

## **Appendix A**

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### ***Tables***

#### **Analysis of Toxic Pollutant Sources and Characteristics Contributing to Water Quality Impairments in the Willamette River Basin**

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## List of Tables

Table 1. Oregon’s 2012 303(d) Listed-Category 5 Toxic Pollutants of the Willamette Basin .....	3
Table 2. Oregon’s 2012 303(d)-Listed Category 5 Toxic Pollutants of the Willamette Basin by Class .....	4
Table 3. TMDL Models .....	5
Table 4. Applicability of TMDL Models .....	6
Table 5. Beneficial Uses in the Willamette Basin .....	7
Table 6. Water Quality Standards for Toxic Pollutants in the Willamette Basin .....	8
Table 7. History of Toxic Pollutant Uses, Sources, and Transport Pathways.....	10
Table 8. Summary of Data Sources for Point and Nonpoint Source Identification .....	12
Table 9. Pesticide Names Applied in the Willamette Basin (2000 to 2016) .....	14
Table 10. Toxic Pollutant Chemical Characteristics Database .....	15
Table 11. Oregon DEQ ECSI Sites Activity Categories .....	16
Table 12. Industry Activity Categories of Permitted Discharge Facilities in the Willamette Basin.....	17
Table 13. Example Calculation of Toxic Pollutant-Containing Pesticide Applications by Subbasin.....	18
Table 14. Point and Nonpoint Sources of the Willamette Basin by Subbasin .....	19
Table 15. Oregon DEQ NPDES-Permitted Facilities in the Willamette Basin.....	20
Table 16. EPA DMR- and TRI-Reporting Facilities in the Willamette Basin.....	21
Table 17. Toxic Pollutant Loadings from EPA Facilities in the Willamette Basin by Industry .....	22
Table 18. DOGAMI Permitted Mining Sites in the Willamette Basin.....	23
Table 19. ODOT Stormwater Outfalls in the Willamette Basin.....	24
Table 20. Toxic Pollutant Pesticide Applications in the Willamette Basin.....	25
Table 21. Oregon DEQ ECSI Sites in the Willamette Basin.....	26
Table 22. Toxic Pollutant Contamination at DEQ ECSI Sites in the Willamette Basin by Industry .....	27
Table 23. EPA Superfund Sites in the Willamette Basin .....	29
Table 24. Point and Nonpoint Sources in the Willamette Basin by Land Use .....	31
Table 25. DEQ NPDES-Permitted Facilities in the Willamette Basin by Subbasin and Industry .....	32
Table 26. Toxic Pollutant Loads from EPA DMR- and TRI-Reporting Facilities in the Willamette Basin by Industry and Subbasin.....	33
Table 27. Toxic Pollutant Loads from EPA DMR- and TRI-Reporting Facilities in the Willamette Basin by Subbasin.....	34
Table 28. DOGAMI Mining Sites by Subbasin in the Willamette Basin.....	35
Table 29. ODOT Outfalls by Subbasin in the Willamette Basin.....	36
Table 30. DEQ ECSI Sites by Subbasin in the Willamette Basin .....	37
Table 31. Chemical Characteristics of Toxic Pollutants in the Willamette Basin.....	38
Table 32. ANOSIM Pair-wise Test Statistics of Cluster Significance .....	40
Table 33. ANOVA Test Statistics of Chemical Characteristic Significance.....	41
Table 34. Results of Environmental Vectors Fitting in NMDS Plot .....	42
Table 35. Chemical Characteristics of Toxic Pollutant Clusters in the Willamette Basin.....	43
Table 36. Data Gaps of Toxic Pollutant Point and Nonpoint Sources Identified in the Willamette Basin..	45
Table 37. Recommendations Toxic Pollutant TMDL Prioritization in the Willamette Basin.....	47

**Table 1. Oregon's 2012 303(d) Listed-Category 5 Toxic Pollutants of the Willamette Basin**

*Provided in electronic format*

**Table 2. Oregon's 2012 303(d)-Listed Category 5 Toxic Pollutants of the Willamette Basin by Class**

Pollutant Class <sup>1,2,3</sup>	Pollutant Name	
<b>Metals</b>	Arsenic Chromium Copper Iron Lead	Mercury Silver Thallium Zinc
<b>Organochlorine Insecticides</b>	Aldrin Chlordane Dieldrin DDE-4,4 DDT-4,4	Endosulfan (I and II) Endrin Aldehyde Heptachlor Hexachlorobenzene
<b>Organophosphorus Insecticides</b>	Chlorpyrifos Guthion (i.e., azinphos-methyl)	
<b>PAHs</b>	Acenaphthene Acenaphthylene Anthracene Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(j)fluoranthene Benzo(k)fluoranthene Benzo(g,h,i)perylene	Chrysene Dibenzo(a,h)anthracene Fluoranthene Fluorene Indeno(1,2,3-cd)pyrene Naphthalene Phenanthrene Pyrene
<b>PCBs</b>	Congeners (209 individual)	
<b>VOCs</b>	Ammonia as N 1,1-Dichloroethylene 1,2-Dichloroethylene cis-1,2-Dichloroethylene trans-1,2-Dichloroethylene	Cyanide Tetrachloroethylene (PCE) Trichloroethylene (TCE)

Notes:

<sup>1</sup> DEQ's 2012 *Integrated Report Assessment Database and 303(d) List*. (DEQ, 2017b)

<sup>2</sup> Toxic pollutants identified for impaired streams, rivers, and wetlands (silver and zinc impairments associated with the Koll Wetland).

