

Oregon DEQ AQ-Technical Services

2014 Oregon Gasoline Dispensing Facility (GDF) Emissions Inventory and Modeling

June 2017

NW-AIRQUEST 2017 Annual Meeting

Richland, Washington

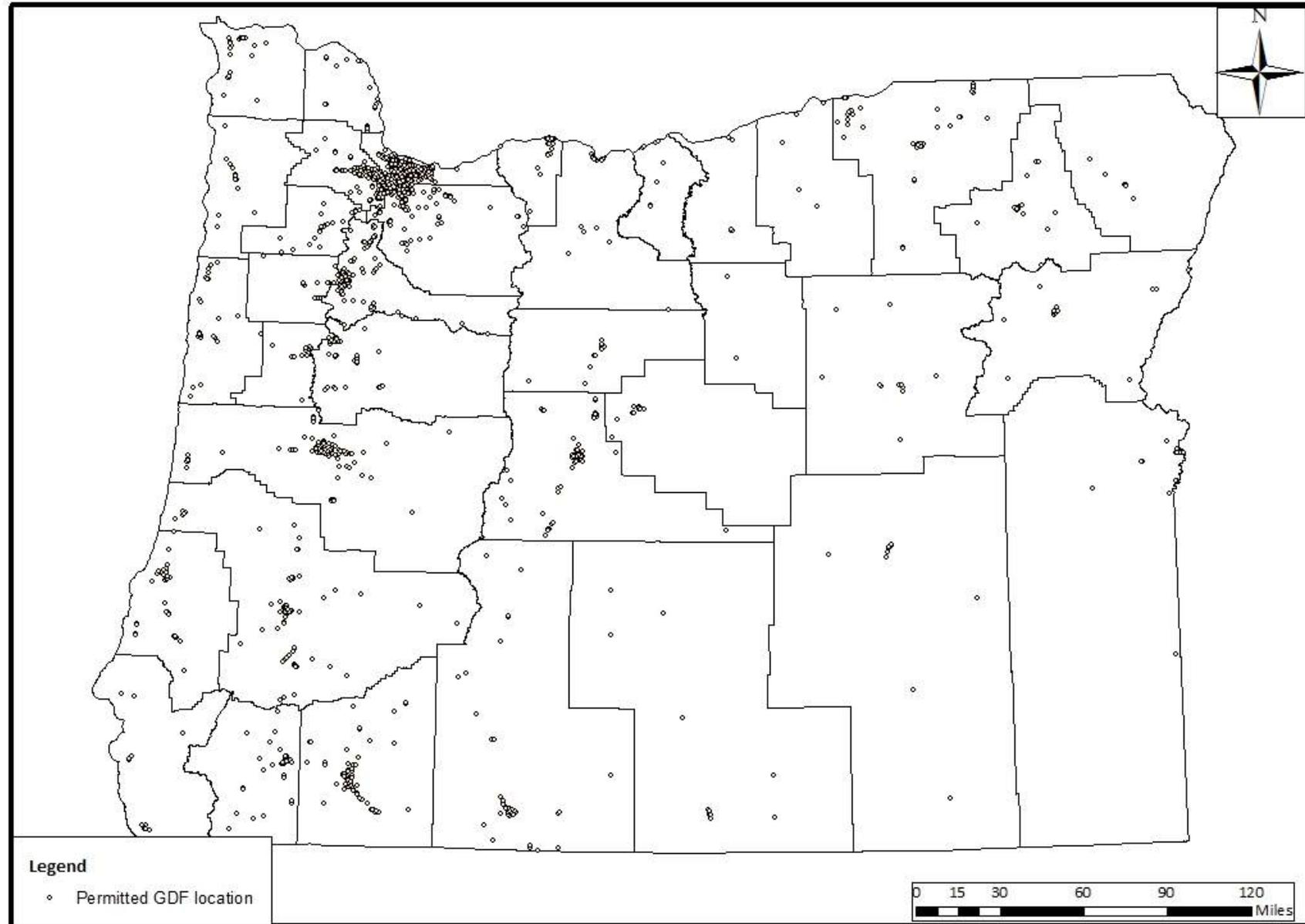
Presentation Road Map

- Emissions Inventory
 - GDF location, processes
 - Activity
 - Emission factors
 - Emissions overview
 - Projections
 - Further work

- Modeling

GDF location

1,584
permitted
GDFs



Processes

Universe of processes:

- *Stage I* = Underground Storage Tank (UST)
 - Tank filling
 - Uncontrolled = “splash” filling
 - Controlled filling
 - Submerged
 - Balanced/submerged
 - Tank “breathing & emptying”
- *Stage II* = Vehicle refueling
 - Pump
 - Uncontrolled
 - Controlled = Vapor Recovery System (VRS)
 - Control Types = 1, 2, 2A, 2E
 - Vehicle
 - Uncontrolled
 - Controlled = Onboard Refueling Vapor Recovery (ORVR)
 - VRS compatible = 1, 2, 2E
 - VRS incompatible = 2A
 - Pump nozzle spillage

Activity – station throughput and controls

- Station annual throughput reported to DEQ/LRAPA
- Station controls
 - Indicated by GDF on initial permit application *or*
 - Stage I control requirements determined by annual throughput:
 - 13,000 gallons or less = splash filling
 - 13,001 to 479,999 gallons = submerged filling
 - 480,000 or more gallons = balanced / submerged filling
 - Stage II controls are required in Multnomah, Washington and Clackamas counties only (with few exceptions)

Activity – station throughput allocated to ORVR and non-ORVR

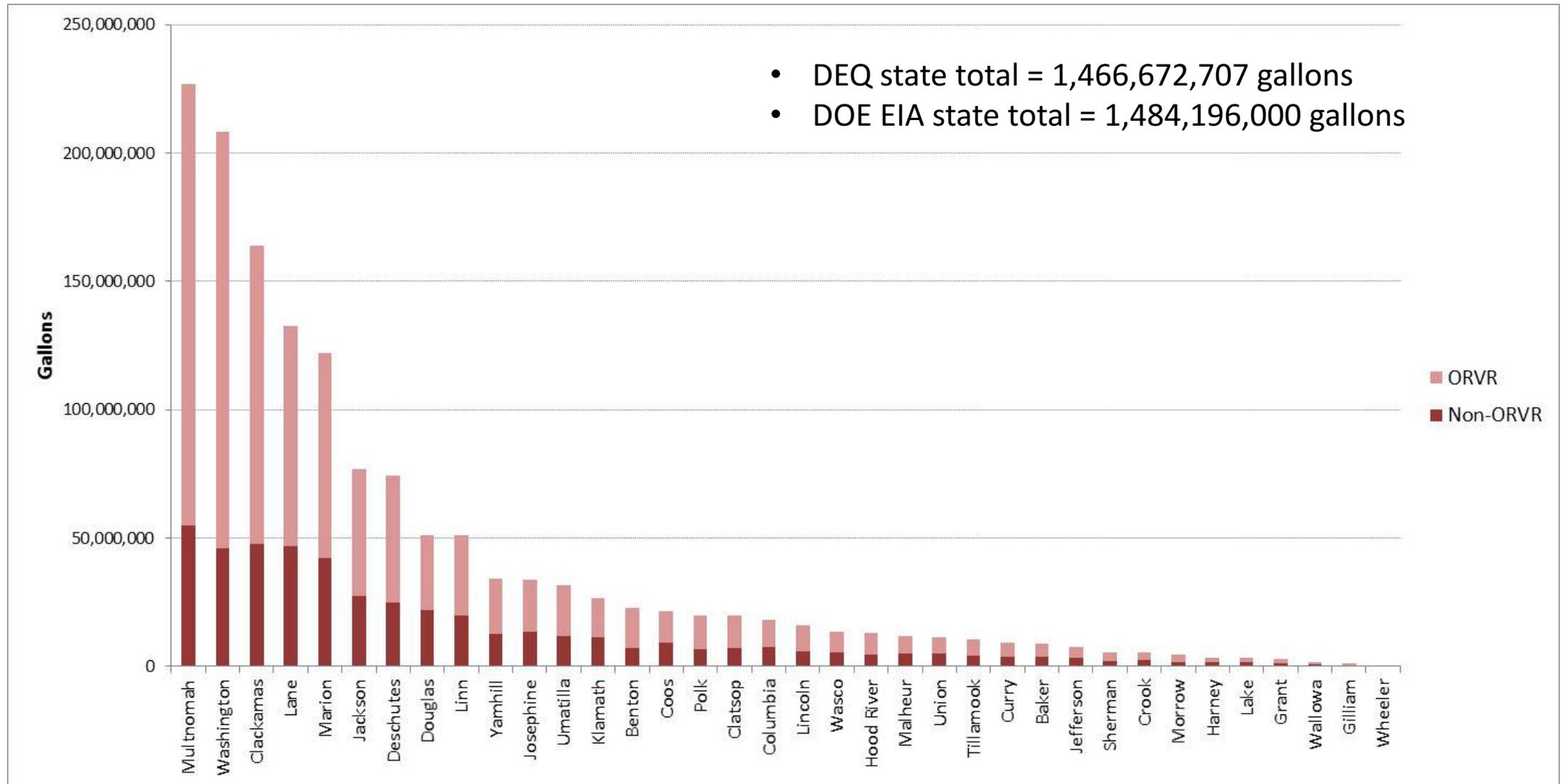
- Oregon ORVR vehicle fleet penetration estimated using:
 - Vehicle registration data
 - Manufacturer compliance rates by vehicle model year

