Gasoline Refueling Equipment Review: Technical Report

PUGET SOUND
Clean Air Agency

A. SUMMARY

The Puget Sound Clean Air Agency (the Agency) analyzed potential hardware changes in gasoline dispensing facility (GDF) Stage II Vapor Recovery Control Systems to evaluate the associated impact on emissions of volatile organic compound (VOC) and benzene in support of a review and revision of PSCAA gasoline dispensing facilities regulations: PSCAA Regulation II 2.07, PSCAA Regulation I 6.03(b)(1) and (2), and PSCAA Regulation I 5.05. This review also considers the implementation feasibility of hardware changes, begins to discuss regulatory mechanisms for the proposed changes and outlines considerations for stakeholder engagement as rulemaking moves forward.

Objective & Scope of Review

This technical support document focuses on Stage 2 vapor recovery at gasoline dispensing facilities including requirements for installation, testing and maintenance (PSCAA Regulation II 2.07) as well as the associated permitting and registration requirements for gasoline dispensing facilities in PSCAA Regulation I 6.03(b) and PSCAA Regulation I Article 5.

Findings

As of December 2023, percentages of vehicles using on-board vapor recovery (ORVR) in PSCAA counties is about 5% lower than 2014 projections estimated. The percentage of vehicles equipped with ORVR technology (ORVR saturation) and the number of stations with older equipment that is incompatible with Stage 2 vapor recovery are the primary variables affecting the “cross over year” of when VOC emission increases from ORVR-incompatible stations fueling ORVR equipped vehicles are equal to the emission reductions achieved by Stage 2 vapor recovery overall. The updated ORVR saturation values, as well as updated information regarding ORVR incompatible gasoline dispensing facilities results in an anticipated cross over year of 2034. About 99% of vehicles in PSCAA jurisdiction must utilize ORVR technology for removal of Stage 2 vapor recovery without an increase in VOC emissions across the airshed. PSCAA estimates that 99% ORVR saturation will be reached in 2034.

VOC emission increase resulting from loosening vapor recovery requirements on GDF Stage 2 vapor recovery range from 460 – 2,000 ton/yr, an estimated 0.1-3% of total VOC emissions in the PSCAA airshed. This range is calculated from two different methodologies for VOC calculation and several different potential hardware change scenarios.

Changes to the GDF Stage 2 vapor recovery system potentially change the distance beyond a GDF where elevated benzene emissions occur. PSCAA analysis calculated the distance needed for benzene emissions to have modeled concentration at or below Acceptable Source Impact Levels (ASILs) for different equipment configurations and gasoline throughputs. PSCAA jurisdiction has many stations with relatively nearby receptors, and the reductions in benzene emissions achieved by continued use of Stage 2 vapor recovery support its continued use, as well as addition of vapor processing units at stations with relatively high throughput.

Proposal

PSCAA proposes linking Stage 2 vapor recovery equipment requirements to gasoline throughput following Option 2 identified in the Appendix A Modeling Report and discussed in Section E of this report:

Table 1: Proposed Refueling Equipment Summary

New Proposed Equipment Requirements		Current Equipment Requirements	
Equipment	Annual Gasoline Throughput (gal/yr)	Equipment	Annual Gasoline Throughput (gal/yr)
Conventional	0 –≤500,000	Conventional	0-≤200,000
Enhanced Conventional Nozzle	>500,000 – ≤700,000	EVR no Vapor Processor	>200,001-≤6,000,000+
EVR no Vapor Processor	>700,000 – ≤1,000,000		
EVR including vapor processor	>1,000,000 – ≤6,000,000+	EVR with vapor processor	Case by case permitting 6,000,000+

Single Stations with ORVR-incompatible equipment are estimated to result in more emissions than enhanced conventional nozzles (with low permeability hoses) by 2033 (corresponding to 99% ORVR saturation). PSCAA recommends a requirement that ORVR-incompatible equipment be replaced prior to 2033.

Stations for which the new proposed regulations would result in installation of Stage 2 EVR with vapor processor will be required to install a vapor processor within 3 years of promulgation.

PSCAA proposes some changes to ongoing Stage 2 testing requirements to support continued maintenance of vapor tight systems. PSCAA proposes to maintain all of the existing installation tests. The proposed testing changes are discussed further in Section I:

Table 2 Proposed Stage 2 Testing Summary

New Proposed Ongoing Testing Requirement		Current Ongoing Testing Requirement	
Gasoline Throughput (gal/yr)	Testing	Gasoline Throughput (gal/yr)	Testing
0-200,000	No ongoing testing (no changes from existing regulation)	0-200,000	No ongoing testing
200,000 – 700,000	Semiannual pressure decay tests Annual static torque of adaptors tests	200,000 and higher	Annual: Dynamic Back Pressure, Static Torque of Adaptors, Tank Tie (if reconfigured), Air to Liquid (Vac Assist only) Semiannual: Pressure Decay
700,000 and higher	Annual: Dynamic Back Pressure, Static Torque of Adaptors, Tank Tie (if reconfigured), Air to Liquid (Vac Assist only) Semiannual: Pressure Decay		

B. BACKGROUND

Gas Station Refueling Emissions and Vapor Control

GDFs emit gasoline vapors (including VOCs and benzene) from the filling of the GDF's gasoline storage tank(s), from refueling of motor vehicles, spills during refueling, and from storage tank venting. Stage I Vapor Recovery Control Systems (VRS) control the vapors that would be released during filling of the GDF storage tanks. Stage I VRS are required for installation on all GDFs in PSCAA jurisdiction with a gasoline storage tank of at least 1,000 gallons. No changes to Stage I VRS are proposed and Stage I VRS are not further discussed in this Technical Support Document. Stage II Vapor Recovery Control Systems (VRS) control the release of gasoline vapors during refueling. Certain Stage II and non-Stage II dispensing equipment also provides controls for spills during refueling and storage tank venting.

Stage II Vapor Recovery Control Systems (VRS) are designed to control volatile organic compound (VOC) releases during the refueling of motor vehicles. During vehicle refueling, VOC, benzene, and other air toxics emitted from the vehicle's gasoline tank are routed to the station's storage tanks using special nozzles and coaxial hoses at the gasoline pump. This process takes the vapors that would otherwise be emitted directly into the atmosphere during refueling and recycles them back into the fuel storage tanks, preventing them from being released to the air.