<sup>3</sup> Individual PAH and dichloroethylene pollutants were not identified in DEQ's 2012 Integrated Report. These compounds are included in the PAH classification (ATSDR, 1994a, 1996c, 1996a; EPA, 2008)

Abbreviations:

PAHs – polycyclic aromatic hydrocarbons

PCBs – polychlorinated biphenyls

VOCs – volatile organic compounds

**Table 3. TMDL Models**

*Provided in electronic format*

**Table 4. Applicability of TMDL Models**

*Provided in electronic format*

**Table 5. Beneficial Uses in the Willamette Basin**

Beneficial Use <sup>1</sup>	Willamette River Tributaries						Mainstem Willamette River			
	Clackamas River	Molalla River	Santiam River	McKenzie River	Tualatin River	All Other Streams & Tributaries	Mouth to Willamette Falls, Including Multnomah Channel	Willamette Falls to Newberg	Newberg to Salem	Salem to Coast Fork
Public Domestic Water Supply <sup>2</sup>	x	x	x	x	x	x	x	x	x	x
Private Domestic Water Supply <sup>2</sup>	x	x	x	x	x	x	x	x	x	x
Industrial Water Supply	x	x	x	x	x	x	x	x	x	x
Irrigation	x	x	x	x	x	x	x	x	x	x
Livestock Watering	x	x	x	x	x	x	x	x	x	x
Fish & Aquatic Life <sup>3</sup>	x	x	x	x	x	x	x	x	x	x
Wildlife & Hunting	x	x	x	x	x	x	x	x	x	x
Fishing	x	x	x	x	x	x	x	x	x	x
Boating	x	x	x	x	x	x	x	x	x	x
Water Contact Recreation	x	x	x	x	x	x	x	x	x	x
Aesthetic Quality	x	x	x	x	x	x	x	x	x	x
Hydro Power	x	x	x	x	x	x	x	x		
Commercial Navigation & Transportation <sup>4</sup>	x						x	x	x	

**Notes:**

<sup>1</sup> Oregon Administrative Rules (OAR, 2005)

<sup>2</sup> "With adequate pretreatment and natural quality that meets drinking water standards."

<sup>3</sup> Fish designations for the basin identified at Figures 340A and 340B of OAR 340-41-041.

<sup>4</sup> "Not to conflict with commercial activities in Portland Harbor."

**Table 6. Water Quality Standards for Toxic Pollutants in the Willamette Basin**

Toxic Pollutant <sup>1</sup>	CAS Number	Aquatic Life Water Quality Criteria <sup>2</sup>	Aquatic Life Water Quality Guidance Values <sup>3</sup>	Human Health Water Quality Criteria <sup>4,5</sup>
		Freshwater, Chronic (µg/L)	Freshwater, Chronic (µg/L)	Water + Organism (µg/L)
Metals				
Arsenic	7440-38-2	150	n/a	2.1
Chromium	7440-47-3	n/a	n/a	n/a
Chromium III	16065-83-1	see footnote 6	n/a	n/a
Chromium VI	18540-29-9	11	n/a	n/a
Copper	7440-50-8	see footnote 7	n/a	1,300
Iron	7439-89-6	1,000	n/a	n/a
Lead	7439-92-1	see footnote 6	n/a	n/a
Mercury	7439-97-6	0.012	n/a	n/a
Silver	7440-22-4	0.10	n/a	n/a
Thallium	7440-28-0	n/a	40	0.043
Zinc	7440-66-6	see footnote 6	n/a	2,100
Organochlorine Insecticides				
4,4-DDE	72-55-9	n/a	n/a	0.000022
4,4-DDT	50-29-3	0.001	n/a	0.000022
Aldrin	309-00-2	n/a	n/a	0.0000050
Chlordane	57-74-9	0.0043	n/a	0.000081
Dieldrin	60-57-1	0.056	n/a	0.0000053
Endrin	72-20-8	0.036	n/a	0.024
Endrin Aldehyde	7421-93-4	n/a	n/a	0.030
Endosulfan	115-29-7	0.056	n/a	n/a
Endosulfan I (alpha)	959-98-8	0.056	n/a	8.5
Endosulfan I (beta)	33213-65-9	0.056	n/a	8.5
Heptachlor	76-44-8	0.0038	n/a	0.0000079
Hexachlorobenzene	118-74-1	n/a	n/a	0.000029
Organophosphorus Insecticides				
Chlorpyrifos	2921-88-2	0.041	n/a	n/a
Guthion (azinphos-methyl)	86-50-0	0.01	n/a	n/a
PAHs				
Acenaphthene	83-32-9	n/a	520	95
Acenaphthylene	208-96-8	n/a	n/a	n/a
Anthracene	120-12-7	n/a	n/a	2,900
Benzo(a)anthracene	56-55-3	n/a	n/a	0.0013
Benzo(a)pyrene	50-32-8	n/a	n/a	0.0013
Benzo(b)fluoranthene	205-99-2	n/a	n/a	0.0013
Benzo(j)fluoranthene	205-82-3	n/a	n/a	n/a
Benzo(k)fluoranthene	207-08-9	n/a	n/a	0.0013
Benzo(g,h,i)perylene	191-24-2	n/a	n/a	n/a
Chrysene	218-01-9	n/a	n/a	0.0013