Compliance Rate	L Car	L Truck	M & H Truck
40%	1998	2001	2004
80%	1999	2002	2005
100%	2000	2003	2006

Source: On-board Refueling Vapor Recovery (ORVR) – How well is it performing? Presentation by Wayne Elson, EPA Region 10. Washington-Oregon Gasoline Vapor Control Committee. Lacey, Washington. May 4, 2005.

- The goal of ORVR is to make VRS obsolete

Activity – 2014* gasoline dispensed by station summed to county



* Lane County = 2016 data

Emission factors – Stage I VOC, with examples

- Loading loss from AP-42, Section 5.2, p.5.2-4
 - Uncontrolled, lb/10³gal = 12.46 (SPM / T)
 - T = °R = NOAA weather station data, avg. county temperatures estimated
 - S, P, M taken from AP-42
 - Impact of controls = (uncontrolled emissions) * (1-eff/100)
 - Controls and rule data taken from EPA and CARB documentation
- UST / AST breathing & emptying from AP-42, Table 5.2-7.
- Examples:

County	2014 Annual Avg. T (F)	Annual Avg T (R)	--- Saturation Factor (S) ---			True Vapor Pressure (P)	Molecular Weight of Vapors (M)	----- Efficiency (eff) -----			----- Stage I, VOC EF, lb/1000 Gal Throughput -----				
			Splash Fill	Submerged Fill	Balanced / Submerged Fill			Splash Fill	Submerged Fill	Balanced / Submerged Fill	2501060201				
											2501060052	2501060051	2501060053	UST Breathing & Emptying	AST Breathing & Emptying
Baker	48.1	508.1	1.45	0.6	1	4.2	66	0%	36.5%	95%	9.856	2.590	0.340	1.0	1.0
Benton	53.3	513.3	1.45	0.6	1	4.2	66	0%	36.5%	95%	9.757	2.564	0.336	1.0	1.0
Clackamas	52.3	512.3	1.45	0.6	1	4.2	66	0%	36.5%	95%	9.776	2.569	0.337	1.0	1.0

Emission factors – Stage II VOC - Pump

- Displacement from refueling: Pump
 - *Displacement from Refueling Emissions for Nonroad Engine Modeling* (EPA420-P-02-003), p. 9
 - Uncontrolled g/gal = $-5.909 - 0.0949 \times dt + 0.0884 \times T + 0.485 \times RVP$
 - This equation is the same as AP-42, Section 5.2, p. 5.2-15, however EPA420-P-02-003 includes an equation for estimating dt: $62 + 0.6 \times (\text{ambient temperature} - 62)$
 - T = °F = NOAA weather station data, avg. county temperatures estimated
 - RVP = EPA MOVES2014a default Oregon data
 - Impact of controls = (uncontrolled emissions) * (1-eff/100)
 - Controls and rule data from EPA, CARB and DEQ data and documentation

Emission factors – Stage II VOC - ORVR

- Displacement from refueling: Vehicles equipped with ORVR
 - No VRS, or VRS compatible
 - EPA document: “*Onboard Refueling Vapor Recovery for Motor Vehicles Fact Sheet*”
 - Control efficiency = 95%
 - VRS incompatible
 - *Preliminary Draft Test Report: Total Hydrocarbon Emissions From Two Phase II Vacuum Assist Vapor Recovery Systems During Baseline Operation and Simulated Refueling of Onboard Refueling Vapor Recovery (ORVR) Equipped Vehicles*. California Air Resources Board, Project number ST-98-XX. June 1999.
 - Control efficiency = 90%

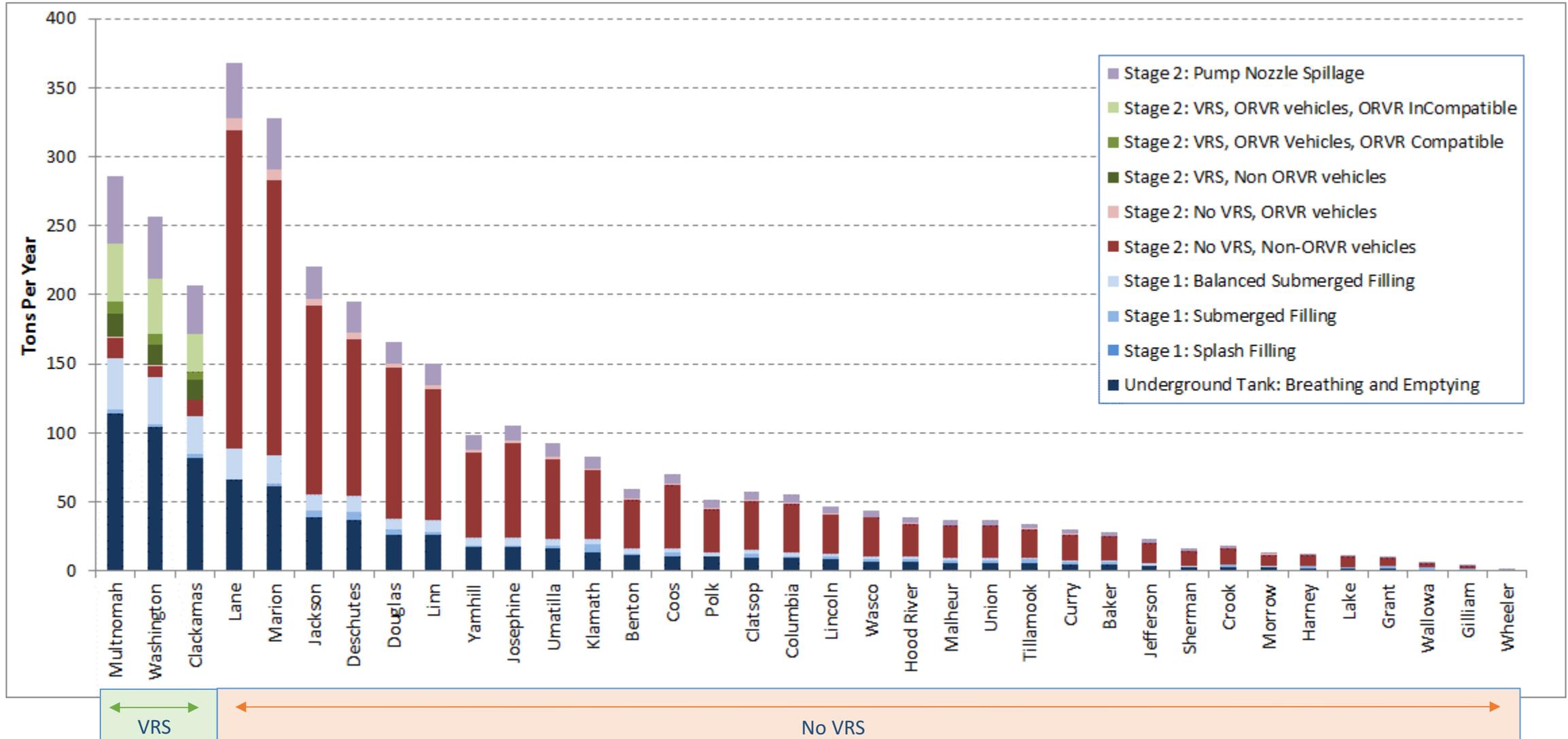
Emission factors – Stage II VOC – Nozzle Spillage, and examples