Stage II VRS may be either a balance type system or a vacuum assist type system. The balance system relies on a tight seal of the nozzle against the vehicle's fuel pipe lip so that gasoline may be transferred into the vehicle tank through a coaxial hose. The difference in pressure drives gasoline vapors back through the coaxial hose to the GDF storage tank. The vacuum assist system uses an electric pump to recovery vapors from the dispensing system to the GDF storage tank.

Beginning in 1998, the Clean Air Act (CAA) required vehicle manufacturers to install onboard refueling vapor recovery (ORVR) systems in vehicles. The ORVR systems are designed to reduce emissions of VOCs and toxics from the vehicle's gasoline tank during refueling. Both onboard refueling vapor recovery (ORVR) and Stage II VRS are systems that capture gasoline emissions that would otherwise be emitted into the air from refueling. Because the Stage II VRS and ORVR systems are largely redundant, on May 9, 2012 EPA determined that Stage II VRS will no longer be required for current and former ozone nonattainment areas classified as serious and above because vehicles with ORVR are now in widespread use.

Gas Stations in PSCAA Jurisdiction

Over 1,300 facilities with gasoline storage tanks and dispensers are located within PSCAA jurisdiction. Of those facilities, a subset of about 1,240 stations are specifically registered as gasoline dispensing facilities and the remaining stations are registered as sites with other equipment in addition to the gasoline dispensing equipment. PSCAA tracks gasoline throughput of stations that are registered specifically as GDFs, as annual registration fees are linked to gasoline throughput for GDFs under PSCAA Regulation I Article 5. Stations which are not registered as gasoline dispensing facilities are subject typically to the base registration fees of Regulation I Article 5, and throughput information has not historically been tracked by PSCAA for those stations. Given that these stations are typically stations of convenience serving a specific fleet with lower throughput, and the absence of specific throughput information, the fleet wide analysis focuses on the 1,240 specifically registered stations.

Based on the throughput information provided to PSCAA by stations as part of the registration program under PSCAA Regulation I Article 5, as well as PSCAA database information about the equipment on-site at these stations, the total VOC emissions across the jurisdiction are estimated, along with the relative contribution of each size of gas station to total throughput and VOC emissions:

Database Throughput (gallon/yr)	# of stations	% of stations	throughput (gallon/yr)		% total gasoline throughput	% total VOC emissions
			upper estimate	lower estimate		
>6,000,000	22	2%	792,000,000	264,000,000	28%-31%	8%-17%
3,600,001 - 6,000,000	44	3%	264,000,000	158,400,044	17%-10%	20%-11%
1,200,001 - 3,600,000	220	17%	792,000,000	264,000,220	28%-31%	36%-35%
840,001 - 1,200,000	180	14%	216,000,000	151,200,180	16%-8%	21%-10%
200,000-840,000	522	40%	438,480,000	104,400,000	11%-17%	15%-20%
<200,000	257	20%	51,400,000	0	0%-2%	0%-8%
uncharacterized	56	4%				

The owners, operators, and employees at gasoline dispensing facilities can fall under a few different models of ownership: corporate, local ownership, group/family-owned with multiple stations, single station ownership, and government ownership. From ongoing regulation of stations, PSCAA is aware of many small sized stations which are owned and operated by people for whom English is not their first language.

Demographics of the people near stations vary widely because communities surrounding gas stations are in diverse locations in our four counties. Typically, the largest throughput stations (>6,000,000 gallons per year with upper limit of throughput at 36,000,000 gallons per year) are co-located with warehouse or large grocery stores. They tend to have fewer close neighbors than typically smaller throughput neighborhood stations which may have neighboring businesses or residences very close to the station's dispensing canopies and/or pressure vent valves. People living near gas stations that serve neighborhoods may be closer to emission points from a GDF, such as in urban locations with housing surrounding a station, and people living near stations near highways and/or arterial roads may be close to GDF emission points and also experience mobile source pollution from vehicle traffic. Certain rural stations may also be close to residences.

Given the high number of gas stations in PSCAA jurisdiction, PSCAA identified 11 zip codes with the most gas stations per zip code: Auburn (98002), Kent (98032), Arlington/Oso (98223), Tukwila/SeaTac/Seattle (98188), Lakewood/Tacoma (98499), Everett (98204, 98201, and 98208), Seattle/Shoreline (98133), and Port Orchard (98366). These zip codes comprised the 95th percentile of gas stations and accounts for 13%-15% of the gasoline throughput in the four county region. Within each of the 11 identified zip codes, PSCAA then located census blocks containing gas stations. PSCAA's Community Air Tool (CAT) 2.0

assigned a composite score of 0-35 to each census block, with a higher score indicating more disproportionate environmental impacts.

Across all of the census blocks contained in the 11 zip codes reviewed, CAT scores ranged from 13 to 35. Census blocks containing 4 or more stations had CAT scores from 19-34. Four census blocks, located in zip codes 98002 and 98032, had CAT scores of 30 or more and contained 4 or more stations. These census blocks are recommended for further outreach as a representative of more highly impacted community living near GDFs during stakeholder engagement. Additional selected demographic information for the four census blocks are shown below:

Census Block	CAT Score	# GDF	% BIPOC	% Below Poverty Line	% Under 18 Yrs	% Over 64 Yrs
530330308011	34	4	27%	20%	37%	8%
530330305011	30	5	27%	30%	11%	16%
530330307002	31	5	12%	13%	32%	14%
530330292061	32	14	43%	40%	32%	7%
PSCAA jurisdiction-wide average	--	--	28%	10%	22%	12%

C. AVAILABLE EQUIPMENT OPTIONS

PSCAA reviewed commercially available gas station hardware for dispensing. Different equipment configurations are arranged from lowest emitting to highest emitting hardware.

In assessing long term commercial availability, PSCAA confirmed that multiple air quality regulatory agencies in WA, OR and CA require Stage 2 vapor recovery for at least a subset of stations with specific throughput and/or location characteristics. PSCAA's existing regulation relies on Stage 2 equipment certification through California Air Resources Board (CARB) Executive Orders.