Toxic Pollutant <sup>1</sup>	CAS Number	Aquatic Life Water Quality Criteria <sup>2</sup>	Aquatic Life Water Quality Guidance Values <sup>3</sup>	Human Health Water Quality Criteria <sup>4,5</sup>
		Freshwater, Chronic (µg/L)	Freshwater, Chronic (µg/L)	Water + Organism (µg/L)
Dibenzo(a,h)anthracene	53-70-3	n/a	n/a	0.0013
Fluoranthene	206-44-0	n/a	n/a	14
Fluorene	86-73-7	n/a	n/a	390
Indeno(1,2,3-cd)pyrene	193-39-5	n/a	n/a	0.0013
Naphthalene	91-20-3	n/a	620	n/a
Phenanthrene	85-01-8	n/a	n/a	n/a
Pyrene	129-00-0	n/a	n/a	290
<b>VOCs</b>				
Ammonia	7664-41-7	see footnote 8	n/a	n/a
1,1-Dichloroethylene	75-35-4	n/a	n/a	230
1,2-Dichloroethylene	540-59-0	n/a	n/a	n/a
cis-1,2-Dichloroethylene	156-59-2	n/a	n/a	n/a
trans-1,2-Dichloroethylene	156-60-5	n/a	n/a	120
Cyanide	57-12-5	5.2	n/a	130
Tetrachloroethylene	127-18-4	n/a	840	0.24
Trichloroethylene	79-01-6	n/a	21,900	1.4
<b>PCBs</b>				
PCBs	n/a	0.014	n/a	0.0000064

**Notes:**

n/a – not available

µg/L – microgram per liter

CAS Number – Chemical Abstracts Service Number (a unique identifier for chemicals)

DDE - Dichlorodiphenyldichloroethylene

DDT - Dichlorodiphenyldichloroethane

PAHs – polycyclic aromatic hydrocarbons

PCBs – polychlorinated biphenyls

VOCs – volatile organic compounds

<sup>1</sup> Oregon Administrative Rule (OAR) 340-041-8033 (DEQ, 2017a)

<sup>2</sup> Table 30 (Aquatic Life Water Quality Criteria for Toxic Pollutants). See footnote 1.

<sup>3</sup> Table 31 (Aquatic Life Water Quality Guidance Values for Toxic Pollutants). See footnote 1.

<sup>4</sup> Table 40 (Human Health Water Quality Criteria for Toxic Pollutants). See footnote 1.

<sup>5</sup> "Water + Organism" criteria based on the Maximum Contaminant Level under the Safe Drinking Water Act.

<sup>6</sup> Freshwater criterion for chromium III, lead, and zinc are calculated separately, as a function of hardness in the water column.

<sup>7</sup> Freshwater criterion for copper is calculated separately, as a function of the concentration of ions, alkalinity, organic carbon, pH, and temperature in the water column.

<sup>8</sup> Freshwater criterion for ammonia is calculated separately, as a function of pH and temperature.

**Table 7. History of Toxic Pollutant Uses, Sources, and Transport Pathways**

Toxic Pollutant Class	History of Use	Sources	Transport Pathways to Surface Waters
<b>Metals</b>	Ongoing	<ul style="list-style-type: none"> <li>- Background</li> <li>- Industrial</li> <li>- Sewage/Wastewater Treatment</li> <li>- Mining</li> <li>- Commercial/agriculture</li> <li>- Contaminated site</li> </ul>	<ul style="list-style-type: none"> <li>- Stormwater</li> <li>- Direct Discharge</li> <li>- Sediment Transport</li> <li>- Atmospheric Deposition</li> </ul>
<b>PAHs</b>	Ongoing	<ul style="list-style-type: none"> <li>- Industrial</li> <li>- Sewage/Wastewater Treatment</li> <li>- Contaminated site</li> </ul>	<ul style="list-style-type: none"> <li>- Stormwater</li> <li>- Direct Discharge</li> <li>- Sediment Transport</li> <li>- Atmospheric Deposition</li> </ul>
<b>PCBs</b>	1929 to 1979	<i>*LEGACY SOURCE*</i> <ul style="list-style-type: none"> <li>- Manufacturing</li> <li>- Commercial/agriculture</li> <li>- Sewage/Wastewater Treatment</li> <li>- Contaminated site</li> </ul>	<ul style="list-style-type: none"> <li>- Stormwater</li> <li>- Direct Discharge</li> <li>- Sediment Transport</li> <li>- Atmospheric Deposition</li> </ul>
<b>Organochlorine Insecticides</b>	<p><i>Aldrin/Dieldrin</i> – 1948 to 1974 (crops); 1972 to 1987 (termites); banned in 1974; cancelled in 1989</p> <p><i>Chlordane</i> – 1948 to 1988 (banned)</p> <p><i>DDE/DDT</i> – 1939 to 1973 (banned)</p> <p><i>Endosulfan</i> – 1954 to 2016 (phased-out since 2010)</p> <p><i>Endrin</i> – 1951 to 1986/1991</p> <p><i>Hexachlorobenzene</i> –1940s/50s to 1984</p>	<i>*LEGACY SOURCE*</i> <ul style="list-style-type: none"> <li>- Manufacturing</li> <li>- Commercial/agriculture</li> <li>- Sewage/Wastewater Treatment</li> <li>- Contaminated site</li> </ul>	<ul style="list-style-type: none"> <li>- Stormwater</li> <li>- Direct Discharge</li> <li>- Sediment Transport</li> <li>- Atmospheric Deposition</li> </ul>