- Nozzle spillage – increased by “topping off”
 - *Revised Emission Factors for Gasoline Marketing Operations at California Gasoline Dispensing Facilities*. California Environmental Protection Agency, Air Resources Board. December 23, 2013.
 - VRS vs. no VRS
- Stage II VOC EF examples

County Name	2014 Avg. Annual T (F)	Gasoline Avg Annual RVP	Dispensed Fuel T (F)	ΔT (F)	Uncontrolled VOC EF (g/gal)	Uncontrolled VOC EF (lb/1000 gal)	25-01-060-101 No Pump VRS Control		25-01-060-102 Pump VRS Control			25-01-060-103
							VOC EF Non-ORVR Vehicles (lb/1000 gal)	VOC EF ORVR Vehicles (lb/1000 gal)	VOC EF Non-ORVR Vehicles (lb/1000 gal)	VOC EF VRS/ORVR Compatible (lb/1000 gal)	VOC EF VRS/ORVR Incompatible (lb/1000 gal)	VOC EF Nozzle Spillage (lb/1000 gal)
Baker	48.1	10.94	53.7	-5.6	4.178	9.210	9.210	0.184	N/A	N/A	N/A	0.61
Benton	53.3	10.94	56.8	-3.5	4.439	9.786	9.786	0.196	N/A	N/A	N/A	0.61
Clackamas	52.3	10.57	56.2	-3.9	4.207	9.274	9.274	0.185	0.640	0.185	1.068	0.42

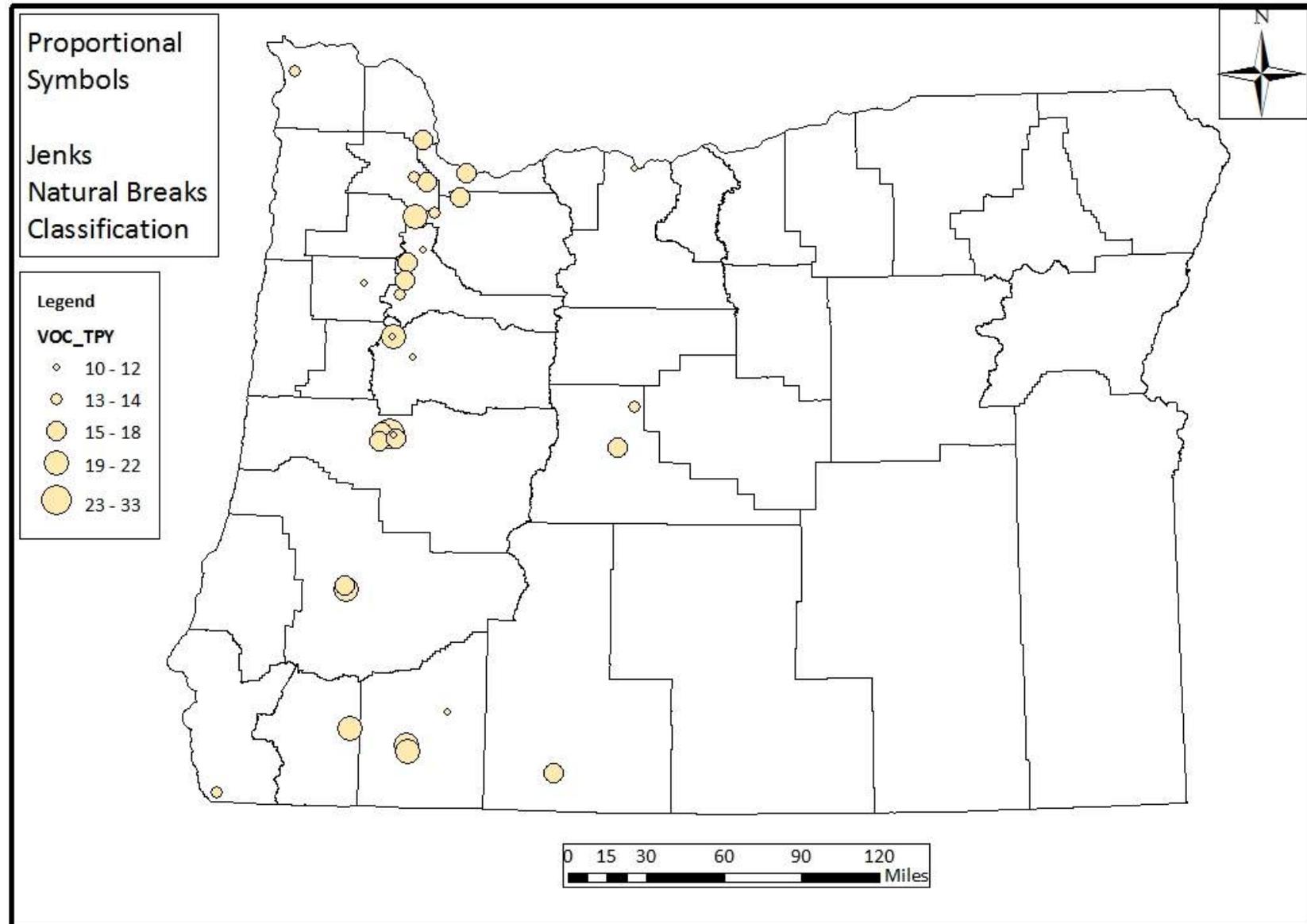
- *AP-42: “It is estimated that the uncontrolled emissions from vapors displaced during vehicle refueling average 1320 mg/L (11.0 lb/1000 gal) of dispensed gasoline.”* – national estimate (?) from 1972 & 1975 data