1. **EVR Stage 2 System w/out ISD**
   The equipment currently installed on certain very large throughput stations are Enhanced Vapor Recovery (EVR), except for use of an In-Station Diagnostic (ISD) system. Vapor processors and EVR balance nozzles or vacuum assist nozzles are utilized on stations with higher throughput.
2. **EVR Stage 2 System w/out Vapor Processor and w/out ISD**
   The equipment currently installed on most stations are vapor balance systems utilizing EVR nozzles but does not utilize vapor processors nor in station diagnostics (ISD) and is modeled using the emission factors for a pre-EVR system for refueling and breathing losses and an EVR system for spillage. Pre-EVR Stage 2 systems must control 90% of vapors during refueling.
3. **Pre-EVR Stage 2 System**
   This is the equipment historically installed on gas stations in PSCAA jurisdiction. Existing PSCAA regulations have specified installation in accordance with current CARB Executive Orders at the time of installation. CARB implemented Stage 2 EVR between 2009 and 2011. Pre-EVR Stage 2 systems must control 90% of vapors during refueling.
   This configuration represents much of the current equipment installed in PSCAA jurisdiction, but is for equipment that would not be widely available and installed moving forward.

4. **Enhanced Conventional Nozzles w/ or w/out Low Permeation Hoses**
   Enhanced conventional nozzles reduce liquid gasoline emissions due to spillage (allowing only 3 drops of liquid to drip from the nozzle, which is an identical specification to EVR Stage 2 nozzles for allowable drips). Enhanced Conventional and Low Permeation hose configurations have been CARB approved for fueling stations where 100% of vehicles fueled are ORVR-equipped.
   The source of PSCAA VOC emission factors (2013 CARB emission factors) have equal VOC emission factors between low permeation hoses and conventional hoses after 2017.
5. **Conventional**
   A conventional refueling configuration utilizes nozzles that do not have a vapor recovery component, nor any reduced drips and spillage design components. Currently, stations with annual throughput below 200,000 gallons/year of gasoline are not required to install Stage 2 vapor recovery per PSCAA Regulations.

D. AIRSHED VOC EMISSIONS

The VOC analysis of this Technical Support Document revisits an analysis completed by PSCAA in 2014. It includes some updates in the internal methodology for VOC emission calculation, use of updated variables associated with ORVR saturation in PSCAA's four counties, and updated information about the existing GDFs in PSCAA's four counties.

VOC emissions are reviewed across the full airshed of the four county PSCAA jurisdiction because VOC reacts with nitrogen oxides and sunlight to form ozone (VOC is an ozone precursor). Ozone is a criteria pollutant subject to National Ambient Air Quality Standards, and the reactions to form ground-level ozone are not localized, so the VOC contribution from gasoline dispensing facilities is reviewed for the full region.

EPA Methodology for VOC Incremental Emissions

The EPA Methodology is entitled "EPA Guidance on Removing Stage II Gasoline Vapor Control Programs from State Implementation Plans and Assessing Comparable Measures," and is suggested for use in State Implementation Plan (SIP) revisions for regions where Stage 2 vapor recovery systems were installed as part of measures to reach or maintain attainment with ozone NAAQs.
The EPA Methodology addresses the impacts on vehicle fuel tank displacement emissions and UST vent pipe emissions from ORVR incompatible Stage II nozzles[1]. The EPA Methodology uses two equations: calculation of an increment which calculates the annual area-wide emission control gain from Stage II installations at GDFs as ORVR technology phases in, and calculation of a delta which is the comparison between the Stage II efficiency and the ORVR efficiency with both technologies in place.

$$increment_i = (Q_{SII})(1 - Q_{ORVRi})(\eta_{iuSII}) - (Q_{SIIva})(CF_i)$$

$$delta_i = (Q_{SII})(\eta_{iuSII}) - (Q_{SIIva})(CF_i) - (Q_{ORVRi})(\eta_{iuORVR})$$

Where:

η_{iuSII}	=	Stage II VRS in-use control efficiency. PSCAA utilized 71.4% efficiency derived from the 2013 CARB Revised TOG Emission Factor in 2014[2]. This factor is unchanged for the 2023 analysis.

[1] EPA Guidance on Removing Stage 2 Section 3.1 (PDF page 13)

[2] 2013 CARB GDF Emission Factors, derived from the difference between pre EVR and conventional refueling EF

Q_{SII}	=	Fraction of highway gasoline throughput covered by Stage II VRS, including both ORVR compatible and ORVR incompatible equipment. The 2014 analysis used 98%. This value was updated based on data pulled from PSCAA registered source database in July 2023 and remained 98%.[3]
Q_{SIIva}	=	Fraction of highway gasoline throughput dispensed through vacuum-assist type Stage II VRS. The 2014 analysis used 43% which assumed all vacuum assist dispensers were incompatible. The 2023 analysis revised this factor given that PSCAA has required ORVR compatible vacuum assist nozzles since April 1, 2003. For the 2023 analysis, only vacuum assist nozzles with install dates in 2003 and unknown nozzles installed in 2003 or earlier were assumed to be incompatible, yielding an upper end value of 7.9%.
VMT_{ORVRi}	=	ORVR Vehicle Miles Traveled, area-wide ORVR saturation in calendar year *i*.
CF_i	=	Compatibility Factor in year *i*, EPA methodology specifies 0.0777x Q_{ORVRi}
Q_{ORVRi}	=	Fraction of annual gallons of highway motor gasoline dispensed to ORVR-equipped vehicles in year *i.* In 2014, analysis used a 2006 projection from Washington State Department of Ecology. This analysis updated the fraction with the 2023 Department of Licensing data for an average ORVR saturation number and linear interpolation to estimate full ORVR saturation occurring in 2035. Each vehicle is assumed to contribute the same amount of gasoline consumption; the percentage of ORVR equipped vehicles is assumed to be the percentage of gasoline throughput to ORVR equipped vehicles.
η_{iuORVR}	=	In-use control efficiency for ORVR. EPA recommends value of 0.98. The 2014 analysis utilized 0.95. Analysis in 2023 is completed with both 0.98 and 0.95.