Toxic Pollutant Class	History of Use	Sources	Transport Pathways to Surface Waters
<b>Organophosphorus Insecticides</b>	<p><i>Chlorpyrifos</i> – 1968 to present (agriculture use only, withdrawn from indoor/pest uses in 1997)</p> <p><i>Guthion (i.e., azinphos-methyl)</i> – 1959 to 2013</p>	<p><i>*LEGACY SOURCE*</i></p> <ul style="list-style-type: none"> <li>- Manufacturing</li> <li>- Sewage/Wastewater Treatment</li> <li>- Commercial/agriculture</li> <li>- Contaminated site</li> </ul>	<ul style="list-style-type: none"> <li>- Stormwater</li> <li>- Direct Discharge</li> <li>- Sediment Transport</li> <li>- Atmospheric Deposition</li> </ul>
<b>VOCs</b>	Ongoing	<ul style="list-style-type: none"> <li>- Industrial</li> <li>- Manufacturing</li> <li>- Mining</li> <li>- Sewage/Wastewater Treatment</li> <li>- Contaminated site</li> </ul>	<ul style="list-style-type: none"> <li>- Stormwater</li> <li>- Direct Discharge</li> <li>- Sediment Transport</li> <li>- Atmospheric Deposition</li> </ul>

Notes:

*Toxicological Profile* for metals: (ATSDR, 1990, 1992, 1999, 2004b, 2005, 2007a, 2007b, 2012)

*Toxicological Profile* for PCBs:(ATSDR, 2000)

*Toxicological Profile* for organochlorine insecticides: (ATSDR, 1994b, 1996b, 2002a, 2002b, 2015a, 2015b)

*Toxicological Profile* for organophosphorus insecticides:(ATSDR, 1997, 2008)

*Toxicological Profile* for VOCs: (ATSDR, 1994a, 1996a, 2004a, 2014a, 2014b)

**Table 8. Summary of Data Sources for Point and Nonpoint Source Identification**

Agency	Data Source	Data Description	Data Availability	Date Downloaded
DEQ	<i>Facility Profiler-Lite</i>	Identifies Facility ID, facility name/city/coordinates, DEQ oversight program, and cleanup status (DEQ, 2018b)	Current as of date of review	October 2017 to May 2018
	<i>Wastewater Permits Database</i> (DEQ, 2017c)	Identifies Facility ID, facility name/city/coordinates, discharge permit type, and type of permitted discharges (DEQ, 2017c).	Current as of date of download	November 1, 2017
	<i>ECSI database</i>	Identifies facility/Cleanup ID, facility name/city/coordinates, cleanup status, and pollutants of concern (DEQ, 2018a).	Current as of date of download	May 10, 2018
DOGAMI	<i>Mineral Land Regulation &amp; Reclamation – Mining Permit Viewer</i>	Identifies facility/permit ID, facility name/city/coordinates, permit type and status, primary commodity mined, permitted acreage, DEQ permit type and DEQ file number (DOGAMI, 2017).	Updated September 28, 2017	October 13, 2017
EPA	Enforcement Compliance History Online (ECHO), <i>Pollutant Loading Tool</i> , <i>Water Pollution Search</i>	Identifies facility/NPDES ID, Facility Name/City/coordinates, average daily flow, and total pounds of pollutants discharged per reporting year (EPA, 2017b).	DMR (2007 to 2017) TRI (2007 to 2015)	October 24, 2017
	<i>NPDES General Permit Inventory and eNOI Search Tool</i>	Identifies facility/NPDES ID, Facility Name/City/coordinates, and discharge permit type (EPA, 2018b).	Current as of end of 2016	October 29, 2017
	<i>Superfund National Priorities List (NPL)</i>	Identifies facility ID, Facility name/city/coordinates, listing status, Record of Decision, cleanup/remediation status, and pollutants of concern (EPA, 2018c).	Current as of date of download	January 10, 2018
ODOT	<i>Stormwater Outfall Inventory Management</i>	Identifies outfall ID and coordinates, side of road, piping, receiving feature and waterbody, road ID, and mile point (ODOT, 2016). ODOT only inventoried outfalls for priority cities at this time.	Current as of June 30, 2010	May 27, 2018

Agency	Data Source	Data Description	Data Availability	Date Downloaded
OSDL	<i>Oregon Watershed Boundary Dataset</i>	Identifies watershed boundaries throughout the state at each Hydrologic Unit Code (HUC) level (OSDL, 2017).	Current as of date of download	December 13, 2017
	<i>National Land Cover Dataset (2011)</i>	Identifies land cover features throughout the state (OSDL, 2011).	Current as of date of download	April 15, 2018
USDA	<i>National Agricultural Statistics Service (NASS), Census of Agriculture</i>	Identifies census survey results of farms throughout the State by county, including total farms, total harvested crops, total irrigation water usage, and other statistics (USDA, 2012b).	2012	July 2018
USGS	<i>National Water Quality Assessment Project (NWQAP), Pesticide National Synthesis Project – County-Level Pesticide Use Estimates</i>	Identifies pesticide name, county Federal Information Processing Standards (FIPS) Code, and estimated pesticide applications (in kilograms) (USGS, 2017).	1992 to 2016 (2013 to 2016 is preliminary data)	October 29, 2017

Notes:

DEQ – Oregon Department of Environmental Quality

DOGAMI – Oregon State Department of Geology and Mineral Industries

DMR – Discharge Monitoring Reports

eNOI – electronic Notice of Intent

ECSI – Environmental Cleanup Site Information

EPA – US Environmental Protection Agency

OSDL – Oregon Spatial Data Library

TRI – Toxic Release Inventory

USDA – United States Department of Agriculture

USGS – United States Geological Survey

**Table 9. Pesticide Names Applied in the Willamette Basin (2000 to 2016)**

*Provided in electronic format*

**Table 10. Toxic Pollutant Chemical Characteristics Database**

*Provided in electronic format*

**Table 11. Oregon DEQ ECSI Sites Activity Categories**

<b>Facility Activity Categories</b>
Agricultural
Automotive
Aviation
Commercial
Dry Cleaner/Laundromat
Food Processing
Industrial/Manufacturing
Landfill
Lumber Mill
Maintenance
Military/Shooting Range
Mining
Oil & Gas
Railyard
Recycling
Spill
Study Area
Utility
Wastewater Treatment