2014 Emissions – VOC by county (ordered descending by throughput as in Slide 7)



Emissions – VOC by GDF, 10 tpy or greater

- 32 GDFs \geq 10 tpy VOC
- = 2.02% of all GDFs



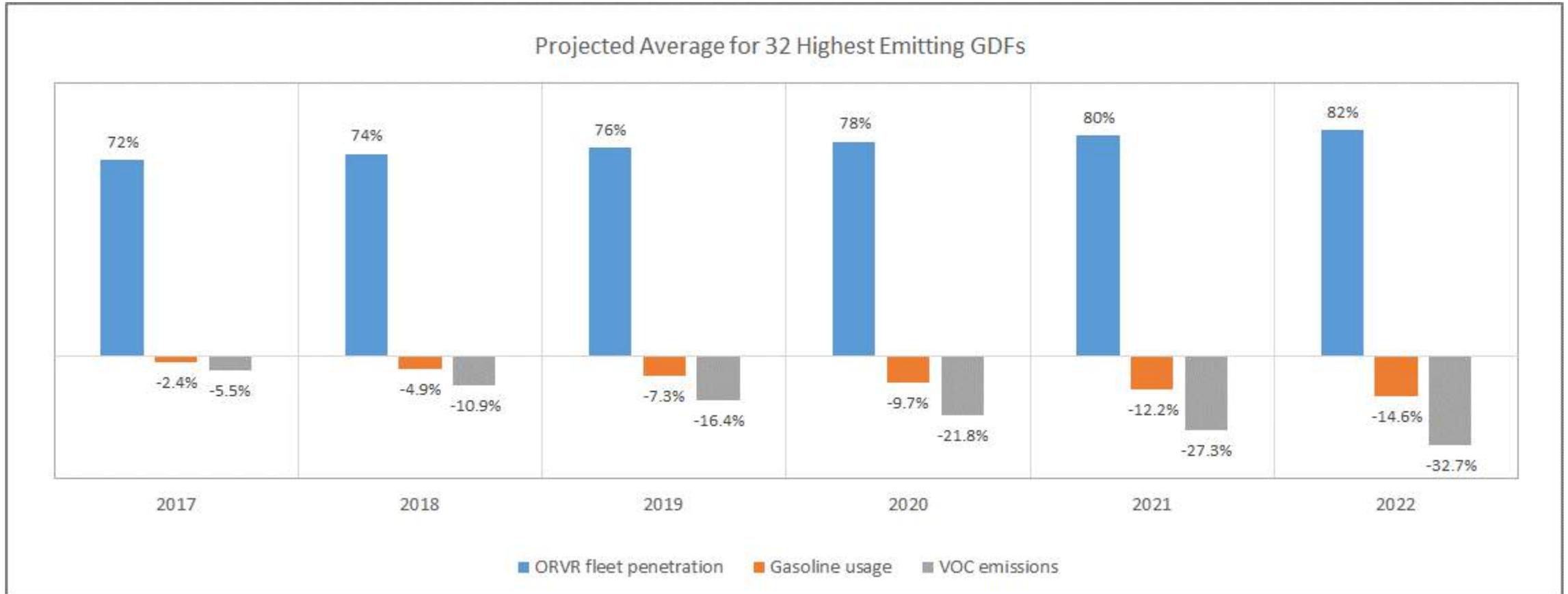
HAPs emitted

- EPA Speciate 4.5: Profile 2455 (Composite Gasoline Vapor from Seattle (5 brands, 3 grades) - 1997)
- 45 HAPs

CAS	NAME	VOC to TOG	Weight Percent	CAS	NAME	VOC to TOG	Weight Percent
95-63-6	1,2,4-trimethylbenzene	1	0.63%	287-92-3	Cyclopentane	1	0.77%
108-67-8	1,3,5-trimethylbenzene	1	0.21%	100-41-4	Ethylbenzene	1	0.66%
141-93-5	1,3-diethylbenzene (meta)	1	0.04%	75-28-5	Isobutane	1	2.71%
611-14-3	1-Methyl-2-ethylbenzene	1	0.15%	78-78-4	Isopentane (2-Methylbutane)	1	28.09%
620-14-4	1-Methyl-3-ethylbenzene	1	0.43%	78-79-5	Isoprene (2-methyl-1,3-butadiene)	1	0.05%
622-96-8	1-Methyl-4-ethylbenzene	1	0.19%	98-82-8	Isopropylbenzene (cumene)	1	0.04%
109-67-1	1-pentene	1	0.68%	1330-20-7	M & p-xylene mixture	1	2.39%
540-84-1	2,2,4-trimethylpentane	1	0.89%	108-87-2	Methylcyclohexane	1	0.09%
75-83-2	2,2-dimethylbutane	1	0.43%	96-37-7	Methylcyclopentane	1	0.05%
565-75-3	2,3,4-trimethylpentane	1	0.29%	106-97-8	N-butane	1	23.43%
79-29-8	2,3-dimethylbutane	1	1.22%	142-82-5	N-heptane	1	0.46%
565-59-3	2,3-dimethylpentane	1	0.75%	110-54-3	N-hexane	1	2.14%
108-08-7	2,4-dimethylpentane	1	0.48%	111-84-2	N-nonane	1	0.05%
592-27-8	2-methylheptane	1	0.15%	111-65-9	N-octane	1	0.13%
591-76-4	2-methylhexane	1	0.52%	109-66-0	N-pentane	1	12.05%
107-83-5	2-methylpentane (isohexane)	1	3.54%	103-65-1	N-propylbenzene	1	0.14%
589-81-1	3-methylheptane	1	0.17%	1120-21-4	N-undecane	1	0.01%
589-34-4	3-methylhexane	1	0.63%	95-47-6	O-xylene	1	0.90%
96-14-0	3-methylpentane	1	1.98%	108-88-3	Toluene	1	4.36%
71-43-2	Benzene*	1	0.82%	624-64-6	Trans-2-butene	1	0.39%
590-18-1	Cis-2-butene	1	0.49%	N/A	Other	1	4.36%
627-20-3	Cis-2-pentene	1	0.52%	N/A	Unidentified	1	1.27%
110-82-7	Cyclohexane	1	0.25%				

* EPA-420-R-10-029, Table 16, p.14

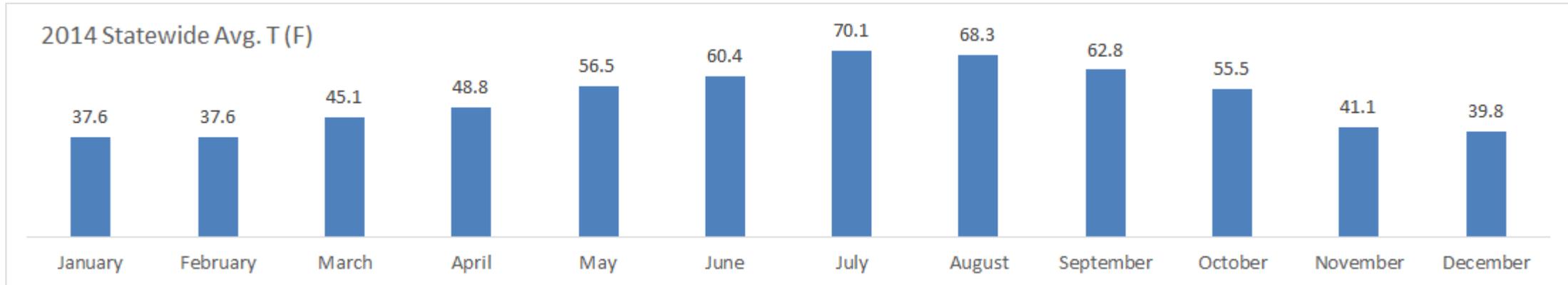
Projections



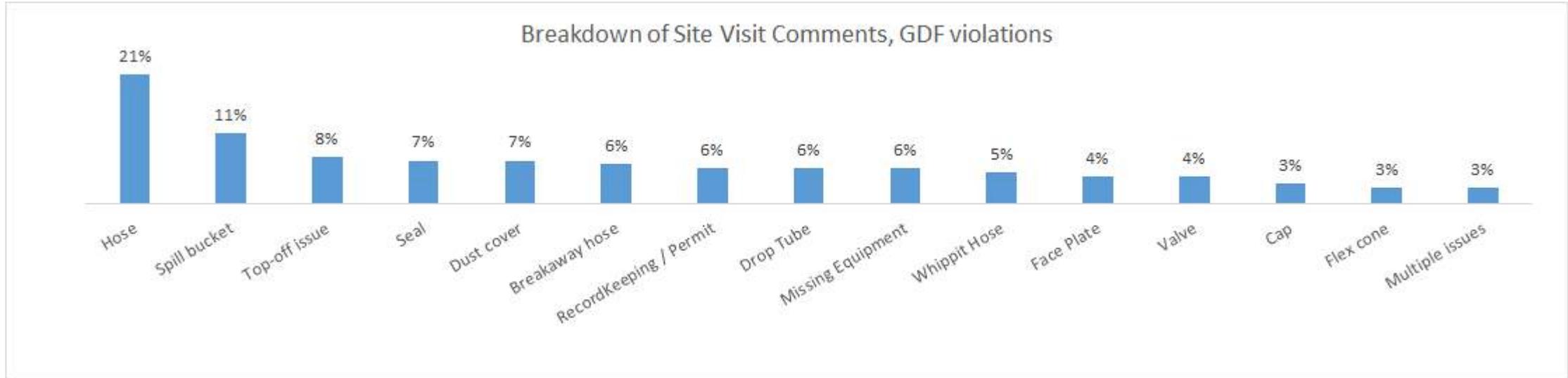
- Gasoline usage source: US Energy Information Administration, Annual Energy Outlook 2017
- Hmm....when will Stage II VRS requirements be discontinued (?)