The EPA methodology was applied to years 2024 through 2040. The 2014 analysis had used a projected ORVR saturation value which estimated that 91% of vehicles would be ORVR equipped in PSCAA jurisdiction in 2022. PSCAA analysis estimates that as of 2023 about 86% of vehicles are ORVR equipped, on average, across King, Kitsap, Pierce and Snohomish counties. ORVR saturation is based on an analysis of data from the Washington State Department of Licensing (DOL). Data from vehicle transactions for the calendar year 2023 were analyzed to produce a profile of gasoline powered vehicles within King, Kitsap, Pierce and Snohomish Counties. PSCAA did a linear interpolation between the 2014 ORVR saturation value of 76% and the 2022 value of 86% and assumed a constant (linear) rate of increase of ORVR equipped vehicles in PSCAA jurisdiction (a theoretical 100% ORVR assumed in 2035).

The EPA methodology also provided an equation for estimating the annual VOC emissions from removal of Stage II VRS in a given year:

$$Tons_i = (Increment_i)(GC_i)(EF)$$

Where:

$Tons_i$	=	VOC emission increase (in tons) in year *i* caused by removal of Stage II VRS
$Increment_i$	=	Area-wide emission control gain in year *i*

[3] Assumes all GDF with reported throughput with greater than or equal to 200k gallon/yr do not utilize Stage II VRS and that all these GDF have throughput of 200k gallon/yr annually. More stations have reported throughputs below 200k gallons/yr since the 2013 analysis though this may not mean that stations have removed the Stage II VRS in place when their throughput was above 200k gallon/yr. Sources not registered as specifically gasoline dispensing facilities, for which there is not available throughput data are excluded from the analysis.

GC_i	=	Total gasoline throughput in region in year *i*
EF	=	Uncontrolled displacement refueling emission factor (g/gal) calculated from Reid Vapor Pressure, dispensed fuel temperature, and the difference between tank fuel temperature and dispensed fuel temperature. As with the 2014 analysis, values for each variable were taken from the August 7, 2012, EPA Guidance on Removing Stage 2. The calculated EF is 2.8 g/gal, or 18.6 lb/1,000 gal.

Assuming 87% ORVR saturation in 2024 and no changes to ORVR incompatible equipment, the increase in VOC emissions from removal of Stage II VRS would be between about 721 and 1,955 TPY VOC . If 100% ORVR saturation is achieved with no changes to ORVR incompatible equipment, the calculation would be a net VOC emission savings of between 54 and 145 TPY VOC from removing Stage II VRS.

The crossover year identified in the analysis would be at 99% ORVR saturation, which is projected to occur in 2034. At this time the removal of Stage II VRS without any changes to ORVR incompatible equipment, would result in estimated VOC emissions savings of 1-3 TPY, with projected VOC savings at 100% ORVR saturation of 54-145 TPY VOC.

The full tabulation of the EPA methodology can be found in Appendix C.

PSCAA Methodology

The PSCAA Methodology as completed in 2014 calculated VOC emissions related to gasoline dispensing emissions from 2014 and from 2030 under two different scenarios: (1) keeping Stage II VRS in place and (2) removing all Stage II VRS. This updated analysis instead considers the differences in VOC emissions related to a total of five different types of emission equipment as identified in Section C of this report, and evaluates VOC emissions with the following configurations of this equipment. The ORVR saturation projections utilized for the EPA methodology are also utilized for the scenarios below.

Scenario A: Current State

This scenario models emissions based on equipment currently in use in PSCAA jurisdiction and assumes:

- All stations with throughput below 200,000 gallons per year utilize conventional equipment,
- All stations with vacuum assist or uncharacterized Stage 2 vapor recovery installed on or before 2003 are ORVR-incompatible
- Select stations permitted under Notice of Construction Orders of Approval utilize EVR with vapor processor,
- Stations with equipment installed on or before 2011 have pre-EVR Stage 2; and
- All other stations with equipment installed after 2011 have EVR Stage 2 without vapor processor.

Scenario B: Conventional Refueling Equipment (Highest VOC emissions)

This scenario assumes that all gasoline dispensing facilities in PSCAA jurisdiction would utilize only conventional refueling equipment. It represents the upper end of anticipated VOC emissions that could be associated with changes to Stage II equipment requirements.

Scenario C: Stage 2 EVR (Lowest VOC emissions)

This scenario assumes that all gasoline dispensing facilities in PSCAA jurisdiction would utilize Stage 2 EVR including vapor processors. It represents the lowest potential VOC emissions that could be associated with changes to Stage II equipment requirements.

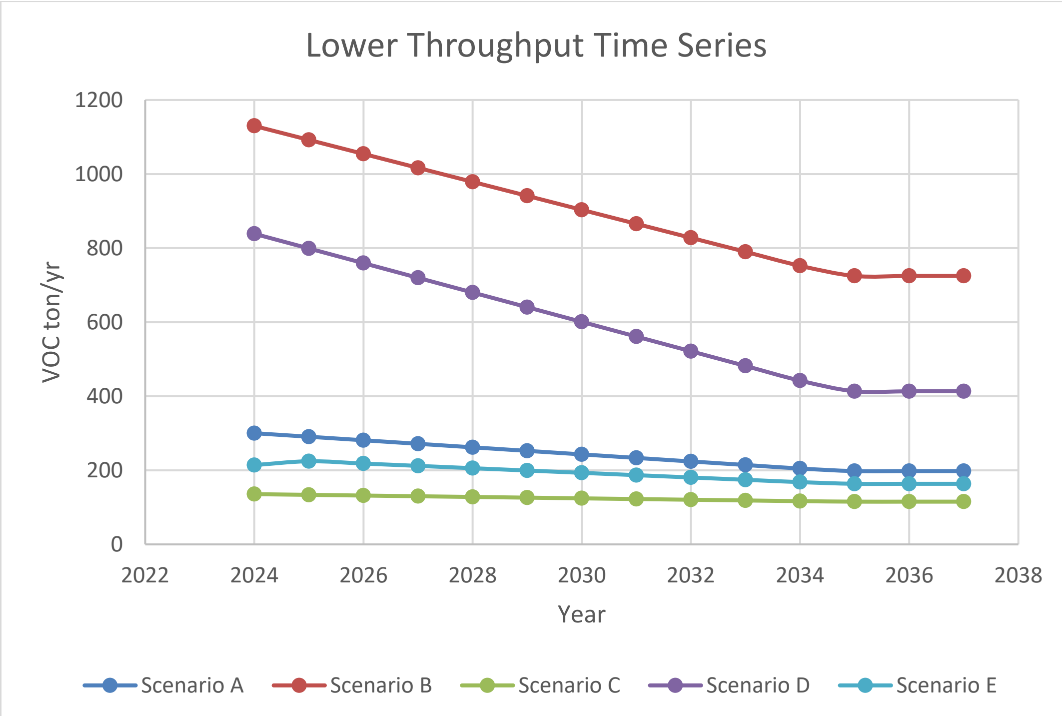
Scenario D: Enhanced Conventional and low permeability hoses
This scenario assumes that all gasoline dispensing facilities in PSCAA jurisdiction would utilize enhanced conventional nozzles and low permeability hoses.