**Table 12. Industry Activity Categories of Permitted Discharge Facilities in the Willamette Basin**

NAICS Codes of Facility Activities		NAICS Codes of <i>Categorized</i> Facility Activities	
NAICS Group Code	NAICS Description	NAICS Group Code	NAICS Description ( <i>Categorized</i> )
11	Agriculture, Forestry, Fishing, and Hunting	11	Agriculture
21	Mining	21	Mining
22	Utilities	22	Utilities
23	Construction	23	Construction
31, 32, 33	Manufacturing	31, 32, 33	Manufacturing
42	Wholesale Trade	42, 44	Retail/Wholesale Trade
44	Retail Trade	42, 44	Retail/Wholesale Trade
48, 49	Transportation and Warehousing	48, 49	Transportation/Warehousing
51	Information	51, 54, 61, 62, 92	Administrative/Service
53	Real Estate Rental and Leasing	53	Real Estate
54	Professional, Scientific, and Technical Services	51, 54, 61, 62, 92	Administrative/Service
56	Waste Management	56	Waste Management
61	Educational Services	51, 54, 61, 62, 92	Administrative/Service
62	Health Care and Social Assistance	51, 54, 61-62, 92	Administrative/Service
71, 72	Arts, Entertainment, and Recreation / Accommodation and Food Services	72	Accommodation/Food/Recreation
72	Accommodation and Food Services	72	Accommodation/Food/Recreation
81	Other Services (except Public Administration)	51, 54, 61, 62, 92	Administrative/Service
92	Public Administration	51, 54, 61, 62, 92	Administrative/Service
n/a	State/County Transportation Roadway Management	n/a	State/County Transportation Roadway Management

**Notes:**

NAICS codes identified for each facility in EPA and DEQ facility databases and the associated NAICS group codes and descriptions were obtained from a NAICS lookup table (DEQ, 2017c; EPA, 2017b; NAICS, 2018). NAICS = North American Industry Classification System.

**Table 13. Example Calculation of Toxic Pollutant-Containing Pesticide Applications by Subbasin**

	Units	Subbasin Total	
		Lower Willamette	Tualatin
Agricultural land in subbasin	acres	27,868	120,790
Agricultural land in Columbia County	acres	148,658	
Total toxic pollutant-containing pesticides applied in Columbia County (2000 to 2016)	pounds	15,083	
<i>Calculation of total toxic-pollutant containing pesticides by subbasin</i>	--	<i>15,083 pounds x 27,868 acres ÷ 146,658</i>	<i>15,083 pounds x 120,790 acres ÷ 146,658</i>
<b>Pesticides applied in subbasin (2000 to 2016)</b>	<b>pounds</b>	<b>2,828</b>	<b>12,256</b>

Notes:

Example calculation quantifies the total toxic pollutant-containing pesticides applied by subbasin (in pounds) based on totals reported at the county level. Pesticide applications were reported by the United States Geological Survey's *National Water Quality Assessment Project (NWQAP)*, *Pesticide National Synthesis Project*, *County-Level Pesticide Use Estimates* (USGS, 2017). Total pesticides reported at the county level (identified as Federal Information Processing Standards (FIPS) codes assigned to every county in the United States) (Bureau, 2010). These codes were evaluated to quantify only the toxic pollutant-containing pesticides applied in the counties of the Basin. Only pesticides with ingredients containing toxic pollutants were included in the final results by reviewing each of the identified pesticide's chemical structures (EPA, 2016; NLM, 2017). Agricultural land area in the Basin was retrieved from the National Land Cover Dataset and evaluated at the 8-digit fourth level Hydrologic Unit Code (HUIC) associated with the Basin (OSDL, 2011).

**Table 14. Point and Nonpoint Sources of the Willamette Basin by Subbasin**

Subbasin	Point Sources					Nonpoint Sources			
	TOTAL	DEQ NPDES Sites	DOGAMI Mining Sites	EPA DMR/TRI Reporting Sites	ODOT Outfalls	TOTAL	Farms Harvesting Crops	DEQ ECSI Sites	EPA Superfund Sites
Coast Fork Willamette	151	116	31	4	0	615	611	3	1
Middle Fork Willamette	80	39	26	4	11	319	315	4	0
McKenzie	541	488	19	29	5	368	365	3	0
South Santiam	93	32	60	1	0	336	322	14	0
Upper Willamette	286	24	147	3	112	4,171	4,030	139	2
North Santiam	440	382	41	17	0	317	311	6	0
Clackamas	216	143	41	11	21	231	202	29	0
Molalla-Pudding	120	19	92	2	7	1,065	1,036	29	0
Middle Willamette	215	35	113	2	65	2,594	2,508	86	0
Yamhill	653	307	336	10	0	1,052	1,036	15	1
Tualatin	604	344	55	32	173	1,872	1,754	118	0
Lower Willamette	311	121	54	8	128	810	323	481	6
<b>TOTAL</b>	<b>3,710</b>	<b>2,050</b>	<b>1,015</b>	<b>123</b>	<b>522</b>	<b>13,751</b>	<b>12,814</b>	<b>927</b>	<b>10</b>

Notes:

Facility coordinates of point and nonpoint sources geospatially referenced in ArcGIS Version 10.5.1 and intersected with the Watershed Boundary Dataset for Oregon at the 8-digit fourth-level USGS Hydrologic Unit Code (HUC) for the Willamette Basin to determine the associated subbasins (DEQ, 2017c, 2018a; DOGAMI, 2017; EPA, 2017b, 2018a; ESRI, 2017; ODOT, 2016; OSDL, 2011). Subbasins listed in order of river flow direction in the Willamette Basin, from south to north. Farms harvesting crops obtained from the United States Department of Agricultural Census survey identified by county. The county boundaries for the Basin were obtained from the Oregon Spatial Data Library and intersected only with the subbasin boundaries (OSDL, 2015; USDA, 2012a).