Further refinements (?)

- Temporal variations: Activity uniform, however temperature varies.....



- Control efficiency (CE): impact of violations (missing or broken controls and other equipment)



Acknowledgements:

- John St. Clair: Southwest Clean Air Agency
- Jerry Ebersole: Oregon DEQ
- Mike Poulsen: Oregon DEQ

Based on data from Chris:

Assess impacts of toxics from GDFs

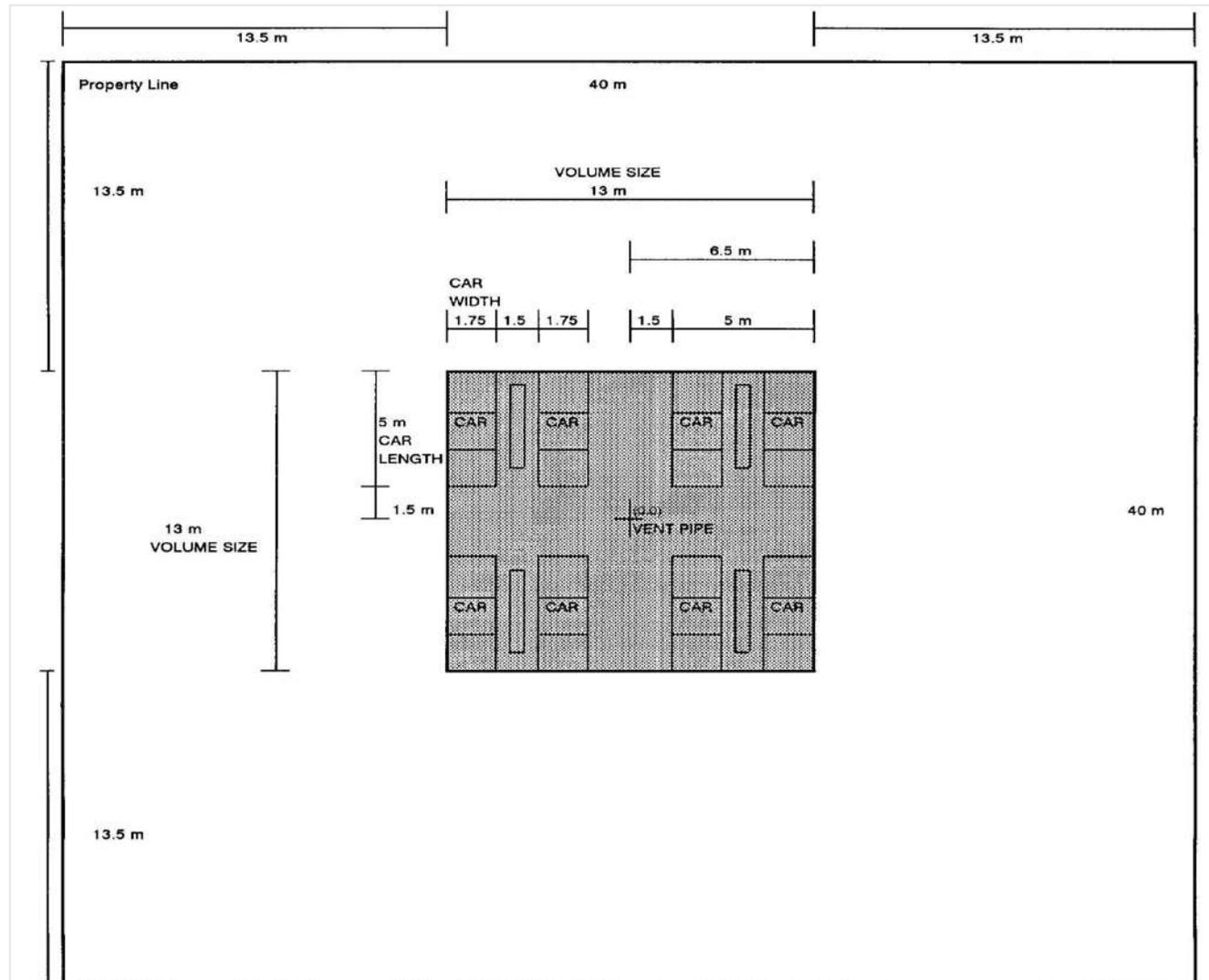
- 1) Select largest stations
- 2) Speciate VOCs into constituent toxics with emission profiles
- 3) Identify toxics with available Risk Based Concentrations
- 4) Use a proxy to estimate cumulative risk from multiple toxics
- 5) Run proxy emissions in Aermoc to estimate risk

Modeling:

Ranking	CountyName	AQ_ID	Source Name	City, State Zip	LAT_DD	LONG_DD	2014 Ann Throughput Final (gal)	Underground Tank: Breathing and Emptying (tpy)	Stage 1: Splash Filling (tpy)	Stage 1: Submerged Filling (tpy)	Stage 1: Balanced Submerged Filling (tpy)	Stage 2: Displacement Loss/Uncontrolled (tpy)	Stage 2: Displacement Loss/Controlled (tpy)	Stage 2: Spillage (tpy)	Total Of VOC TPY (tpy)	Calculated Excess Cancer Risk (x 1E-6)
1	Lane	201304	Costco Wholesale Corporation-Ga	Eugene	44.0889	-123.0662	11,974,583	5.99			2.01	21.57		3.65	33.22	30
2	Jackson	15-9569	Fred Meyer Fuel #195	MEDFORD, OR 97504-4181	42.3520	-122.8735	7,935,280	3.97			1.33	14.63		2.42	22.35	20
3	Linn	22-8058	Costco Gasoline #682	ALBANY, OR 97321	44.6374	-123.0665	6,861,450	3.43			1.16	13.09		2.09	19.77	18
4	Douglas	10-0180	Costco Gasoline	ROSEBURG, OR 97470	43.2104	-123.3679	6,180,470	3.09			1.04	13.49		1.89	19.51	18
5	Josephine	17-0101	Fred Meyer Fuel #126	GRANTS PASS, OR 97526	42.4363	-123.2989	6,323,660	3.16			1.06	13.30		1.93	19.45	18
6	Yamhill	36-0034	Fred Meyer Fuel #220	NEWBERG, OR 97132	45.3128	-122.9207	6,666,210	3.33			1.12	12.43		2.03	18.92	17
7	Jackson	15-9605	Fred Meyer Fuel #196	MEDFORD, OR 97501-7936	42.3123	-122.8576	6,381,700	3.19			1.07	11.77		1.95	17.97	16
8	Lane	202829	Fred Meyer Stores	Eugene	44.0980	-123.1264	6,336,684	3.17			1.07	11.41		1.93	17.58	16
9	Columbia	05-2630	Fred Meyer Fuel #462	SCAPPOOSE, OR 97056	45.7426	-122.8768	5,652,440	2.83			0.96	11.25		1.72	16.76	15
10	Deschutes	09-9538	Fred Meyer Fuel #21	BEND, OR 97702	44.0358	-121.3053	6,512,627	3.26			1.11	10.34		1.99	16.69	15
11	Lane	202827	Fred Meyer Stores	Eugene	44.0495	-123.1430	5,925,170	2.96			1.00	10.67		1.81	16.44	15
12	Douglas	10-0174	Bassett-Hyland Energy - Garden V	ROSEBURG, OR 97471-19	43.2339	-123.3756	5,045,110	2.52			0.85	11.01		1.54	15.92	15
13	Marion	24-9310	Pilot Travel Centers #386	BROOKS, OR 97305	45.0496	-122.9750	5,959,370	2.98			1.00	10.09		1.82	15.89	15
14	Clackamas	03-0084	Costco Gasoline	CLACKAMAS, OR 97015-9	45.4278	-122.5754	11,653,843	5.83			1.96		5.49	2.45	15.73	14
15	Washington	34-0132	Costco Gasoline #9	ALOHA, OR 97006-5045	45.5082	-122.8424	11,139,852	5.57			1.87		5.62	2.34	15.39	14
16	Lane	202832	Fred Meyer Stores	Springfield	44.0635	-123.0177	5,485,513	2.74			0.92	9.88		1.67	15.22	14
17	Multnomah	26-9724	Costco Gasoline #2	PORTLAND, OR 97230	45.5575	-122.5199	10,722,162	5.36			1.80		5.35	2.25	14.76	13
18	Klamath	18-9527	Fred Meyer Fuel #165	KLAMATH FALLS, OR 9760	42.2138	-121.7568	5,058,313	2.53			0.87	9.73		1.54	14.67	13
19	Marion	24-9281	Fred Meyer Fuel #90	SALEM, OR 97301-1826	44.9498	-122.9869	5,420,580	2.71			0.91	9.18		1.65	14.45	13
20	Deschutes	09-0063	Fred Meyer Fuel #650	REDMOND, OR 97756	44.2688	-121.1768	5,346,118	2.67			0.91	8.49		1.63	13.70	13
21	Washington	34-9559	Costco Gasoline #766	WILSONVILLE, OR 97070-5	45.3324	-122.7656	9,671,731	4.84			1.62		4.88	2.03	13.36	12
22	Curry	08-0058	Fred Meyer Fuel #30	BROOKINGS, OR 97415-96	42.0500	-124.2816	4,297,020	2.15			0.72	8.68		1.31	12.86	12
23	Marion	24-9304	Safeway	SALEM, OR 97306-1223	44.8736	-123.0250	4,749,890	2.37			0.80	8.04		1.45	12.67	12
24	Washington	34-9553	Costco Gasoline #692	HILLSBORO, OR 97123	45.5342	-122.9358	9,112,770	4.56			1.53		4.59	1.91	12.59	12
25	Clatsop	04-0096	Fred Meyer Fuel #218	WARRENTON, OR 97146	46.1005	-123.9190	4,439,570	2.22			0.75	8.11		1.35	12.43	11
26	Jackson	15-9572	Butte Falls Service Station	BUTTE FALLS, OR 97522	42.5434	-122.5676	4,108,000	2.05			0.69	7.57		1.25	11.57	11
27	Marion	24-9305	Safeway	WOODBURN, OR 97071	45.1242	-122.8554	4,010,410	2.01			0.67	6.79		1.22	10.69	10
28	Lane	200577	B P West Coast Products LLC	Springfield	44.0846	-123.0410	3,782,716	1.89			0.64	6.81		1.15	10.49	10