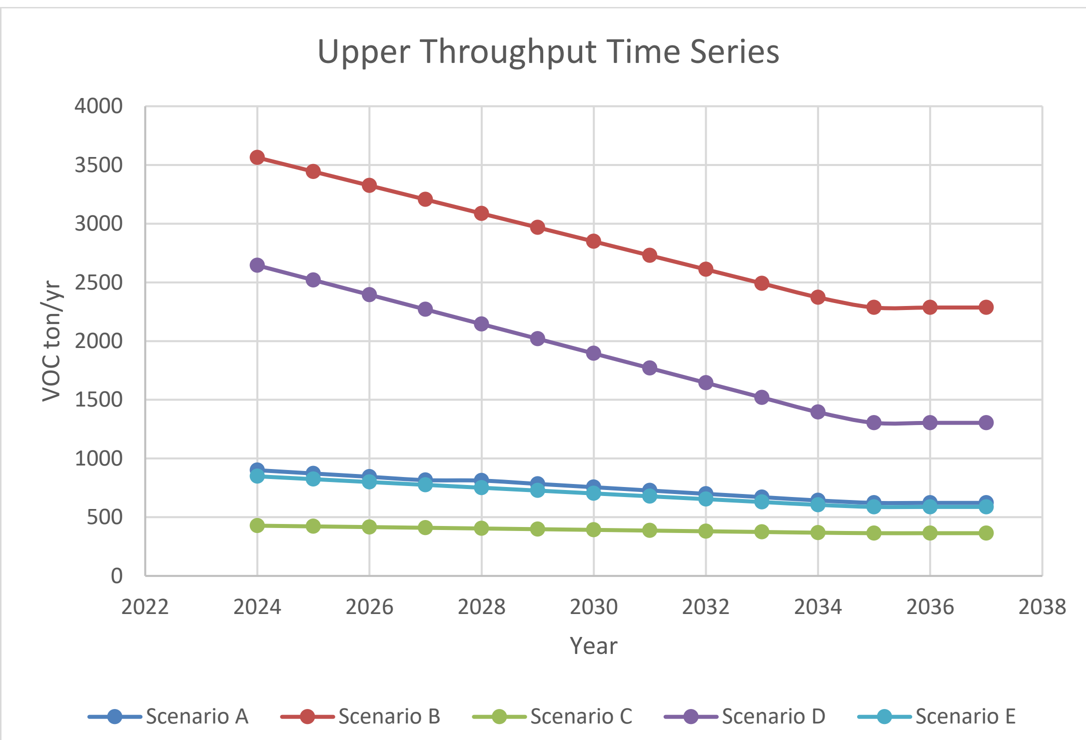
Scenario E: Tiered Requirements
This scenario considers a mix of Stage 2 equipment requirements, informed by the air toxics analysis discussed in Section E of this report[4]. See table below for equipment and corresponding throughput ranges:

Equipment	Annual Gasoline Throughput (gal/yr)
Conventional	0-≤500,000
Enhanced Conventional	>500,000 – ≤700,000
EVR no Vapor Processor	>700,000 – ≤1,000,000
EVR	>1,000,000 – ≤6,000,000+

The time series plots below show the lower end and upper end estimate of VOC emissions across all registered gas stations. Scenarios B and D (conventional and enhanced conventional) are most impacted by increasing ORVR saturation. At the projected date of estimated 100% ORVR saturation, emissions level out for each scenario, assuming constant gasoline throughput in the region.

[4] The throughput information in PSCAA database is linked to the existing bins for gasoline throughput (gallons/yr): 0 – 200,000, 200,000 – 840,000, 840,000 – 1,200,000, 1,200,000 – 3,600,000, 3,600,000 – 6,000,000 and 6,000,000+. With the proposed equipment breakdown of Option 2, stations within existing bins that span multiple new bins were evenly split between each new bin.





This methodology accounts for the emissions from refueling, from spillage, and from pressure-driven losses. As with the 2014 analysis, the emission factors were derived from the December 23, 2013, CARB report "Revised Emission Factors for Gasoline Marketing Operations at California Gasoline Dispensing Facilities". Given that the analysis is comparative between different options for hardware, the VOC calculations do not include Stage 1 related emissions.

The table below summarizes the VOC emissions plotted in the lower and upper throughput plots above:

Scenario	Estimated VOC Emissions (TPY)	
	2024	2035 (100% ORVR saturation projection)
A	300 – 900	198 –622
B	1130 – 3563	725 – 2286
C	136 - 428	115 – 364
D	839 – 2645	414 – 1304
E	214– 848	164 – 588

Airshed-wide VOC emissions from all sources across King, Kitsap, Pierce, and Snohomish counties were calculated in the WA Department of Ecology 2020 Comprehensive Emissions Inventory and totaled 112,551 tons of VOC. The upper end of the estimated emission changes associated with this rulemaking is about 2% of all VOC emissions in PSCAA's four-county jurisdiction.