**Table 15. Oregon DEQ NPDES-Permitted Facilities in the Willamette Basin**

*Provided in electronic format*

**Table 16. EPA DMR- and TRI-Reporting Facilities in the Willamette Basin**

*Provided in electronic format*

**Table 17. Toxic Pollutant Loadings from EPA Facilities in the Willamette Basin by Industry**

[NAICS Code Group] Industry Category	Total Pollutant Discharges (pounds) 2007 to 2016														
	Total Pollutants	Total Average Daily Flow (MGD)	Metals								PAHs		VOCs		
			Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Silver	Zinc	Benzo(g,h,i)perylene	Naphthalene	Ammonia	Cyanide	Trichloroethylene
[72] Accommodation/Food/ Recreation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[51, 54, 61-62, 92] Administrative/Service	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[31-33] Manufacturing	<b>2,214,288</b>	$3.5 \times 10^{-4}$	127	16	883	21,795	2,567	5	-	140,870	8	24	2,046,945	1,032	15
[42, 44, 53] Real Estate/Retail	<b>827</b>	-	-	-	-	-	-	-	-	-	-	-	827	-	-
[48-49] Transportation/ Warehousing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[22] Utilities	<b>68,803,649</b>	$1.8 \times 10^{-2}$	20	4	53	121	17	-	16	1,409	8	24	68,801,822	187	-
[56] Waste Management	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>TOTAL</b>	<b>71,018,763</b>	$1.8 \times 10^{-2}$	<b>147</b>	<b>20</b>	<b>936</b>	<b>21,916</b>	<b>2,585</b>	<b>5</b>	<b>16</b>	<b>142,279</b>	<b>8</b>	<b>24</b>	<b>70,849,594</b>	<b>1,219</b>	<b>15</b>

Notes:

Pollutant discharges reported in EPA's Water Pollution Search database (DMR and TRI reporting programs) and queried only for the toxic pollutants of the Willamette River Basin, at the 8-digit fourth-level USGS Hydrologic Unit Code (HUC) (EPA, 2017b; OSDL, 2017). MGD = million gallons per day. NAICS = North American Industry Classification System. Where no values are identified, no pollutants were reported.

**Table 18. DOGAMI Permitted Mining Sites in the Willamette Basin**

*Provided in electronic format*

**Table 19. ODOT Stormwater Outfalls in the Willamette Basin**

*Provided in electronic format*



**Table 20. Toxic Pollutant Pesticide Applications in the Willamette Basin**

*Provided in electronic format*

**Table 21. Oregon DEQ ECSI Sites in the Willamette Basin**

*Provided in electronic format*

**Table 22. Toxic Pollutant Contamination at DEQ ECSI Sites in the Willamette Basin by Industry**

Toxic Pollutant	Site Activity Category																		
	Agricultural	Automotive	Aviation	Commercial	Dry Cleaner/Laundromat	Food Processing	Industrial/Manufacturing	Landfill	Lumbermill	Maintenance	Military Shooting Range	Mining	Oil & Gas	Railyard	Recycling	Spill	Study Area	Utility	Wastewater Treatment
Metals																			
Arsenic	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	
Chromium	X	X	X		X	X	X	X	X			X	X	X	X	X	X		
Copper		X				X	X	X					X	X	X		X		
Iron					X		X	X											
Lead	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		
Mercury		X		X	X	X	X	X	X			X	X	X	X	X	X		
Silver		X		X		X	X	X					X						
Thallium							X	X					X						
Zinc	X	X				X	X	X	X			X	X	X	X		X		
Organochlorine Insecticides																			
Aldrin		X					X	X							X		X		
Chlordane	X						X	X							X				
Dieldrin	X	X	X	X			X	X					X		X		X		
Endosulfan (alpha/beta)	X	X	X				X	X								X			
Endrin/Endrin Aldehyde	X	X					X	X							X				
DDD/DDE/DDT	X	X	X	X			X	X			X		X	X			X		
Heptachlor/Heptachlor Epoxide	X						X	X							X		X		
Hexachlorobenzene							X												
Pesticides (unspecified)	X						X									X			
VOCs																			
Ammonia							X	X										X	

Toxic Pollutant	Site Activity Category																		
	Agricultural	Automotive	Aviation	Commercial	Dry Cleaner/Laundromat	Food Processing	Industrial/Manufacturing	Landfill	Lumbermill	Maintenance	Military Shooting Range	Mining	Oil & Gas	Railyard	Recycling	Spill	Study Area	Utility	Wastewater Treatment
Cyanide			X				X	X					X		X		X		
Tetrachloroethylene	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		
Trichloroethylene	X	X	X	X	X	X	X	X	X	X	X		X	X	X		X	X	
Vinyl Chloride		X		X	X	X	X	X		X	X				X		X		
1,1-Dichloroethylene		X	X		X	X	X	X	X		X		X	X			X	X	
1,2-Dichloroethylene			X				X				X		X				X		
cis-1,2-Dichloroethylene	X	X		X	X	X	X	X	X				X		X		X		
trans-1,2-Dichloroethylene		X			X	X	X	X					X				X		
VOCs (unspecified)		X					X						X		X		X		
PAHs																			
PAHs		X	X				X	X	X	X		X	X	X	X	X	X	X	
PCBs																			
Aroclors (1016, 1232, 1242, 1248, 1254, 1260)	X	X			X	X	X	X	X				X	X	X	X	X	X	X

