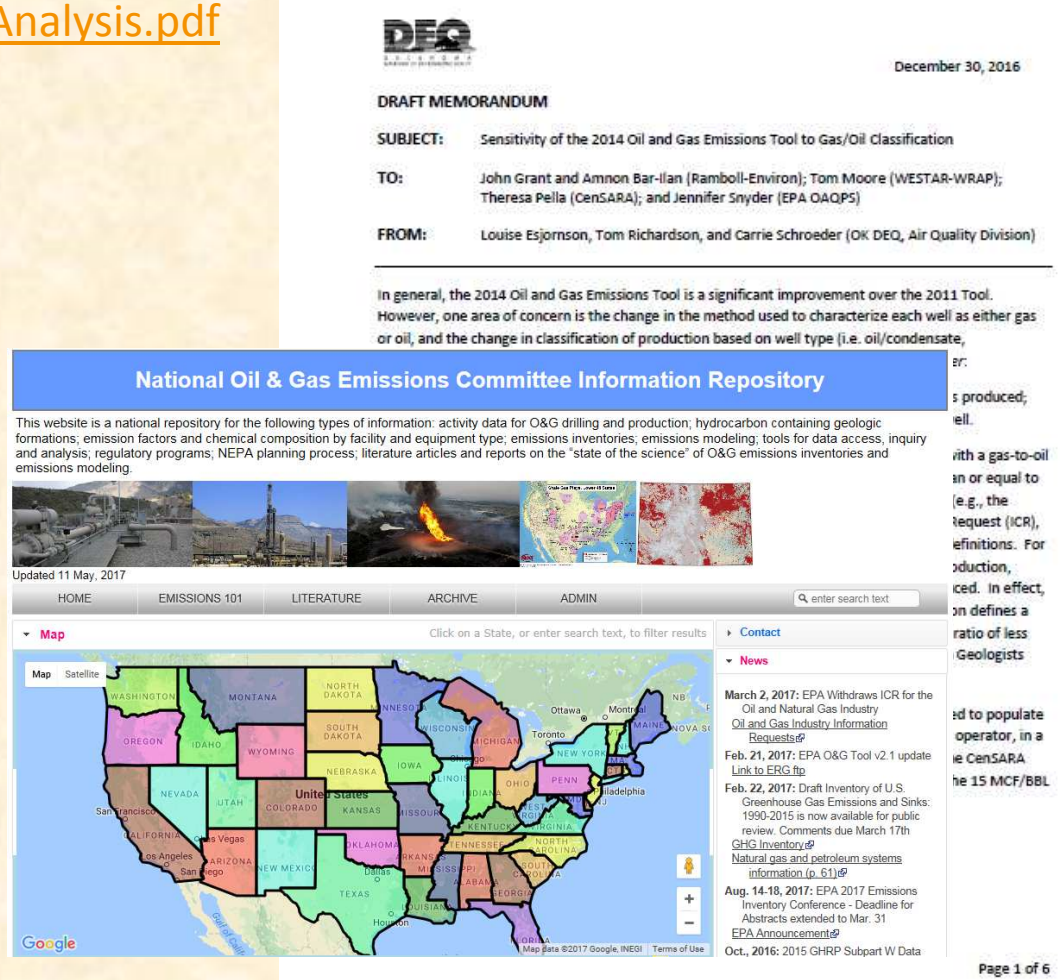
OKDEQ Simple Sensitivity Analysis

http://vibe.cira.colostate.edu/ogec/docs/meetings/2017-05-11/OKDEQ2014OGToolSensitivityAnalysis.pdf

The tool is sensitive to classification hydrocarbons as:

- Oil (crude and associated gas)
- Gas (condensate and gas well gas)

If "gas wells" (and their associated production) are classified in the Tool as "oil wells", VOC and NOx emissions would be underestimated.



DEQ

December 30, 2016

DRAFT MEMORANDUM

SUBJECT: Sensitivity of the 2014 Oil and Gas Emissions Tool to Gas/Oil Classification

TO: John Grant and Amnon Bar-Ilan (Ramboll-Environ); Tom Moore (WESTAR-WRAP); Theresa Pella (CenSARA); and Jennifer Snyder (EPA OAQPS)

FROM: Louise Esjornson, Tom Richardson, and Carrie Schroeder (OK DEQ, Air Quality Division)

In general, the 2014 Oil and Gas Emissions Tool is a significant improvement over the 2011 Tool. However, one area of concern is the change in the method used to characterize each well as either gas or oil, and the change in classification of production based on well type (i.e. oil/condensate,

National Oil & Gas Emissions Committee Information Repository

This website is a national repository for the following types of information: activity data for O&G drilling and production; hydrocarbon containing geologic formations; emission factors and chemical composition by facility and equipment type; emissions inventories; emissions modeling; tools for data access, inquiry and analysis; regulatory programs; NEPA planning process; literature articles and reports on the "state of the science" of O&G emissions inventories and emissions modeling.

Updated 11 May, 2017

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Contact

News

March 2, 2017: EPA Withdraws ICR for the Oil and Natural Gas Industry
Oil and Gas Industry Information Requests
Feb. 21, 2017: EPA O&G Tool v2.1 update
Link to ERG ftp
Feb. 22, 2017: Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015 is now available for public review. Comments due March 17th
GHG Inventory
Natural gas and petroleum systems information (p. 61)
Aug. 14-18, 2017: EPA 2017 Emissions Inventory Conference - Deadline for Abstracts extended to Mar. 31
EPA Announcement
Oct., 2016: 2015 GHRP Subpart W Data

Page 1 of 6

Remaining Questions/Concerns (Continued)

- Better Characterizing Super-Emitters
- Reconciling Top-Down vs Bottom-Up Estimates
- Closing the Midstream Gap
- Identifying and Characterizing Other Missing Sources

http://www.ladco.org/about/general/Air_Quality_Workshop_Meeting_2016/6.2_Gibbs_OKDEQ_-_The_Future_of_Oil_and_Gas_Inventories_6-20-16.pdf

Questions?

Carrie Schroeder
Oklahoma DEQ, Emission Inventory
Carrie.Schroeder@deq.ok.gov