Single Station with ORVR Incompatible Vacuum Assist Equipment
For a single station with ORVR incompatible vacuum assist equipment, a disbenefit of increased VOC emissions due to the interaction between the incompatible system begins at an ORVR saturation of 98%, which PSCAA estimates will occur on average in 2032.

E. LOCALIZED BENZENE EMISSIONS
Stage II vapor recovery systems also have a toxics reduction co-benefit through reduction in benzene and other air toxics that are present in gasoline emissions. This review focuses on benzene as a representative air toxic based on California Air Resources Board (CARB) Gasoline Service Station Industry-wide Risk Assessment Technical Guidance (February 18, 2022)[5] and Supplemental Policy Guidance (July 21, 2022) which identifies benzene as the most toxic component of gasoline.

PSCAA identified three different methodologies for estimating speciated benzene emission calculations from total VOC emission factors:

(1) The methodology utilized in historic PSCAA permitting and the 2014 analysis, which utilizes the federal regulatory limit[6] of 0.62% by volume for average benzene content in gasoline, and the density of benzene relative to gasoline to determine a percentage of gasoline emissions by weight which are benzene in the vapor phase. This results in benzene emissions of 0.224% by weight of evaporative emissions and 0.815% by weight for spilled gasoline. These percentages were applied to the CARB emission factors for VOCs to estimate the portion of total emissions which are benzene. of gasoline,

[5] Gasoline Service Station Industrywide Risk Assessment Supplemental Policy Guidance Document (July 21, 2022) pg 15 & Gasoline Service Station Industrywide Risk Assessment Technical Guidance (February 18, 2022):
[6] Mobile Source Air Toxics Rule 40 CFR Part 1090.210 Benzene Standards

(2) Hsieh, Shearston, and Hilpert's December 2020[7] paper "We assumed that current US liquid gasoline (except in California) contains about 1% of benzene by volume. Like CAPCOA and Hilpert et al., we assumed a mass fraction of benzene in the ullage/headspace of the underground storage tank of 0.003 (by weight benzene in vapors)."
   a. Hilpert et al. "assumed like the [1997] CAPCOA study…that the density of the mixture of gasoline vapors and fresh air was 1.05 lb/ft3…and that the emitted vapor/air mixture contained 0.3% of benzene by weight"[8]

   Following the methodology from the Hsieh paper would result in slightly higher percentages of benzene by weight in the liquid gasoline (spills) and also slightly higher percentages of benzene vapors in the fuel than the 2014 study due to differences in the assumed benzene content and the density assumed for gasoline: 0.3% by weight for evaporative emissions and 1.31% by weight for spilled gasoline.

(3) CARB & CAPCOA Gasoline Service Station Industrywide Risk Assessment Technical Guidance February 18, 2022, which utilized CA-specific factors for benzene based on measured speciation profiles. The speciation profiles do not apply to Washington's gasoline profile.

PSCAA opted to utilize Methodology (2) for the localized benzene emission analysis under this review. 40 CFR 1090.210 specifies that a gasoline manufacturer must meet a benzene average standard of 0.62% by volume for each compliance period (annual), however this average may be achieved through use of credits, and the regulatory maximum benzene average standard is 1.3 % by volume. To capture the variability and potential of higher average benzene content, 1% by volume is used consistent with Methodology (2).

While the VOC analysis focuses on the airshed total VOC emissions, the air toxics impact analysis for benzene looks at a few different examples of gasoline dispensing facilities and the immediate surrounding area (from the ambient air on-site at the facility out to 500 meters from the site). The benzene analysis also attempts to capture the variability in ORVR saturation by zip codes. The model set-up and cases are discussed further in Appendix A.

There are different mechanisms for assessing the risk of benzene for long-term health effects. This analysis compares modeled ambient benzene concentrations to the acceptable source impact level (ASIL) for benzene specified in Washington state's air toxics rule for permitting of new sources, WAC 173-460. The analysis reviewed the distance at which concentrations reached the benzene ASIL (0.13 $\mu g/m^3$). The analysis compares different equipment for refueling vapor recovery hardware options. The aggregate of benzene impacts on people living and or working near a gas station will vary based on many factors including emissions from vehicles near the stations and driving to the station for fueling, geometry of the station(s), terrain surrounding the station(s), and the prevailing wind/weather patterns.

Review of a single gas station with varying throughput and equipment configuration as well as review of 4 clustered stations (as on each corner of an intersection) yielded two different sets of tiered throughput bins and associated required equipment. The throughput cutoffs correspond to the

[7] Hsieh, Shearston, and Hilpert. "Benzene emission from gas station clusters: a new framework for estimating lifetime cancer risk." *Journal of Environmental Health Science and Engineering.* 7 Jan 2021.
[8] Hilpert, Rule, Mora & Tiberi. "Vent Pipe Emissions from Storage Tanks at Gas Stations: Implications for Setback Distances". *Sci Total Environ.* 10 Feb 2019.

throughput resulting in benzene concentrations at or below the ASIL 19 meters from the nearest canopy of the station(s) which were rounded down to the nearest 50,000 gallons:

Option 1: Four Station Intersection Modeled Emissions at or Below Benzene ASIL at 19 Meters

Equipment	Single Station Annual Gasoline Throughput (gal/yr)
Conventional	0 –≤200,000
Enhanced Conventional	>200,000 – ≤500,000
EVR no Vapor Processor	>500,000 – ≤650,000
EVR	>650,000 – ≤6,000,000+

Option 2: Single Station Modeled Emissions at or Below Benzene ASIL at 19 Meters

Equipment	Annual Gasoline Throughput (gal/yr)
Conventional	0 –≤500,000
Enhanced Conventional	>500,000 – ≤700,000
EVR no Vapor Processor	>700,000 – ≤1,000,000
EVR	>1,000,000 – ≤6,000,000+

Gas station configuration, distance to receptors and throughput are varied across PSCAA jurisdiction. Many larger throughput stations (i.e. >6,000,000 gallons/year) are located at larger grocery stores or warehouse stores with a larger footprint and distance (often exceeding 100 meters from the center of the gas station canopy) before reaching other businesses or residences. Many stations with relatively lower throughput are nestled into neighborhoods with less than 20 meters from the fueling canopy to a receptor.