**Notes:**

Toxic pollutants reported in DEQ's ECSI database and queried only for the toxic pollutants of the Willamette River Basin, at the 8-digit fourth-level USGS Hydrologic Unit Code (HUC) (DEQ, 2018a; OSDL, 2017). "X" indicates the site in the activity category is contaminated with that toxic pollutant. Organophosphorus insecticide-contaminated properties were not identified. Vinyl chloride is a breakdown product of trichloroethylene, a toxic pollutant in the Basin, therefore, it is included in this list (ATSDR, 2014b).

**Table 23. EPA Superfund Sites in the Willamette Basin**

<b>Superfund Site (DEQ ECSI Site ID)</b>	<b>Location (County, Subbasin)</b>	<b>Site Size and Contaminated Media</b>	<b>Toxic Pollutants</b>	<b>Site Status</b>	<b>Pollutant Transport Pathway (from Site)</b>
<b>Discharges to the Willamette River</b>					
Allied Plating, Inc. (ECSI ID 6)	Multnomah County (Lower Willamette)	Sludge, soil, groundwater	Arsenic, cadmium, chromium, copper, lead, mercury	Listed 1987, ROD 1993, NFA/deleted 1994	Columbia Slough to Willamette River
Black Butte Mine (ECSI ID 1657)	Lane County (Coast Fork Willamette)	5 acres – soil, sediment, surface water, groundwater	Mercury, methylmercury	Listed 2010, cleanup 2007	Coast Fork Willamette River
Gould, Inc. <sup>3</sup> (ECSI ID 49)	Multnomah County (Lower Willamette)	4 acres - soil, sediment, solid waste, groundwater	Lead	Listed 1982, ROD 1988, deleted 2002	Willamette River
Harbor Oil (ECSI ID 24)	Multnomah County (Lower Willamette)	4.2 acre – soil, sediment, groundwater	Metals, pesticides, PCBs	Listed 2002, deleted 1994, NFA 2013	Columbia Slough to Willamette River
McCormick & Baxter Creosoting Co. <sup>3</sup> (ECSI ID 74)	Multnomah County (Lower Willamette)	41 acres (plus 23 acres river sediments) – soil, sediment, groundwater	PAHs, arsenic, copper	Listed 1993, cleanup 2005, long term remedy	Willamette River
Northwest Pipe & Casing/ Hall Process Co (ECSI ID 139)	Clackamas County (Lower Willamette)	85 acres – soil and groundwater	Arsenic, PAHs, PCBs, vinyl chloride, TCE, PCE	Listed 1992, remedy 2000s	Dean Creek to Willamette River
Portland Harbor <sup>4</sup> (ECSI ID 2068)	Multnomah County (Lower Willamette)	12 miles of the Willamette River - river and sediment (and upland areas, river miles 1.9 to 11.8	Arsenic, cadmium, chromium, copper, lead, mercury, zinc, PAHs, PCBs, aldrin, dieldrin, chlordane, TCE, PCE, DDD/DDE/DDT, 1,1- dichloroethene (trans and cis- 1,1-DCE), vinyl chloride	Listed 2000, ROD 2016, Early Action cleanup areas, current Baseline Sampling (fish/sediment)	Willamette River
Taylor Lumber and Treating (ECSI ID 666)	Yamhill County (Yamhill)	40 acres – soil and groundwater	Arsenic, chromium, dieldrin, PAHs, PCBs,	Listed 2000, cleanup 2005- 2008	South Yamhill River

Superfund Site (DEQ ECSI Site ID)	Location (County, Subbasin)	Site Size and Contaminated Media	Toxic Pollutants	Site Status	Pollutant Transport Pathway (from Site)
Teledyne Wah Chang (ECSI ID 315)	Linn County (Upper Willamette)	225 acres – soil, sediment, and groundwater	Arsenic, PAHs, cadmium, chromium, copper, zinc, 1,1- dichloroethene/ane, hexachlorobenzene, lead, mercury, PCBs, TCE, PCE	Listed 1982, remedy 1989- 1995, cleanup 1998-2009	Truax Creek to Willamette River
United Chrome Products, Inc (ECSI ID 317)	Benton County (Upper Willamette)	2.5 acres – soil, sediment, surface water, groundwater	Chromium	Listed 1983, remedy 1986, remedy review 2011 (protective)	Willamette River
<b>Discharges to other rivers</b>					
Reynolds Metals Company (ECSI ID 154)	Multnomah County (Lower Willamette)	800 acres – soil, sediment, surface water, groundwater	1,1-dichloroethene, PCBs, arsenic, copper, PAHs, lead, mercury, silver, zinc	Listed 1994, cleanup 2006, redevelopment status 2012	Sandy River to Columbia River

**Notes:**

Superfund Sites reported in EPA's Superfund Site search database queried only for the toxic pollutants of the Willamette River Basin, at the 8-digit fourth-level USGS Hydrologic Unit Code (HUC) (EPA, 2018a; OSDL, 2017). Pollutant transport pathways for each site based on facility information in DEQ's ECSI database or documentation in EPA's Superfund Site webpages. Facility coordinates (latitude/longitude) were geospatially referenced in ArcGIS Version 10.5.1 to determine their subbasin location (DEQ, 2018a; EPA, 2017a; ESRI, 2017).