Costco Gasoline #682					RBC= 1.00		RER=	Cancer	Chronic	Acute	factor	factor
	Chris Swab GDF Table tpg	lbs/hr	Speciation	CAS	poll description	lbs/hr	RBC Cancer ug/m3	RBC Chronic ug/m3	RBC Acute 24-hr ug/m3	Proxtox Equivalent Emissions Cancer lbs/yr	Proxtox Equivalent Emissions Chronic lbs/yr	Proxtox Equivalent Emissions Acute 24-hr lbs/yr
Stage 1 Balanced Submerged Filling	1.16	0.265			Stack 1: Filing							
			0.82%	71432	Benzene	2.2E-3	1.30E-01	30	30	1.67E-02	7.22E-05	7.22E-05
			0.63%	95636	1,2,4-trimethylbenzene	1.7E-3		60			2.78E-05	
			0.04%	98828	Isopropylbenzene (cumene)	1.1E-4		400			2.65E-07	
			0.66%	100414	Ethylbenzene	1.7E-3	4.00E-01	1,000	22,000	4.37E-03	1.75E-06	7.94E-08
			0.21%	108678	1,3,5-trimethylbenzene	5.6E-4		60			9.27E-06	
			4.36%	108883	Toluene	1.2E-2		5,000	7,500		2.31E-06	1.54E-06
			2.14%	110543	N-hexane	5.7E-3		700			8.09E-06	
			0.25%	110827	Cyclohexane	6.6E-4		6,000			1.10E-07	
			2.39%	1330207	M & p-xylene mixture	6.3E-3		200	8,700		3.16E-05	7.27E-07
									Total stack	2.10E-02	1.53E-04	7.45E-05
Stage 1 Underground Tank: Breathing and Emptying	3.43	0.783			Stack 2: Breathing							
			0.82%	71432	Benzene	6.4E-3	1.30E-01	30	30	4.93E-02	2.14E-04	2.14E-04
			0.63%	95636	1,2,4-trimethylbenzene	4.9E-3		60			8.22E-05	
			0.04%	98828	Isopropylbenzene (cumene)	3.1E-4		400			7.83E-07	
			0.66%	100414	Ethylbenzene	5.2E-3	4.00E-01	1,000	22,000	1.29E-02	5.17E-06	2.35E-07
			0.21%	108678	1,3,5-trimethylbenzene	1.6E-3		60			2.74E-05	
			4.36%	108883	Toluene	3.4E-2		5,000	7,500		6.83E-06	4.55E-06
			2.14%	110543	N-hexane	1.7E-2		700			2.39E-05	
			0.25%	110827	Cyclohexane	2.0E-3		6,000			3.26E-07	
			2.39%	1330207	M & p-xylene mixture	1.9E-2		200	8,700		9.36E-05	2.15E-06
									Total stack	6.22E-02	4.54E-04	2.21E-04
Stage 2 Displacement	13.09	2.987			Volume 1: Displacement loss							
			0.82%	71432	Benzene	2.4E-2	1.30E-01	30	30	1.88E-01	8.15E-04	8.15E-04
			0.63%	95636	1,2,4-trimethylbenzene	1.9E-2		60			3.14E-04	
			0.04%	98828	Isopropylbenzene (cumene)	1.2E-3		400			2.99E-06	
			0.66%	100414	Ethylbenzene	2.0E-2	4.00E-01	1,000	22,000	4.93E-02	1.97E-05	8.96E-07
			0.21%	108678	1,3,5-trimethylbenzene	6.3E-3		60			1.05E-04	
			4.36%	108883	Toluene	1.3E-1		5,000	7,500		2.61E-05	1.74E-05
			2.14%	110543	N-hexane	6.4E-2		700			9.13E-05	
			0.25%	110827	Cyclohexane	7.5E-3		6,000			1.24E-06	
			2.39%	1330207	M & p-xylene mixture	7.1E-2		200	8,700		3.57E-04	8.21E-06
									Total volume 1	2.37E-01	1.73E-03	8.41E-04
									1/2	1.19E-01		
Stage 2 Spillage (nozzle)	2.09	0.478			Volume 2: Spillage							
			0.82%	71432	Benzene	3.9E-3	1.30E-01	30	30	3.01E-02	1.30E-04	1.30E-04
			0.63%	95636	1,2,4-trimethylbenzene	3.0E-3		60			5.02E-05	
			0.04%	98828	Isopropylbenzene (cumene)	1.9E-4		400			4.78E-07	
			0.66%	100414	Ethylbenzene	3.2E-3	4.00E-01	1,000	22,000	7.88E-03	3.15E-06	1.43E-07
			0.21%	108678	1,3,5-trimethylbenzene	1.0E-3		60			1.67E-05	
			4.36%	108883	Toluene	2.1E-2		5,000	7,500		4.17E-06	2.78E-06
			2.14%	110543	N-hexane	1.0E-2		700			1.46E-05	
			0.25%	110827	Cyclohexane	1.2E-3		6,000			1.99E-07	
			2.39%	1330207	M & p-xylene mixture	1.1E-2		200	8,700		5.71E-05	1.31E-06
									Total volume 2	3.79E-02	2.77E-04	1.35E-04
									1/2	1.90E-02		

Modeling:

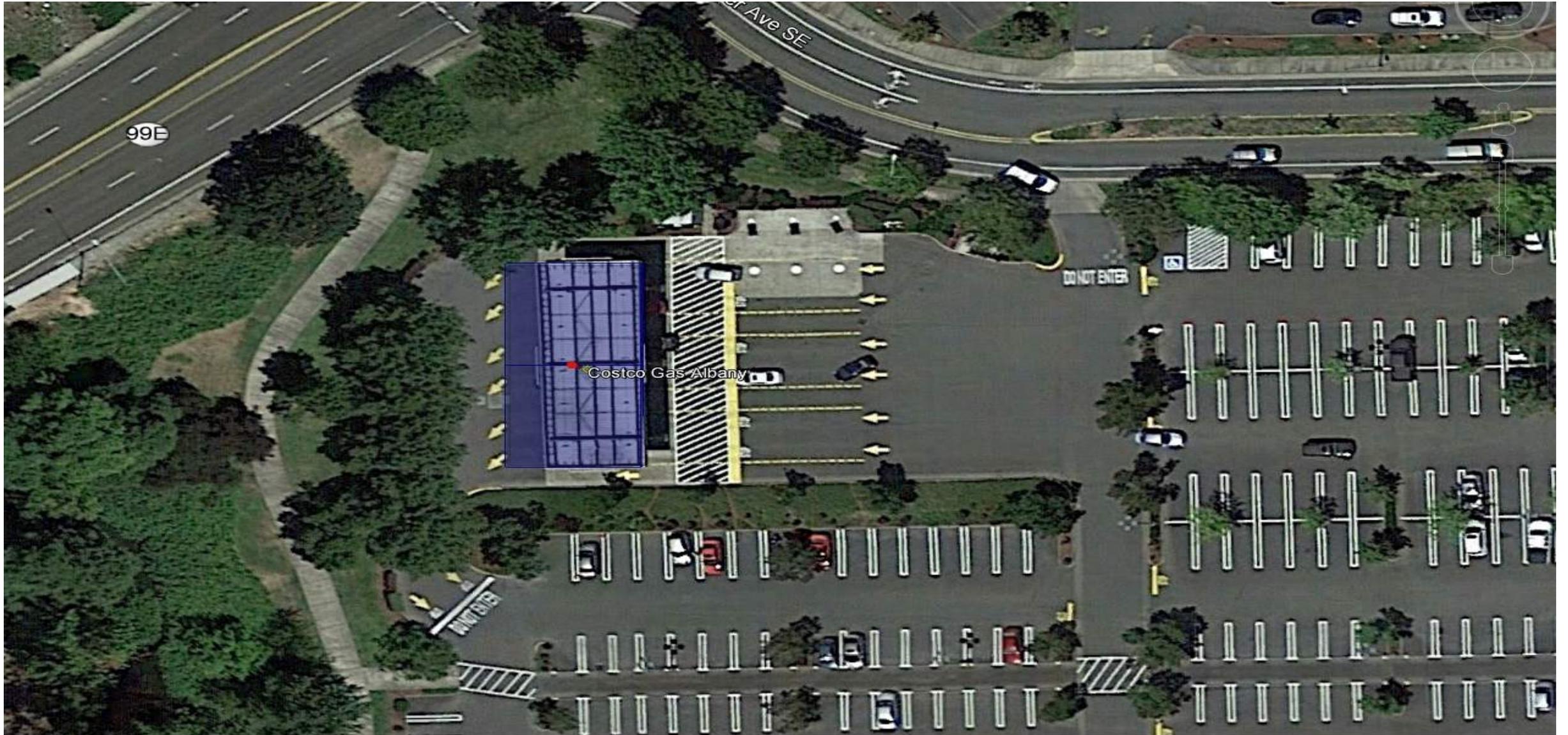


Plot Plan Showing Volume Source Size Relative to Cars and Gas Pump Location

(The Shaded Area Represents the Volumes Used For Modeling Spillage and Refueling Emissions)

(The Vent Pipe Represents the Points Used for Modeling Loading and Breathing Emissions)

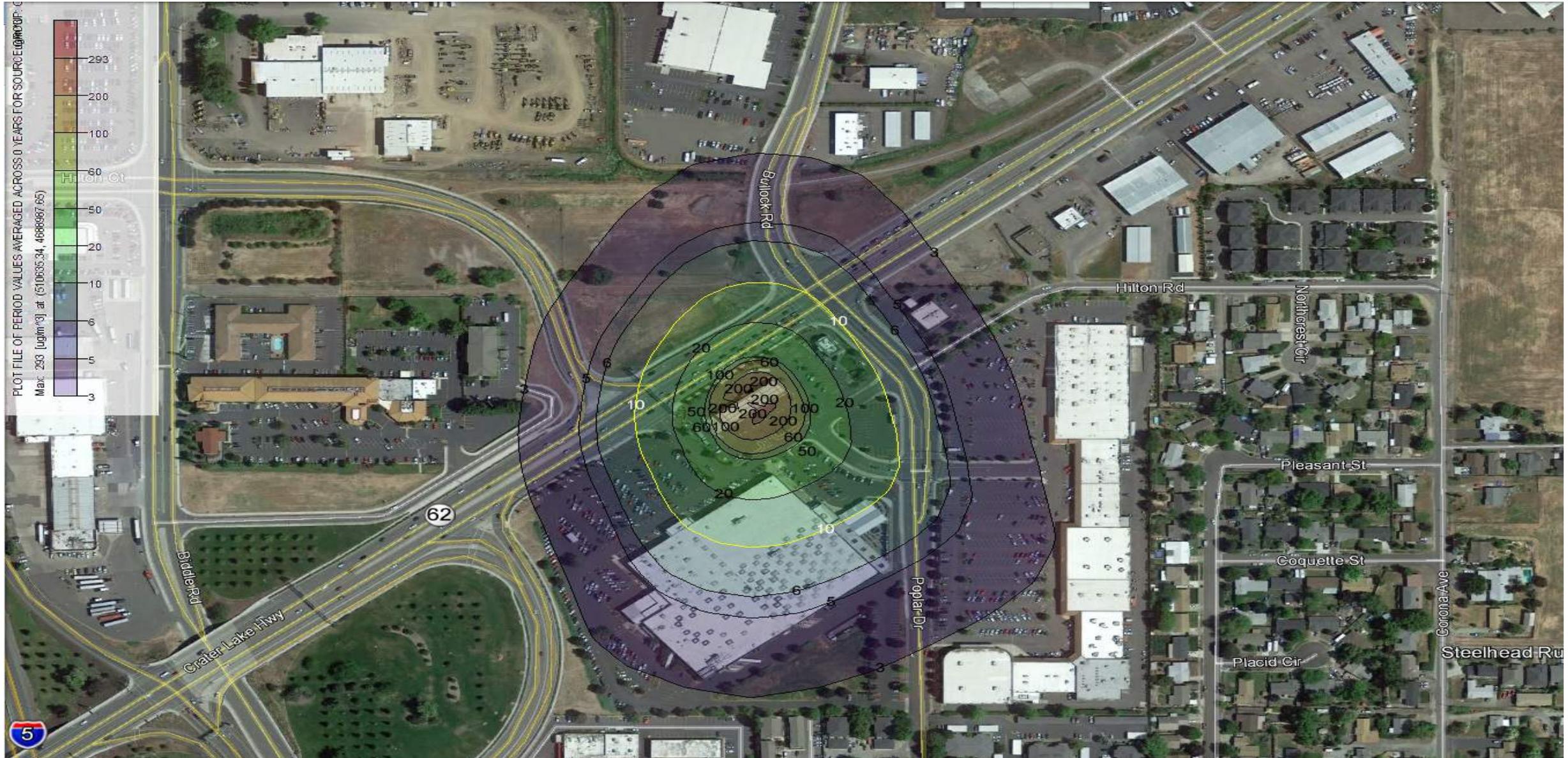
Modeling:



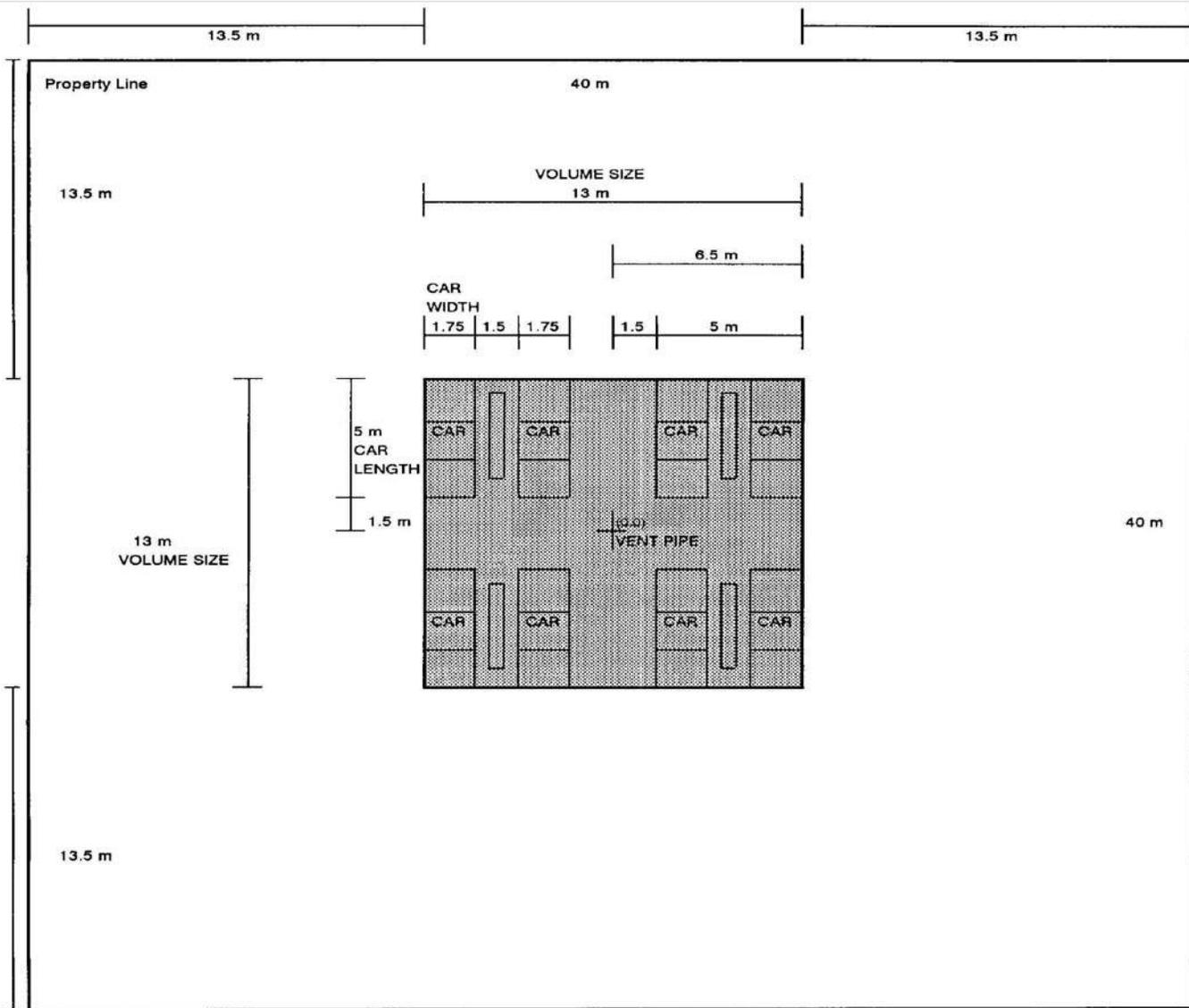
Modeling:



Modeling:

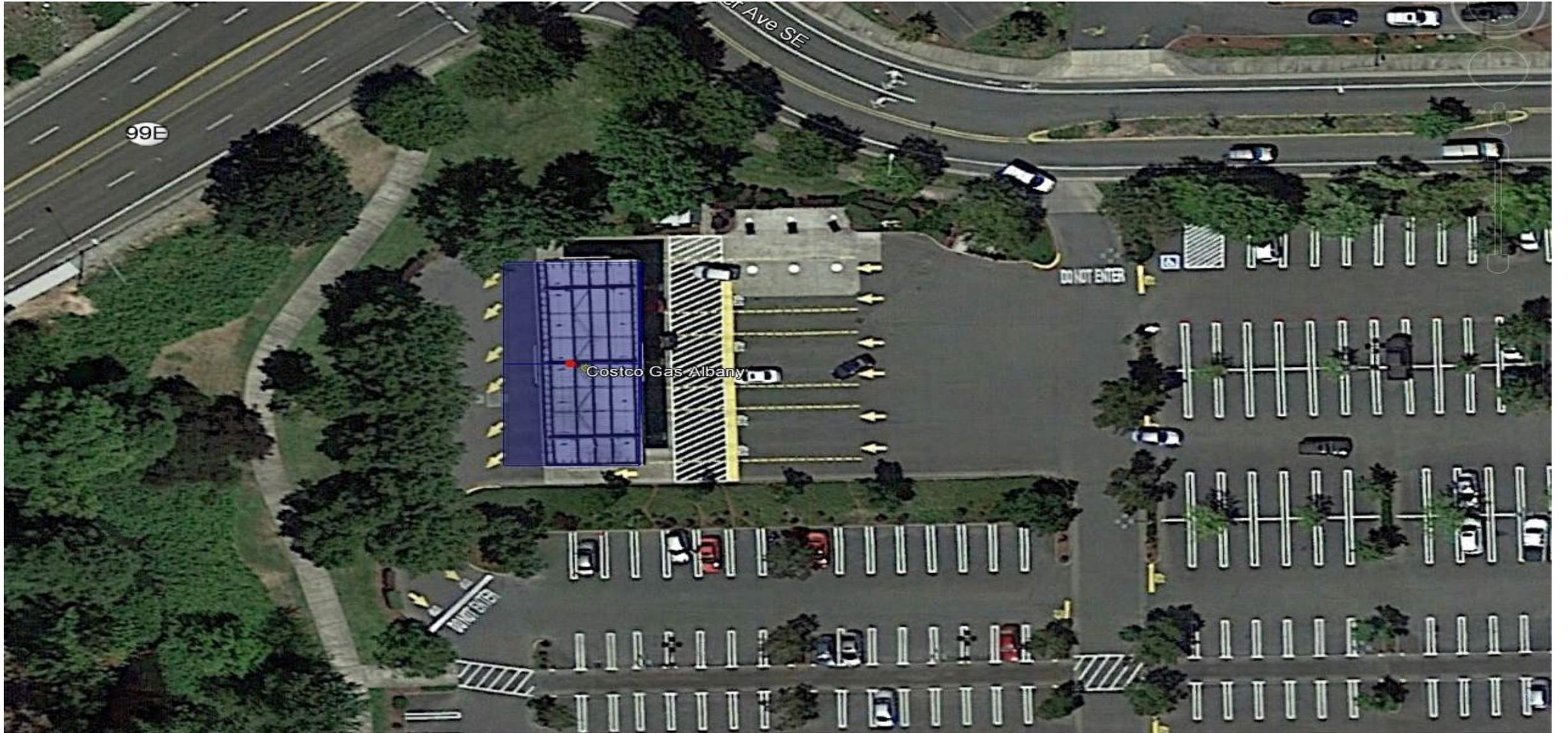


Modeling:



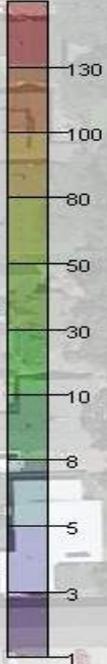
Plot Plan Showing Volume Source Size Relative to Cars and Gas Pump Location

**(The Shaded Area Represents the Volumes Used For Modeling Spillage and Refueling Emissions)
 (The Vent Pipe Represents the Points Used for Modeling Loading and Breathing Emissions)**



PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0 YEARS FOR SOURCE (gmpbp: A

Max: 130 [$\mu\text{g}/\text{m}^3$] at (494511.66, 4942825.07)





PLOT FILE OF PERIOD VALUES AVERAGED ACROSS 0. YEARS FOR SOURCE (approx): C

Max: 293 (ug/m³) at (510635.34, 4686867.65)