PSCAA recommends use of Option 2 rather than Option 1 to guide the throughput-based hardware requirements because (1) clusters of stations are each operating as independent businesses and would not be anticipated to have matched throughputs, (2) for permitting of new sources, the Washington Administrative Code (WAC) 173-460 air toxics regulations apply the ASIL to a single source's incremental increase in toxic emissions rather than aggregated sources, (3) 4 clustered stations at each corner of an intersection occur relatively infrequently, estimated to be less than 20 clusters of 4 stations across PSCAA jurisdiction, or less than 7% of gas stations.

F. COST ANALYSIS

PSCAA estimated equipment, installation, maintenance, and testing costs for each hardware configuration (conventional, enhanced conventional nozzles only, enhanced conventional nozzles with low permeability hoses, EVR without vapor processor and EVR with vapor processor) at the upper and lower gasoline throughput of the Option 2 proposed throughput-based hardware requirements. For each of the cases, the assumption was 8 nozzles and hanging hardware sets per station.

Equipment cost data was sourced as an average from online vendor data, historic PSCAA notification data, Southwest Clean Air Agency February 2020 rulemaking supporting documentation, and Oregon Department of Environmental Quality March 2024 rulemaking supporting documentation, except for vapor processors, which were taken as a median value across three available processors.

Installation costs were estimated based on the EPA Air Pollution Control Cost Manual which estimates purchased equipment cost, direct and indirect installation costs, contractor fees, and contingencies from set factors that are applied to the equipment cost.

Annual maintenance costs include annual testing of the Stage 2 system which is estimated from economic benefit calculations utilized in PSCAA enforcement for gasoline dispensing facilities. PSCAA also assumes some replacement of parts (1 out of 8 of the nozzle/dispenser/hoses) annually to reflect the intermittent replacement and repair of fittings, nozzles, and hoses.

Annualized cost was determined by utilizing the Cost Recovery Factor (CRF) from the ODEQ rulemaking completed March 2024, which converts the present value of the equipment costs into annualized costs over the life of the equipment. PSCAA utilized the 10% discount and 10 year life across all of the purchased equipment. The cost per ton of VOC emission reduction was calculated as follows:

(Total annual cost of equipment – total annual cost of conventional equipment)/(Conventional VOC emissions – Specified Equipment VOC emissions)

Cost Assessment Summary

Throughput	Equipment	Total Annual Cost	$/ton VOC
0-500,000 gallon/yr	Conventional	$3974	NA; base case
500,000 – 700,000 gallon/yr	Enhanced Conventional & Low Perm	$6,714	$10,958 -$15,341
	Enhanced Conventional Nozzle only	$5,585	$6,444 - $9,023
700,000 – 1,000,000 gallon/yr	EVR without vapor processor	$11,008	$6,639 - $9,485
1,000,000 – 6,000,000+ gallon/yr (36,000,000 gallon/yr upper limit)	EVR and vapor processor	$19,645	Excluding recovered gasoline benefit: $386 - $15,446
			Including recovered gasoline benefit: -$279 – -$13,765*

*negative values indicate savings, assuming 5 gallon recovered per 1,000 gallon pumped and sale price of $4.00/gallon.

Additional information about the inputs for the cost analysis can be found in Appendix B Cost Analysis.

G. PROPOSAL & FEASIBILITY

Review of airshed VOC emissions, localized benzene emissions, gasoline dispensing facility profiles, and cost assessment together support continued use of Stage 2 vapor recovery equipment, following the proposed throughput-based equipment requirements of Option 2. With increased ORVR saturation, stations with throughput up to 500,000 gallons/yr may utilize conventional fueling equipment to balance cost burden and localized benzene impact. For stations at or above 1,000,000 gallons per year throughput, full EVR with vapor processor is both financially viable, particularly with recovered gasoline benefit, and protective of surrounding receptors. Use of enhanced conventional nozzles rather than full EVR systems may provide a lower cost buffer for stations in the 500,000 – 700,000 gallon/yr throughput category.

All hardware configurations reviewed are commercially available and used widely where CARB-certified EVR systems are required, in the case of EVR equipment and enhanced conventional nozzles. Enhanced conventional nozzles are also required for certain stations elsewhere in Washington state (e.g. SWCAA) and in some cases in Oregon. For EVR systems, the required testing and equipment configurations will continue to be linked to CARB Executive Orders, however as the analysis is based on current equipment configurations, PSCAA proposes looking to the CARB Executive Orders in place at the time of rulemaking, or equipment corresponding to the most recent CARB Executive Order, should equipment become unavailable. PSCAA proposes that enhanced conventional nozzles will need to be demonstrated by the manufacturer to meet the dripless requirements of CARB's CP-207.

Review of a single station with ORVR incompatible equipment indicates that a disbenefit (greater VOC emissions with ORVR incompatible Stage 2 installed than the same station with conventional equipment installed) at a given station will occur when ORVR saturation reaches 98% of vehicles fueling at that given station. PSCAA predicts that change will occur, on average, around 2032.

H. POTENTIAL IMPACTS

The smallest throughput stations (0-200,000 gallons/yr) will see no changes with respect to emissions or annual costs. 200,000 – 500,000 gallon/year stations will see an emission increase in VOC and benzene associated with the switch from stage 2 vapor recovery systems (with current-state equipment installed ranging from pre-EVR systems to EVR systems without vapor processor, depending on the date of installation) and a decrease in annual costs. Stations in the 500,000-700,000 gallon/year category will also see an emission increase in VOC and benzene associated with moving from Stage 2 either pre-EVR or EVR systems to enhanced conventional nozzles, and will see a corresponding decrease in annual costs.

Stations from 700,000 – 1,000,000 gallons per year will be subject to the same requirements of EVR systems without vapor processor and will have no projected changes to emissions nor annual costs.

Larger stations from 1,000,000 up through the upper limit of throughput in PSCAA jurisdiction (potential throughput of 36,000,000) will be required to utilize a vapor processor in addition to the EVR systems and will result in an emission decrease of VOC and benzene, and an increase in annualized costs, if recovered gasoline benefits are not included. If recovered gasoline benefits are included, there is a decrease in annual costs.

The table below summarizes the changes anticipated in cost and emissions for a single station, as well as an estimate of the number of stations impacted. The estimated number of stations impacted has a large range due to the existing throughput bin information available in the PSCAA database (exact throughput information for stations is not known.)

Throughput Category (gallon/yr)	Change in VOC emissions (TPY)	Change in Benzene emissions (lb/yr)	Change in annualized cost for station ($/yr)	Estimated # of stations affected
0-≤500,000	Lower: 0 Upper: 0.5	Lower: 0 Upper: 7.7	-$7,034 - $0	0 – 522
>500,000 – ≤700,000	Lower: 0.31 Upper: 0.43	Lower: 1.0 Upper: 1.3	-$2,740	180 – 700
>700,000 – ≤1,000,000	No change	No change	No change	180 – 700
>1,000,000 – ≤36,000,000	Lower: -0.3 Upper: -10.9	Lower: -3.6 Upper: -131.4	$8,637*	265

*without gasoline recovery benefit

I. IMPLEMENTATION CONSIDERATIONS

This section looks at how changing hardware requirements may affect testing, maintenance, and permitting requirements in the existing rule.

Maintenance Requirements
The existing Stage 1 VRS maintenance requirements found in PSCAA Regulation II 2.07(d)(1) require all vapor recovery systems to be maintained in accordance with the CARB Executive Order in place at the time of installation. As PSCAA proposes no changes to Stage 1 VRS, no changes to the content of Regulation II 2.07(d)(1) are anticipated.

The existing Stage 2 VRS maintenance requirements found in PSCAA Regulation II 2.07(d)(2) require maintenance in accordance with the CARB Executive Order in place at time of installation. Given that the analysis completed for this rulemaking incorporates current CARB EOs, PSCAA proposes updating the requirement for Stage 2 VRS installation and maintenance per active CARB EOs at time of rule promulgation, or a site may choose to install and maintain per the most current version of the CARB EO at time of installation. Updates will also clarify cases where vapor processors are and are not required. PSCAA proposes no changes to requirements for ISD.

Certain Stage 2 defects (primarily any leaking gas from nozzles and hoses) summarized in Table 1 will continue to be an indicator of inadequate maintenance; in all proposed equipment configurations nozzle and hose leaks are indicative of maintenance issues.

Testing Requirements
The existing testing regulations of PSCAA Regulation II 2.07(e) requires one-time testing following installation for all stations (those with Stage 1 vapor recovery systems) and requires ongoing testing only of those stations which utilize Stage 2 vapor recovery systems. The ongoing testing requirements for Stage 2 vapor recovery systems are summarized in Table 3 of PSCAA Regulation II 2.07 and include: static pressure decay, dynamic back pressure, tank tie test, static torque of adaptors, and air to liquid ratio test (for vacuum assist systems only).

PSCAA inspectors and historic test reports for semiannual testing indicate that a common repair is the P/V valve from the pressure decay test, which is a critical component at the station controlling emissions both when gasoline is delivered and when gasoline is pumped. Given instances of required repairs of P/V valves, as well as replacement of damaged or leaking nozzles and other leak repairs, for stations PSCAA proposes continuing semiannual static pressure decay testing and annual dynamic back pressure, static torque of adaptors, and air to liquid ratio tests (for vacuum assist systems only) for stations with >700,000 gallons/year throughput. For stations from 200,000 – 700,000 gallon/year throughput, PSCAA proposes continuing to require semiannual static pressure decay testing. Additionally, since the static torque of adaptors test is a measure of the Stage 1 vapor recovery system, static torque of adaptors annual testing is also proposed to continue for all stations above 200,000 gallons per year annual throughput. Table 2 Proposed Stage 2 Testing Summary summarizes these proposed changes.

PSCAA proposes no changes to the reporting requirements for testing outlined in PSCAA Regulation II 2.07(e)(4)-(5).

PSCAA proposes no changes to the certification process for testing and installation outlined in PSCAA Regulation II 2.07(f).

Permitting Equipment Changes
Notification of changes in equipment at gas stations as required in PSCAA Regulation I 6.03(b)(1)-(2) is important for tracking equipment and emissions controls installed at gas stations. PSCAA proposes to continue to utilize a notification system under PSCAA Regulation I 6.03(b) for equipment changes at gas stations, however; the specific information of the form itself will need to be updated to reflect the changes in rule requirements.

Additional Throughput Tracking and Reporting
PSCAA proposes the addition of some annual throughput reporting of gallons of gasoline pumped given the proposed rule bases equipment requirements on gasoline throughput more than the existing rule.

J. ADDITIONAL FACTORS & LIMITATIONS

Clean Fuel Standard
Washington state's Clean Fuel Standard (CFS) requires fuel suppliers to lower the carbon intensity of transportation fuels, including gasoline. One path for fuel suppliers to comply with the CFS involves blending ethanol with gasoline, which reduces the benzene percentage in the fuel as a co-benefit to reduced carbon intensity. The Clean Fuel Standard is implemented through a market of credits (from fuels with carbon intensity below the standard) and deficits (from fuels with carbon intensity above the standard), which makes quantification of benzene reductions difficult to predict, however a 2015 analysis of Air Toxic Impacts identifies that benzene emissions may be reduced by up to 7% over 10 years of CFS implementation[9].

Gasoline Throughput Variation: Electrification & Regional Growth
This analysis holds gasoline throughput constant based on reporting to PSCAA for registered GDFs. Regional growth may contribute to increased gasoline throughput and increased total emissions, while electrification of passenger vehicles may contribute to reduced gasoline throughput. Given that the airshed-wide change in VOC anticipated for the current throughput of gasoline is relatively small (0.1-3%) and the primary driver of continued use of Stage 2 is the more localized benzene impact, changes in airshed-wide gasoline throughput are not anticipated to affect recommendations. The localized impact of changes in throughput due to an increase in electric vehicles may translate to individual stations with lower throughput, however there is uncertainty in determining where those reductions might occur.

[9] Criteria and Air Toxic Pollutant Emission Impacts Associated with a Washington Clean Fuel Standard, April 3, 2015, Figure 48 Change in benzene TTW emissions relative to the BAU