**Table 24. Point and Nonpoint Sources in the Willamette Basin by Land Use**

Land Use	Point Sources					Nonpoint Sources			
	TOTAL	DEQ NPDES Sites	DOGAMI Mining Sites	EPA DMR/TRI Reporting Sites	ODOT Outfalls	TOTAL	Farms Harvesting Crops	DEQ ECSI Sites	EPA Superfund Sites
Agriculture	604	379	211	8	6	12,846	12,814	32	0
Barren Land	38	13	23	1	1	3	0	3	0
Forest	441	173	252	5	11	34	0	33	1
Open Water	104	21	58	5	20	7	0	6	1
Perennial Snow/Ice	0	00	0	0	0	0	0	0	0
Urban Developed	2,157	1,437	137	104	479	849	0	840	9
Wetlands	66	27	34	0	5	7	0	7	0
<b>TOTAL</b>	<b>3,410</b>	<b>2,050</b>	<b>715</b>	<b>123</b>	<b>522</b>	<b>13,746</b>	<b>12,814</b>	<b>921</b>	<b>11</b>

Notes:

Facility coordinates of point and nonpoint sources geospatially referenced in ArcGIS Version 10.5.1 and intersected with the National Land Cover Dataset for Oregon to determine the land cover uses associated with each source (DEQ, 2017c, 2018a; DOGAMI, 2017; EPA, 2017b, 2018a; ESRI, 2017; ODOT, 2016; OSDL, 2011). Farms harvesting crops obtained from the United States Department of Agricultural Census survey reported by county. The county boundaries for the Basin were obtained from the Oregon Spatial Data Library and intersected only with agricultural land within the Basin (OSDL, 2015; USDA, 2012a).

**Table 25. DEQ NPDES-Permitted Facilities in the Willamette Basin by Subbasin and Industry**

Subbasin	Total Facilities	[NAICS Code] Industry Category											
		[72] Accommodation/Food/ Recreation	[51, 54, 61-62, 92] Administrative/Service	[11] Agriculture	[23] Construction	[31-33] Manufacturing	[21] Mining	[53] Real Estate	[42, 44] Retail/Wholesale Trade	[48-49] Transportation/Warehousing	[22] Utilities	[n/a] State/County Transportation Roadway Management	[56] Waste Management
Coast Fork Willamette	40	1	5	1	4	7	3	3	2	2	11	-	1
Middle Fork Willamette	26	1	2	3	6	3	2	2	1	-	6	-	-
McKenzie	31	9	2	2	7	3	1	-	-	-	7	-	-
South Santiam	34	3	1	3	6	4	4	3	1	-	9	-	-
Upper Willamette	345	10	16	3	81	134	18	4	21	22	34	-	2
North Santiam	19	3	1	1	1	3	5	-	1	-	4	-	-
Clackamas	116	2	2	3	44	11	4	5	5	6	33	-	1
Molalla-Pudding	143	4	6	1	44	23	9	7	3	10	32	1	3
Middle Willamette	380	4	15	9	176	92	22	-	12	18	30	-	2
Yamhill	121	3	4	6	27	41	9	-	5	3	22	-	1
Tualatin	307	5	10	5	146	78	9	1	14	15	22	-	2
Lower Willamette	488	2	23	0	172	130	8	1	51	60	36	1	4
TOTAL	2,050	47	87	37	714	529	94	26	116	136	246	2	16

**Notes:**

Facilities reported in DEQ's Wastewater permit database and queried only for the toxic pollutants of the Willamette River Basin, at the 8-digit fourth-level USGS Hydrologic Unit Code (HUC) (DEQ, 2017c; OSDL, 2017). Facility coordinates (latitude/longitude) were geospatially referenced in ArcGIS Version 10.5.1 to determine their subbasin location (ESRI, 2017). NAICS = North American Industry Classification System.



**Table 26. Toxic Pollutant Loads from EPA DMR- and TRI-Reporting Facilities in the Willamette Basin by Industry and Subbasin**

Subbasin	Total Pollutants Discharged (pounds) 2007 to 2016							
	Total Pollutants Discharged (pounds)	[NAICS Code] Industry Category						
		[72] Accommodation/Food/ Recreation	[51, 54, 61-62, 92] Administrative/Service	[31-33] Manufacturing	[42, 44, 53] Real Estate/Retail	[48-49] Transportation/ Warehousing	[22] Utilities	[56] Waste Management
Coast Fork Willamette	29,014	-	-	-	-	-	29,014	-
Middle Fork Willamette	1,055	-	-	1,055	-	-	-	-
McKenzie	57,500	-	-	57,500	-	-	-	-
South Santiam	10,431,772	-	-	-	-	-	10,431,772	-
Upper Willamette	8,967,202	-	-	1,562,286	-	-	7,404,916	-
North Santiam	37,030	-	-	-	-	-	37,030	-
Clackamas	2,129,073	-	-	-	-	-	2,129,073	-
Molalla-Pudding	183,087	-	-	35	-	-	183,052	-
Middle Willamette	15,904,571	-	-	533,877	-	-	15,370,694	-
Yamhill	610,570	-	-	515	-	-	610,055	-
Tualatin	16,098,473	-	-	30,605	-	-	16,067,868	-
Lower Willamette	16,569,416	-	-	28,414	827	-	16,540,175	-
<b>TOTAL</b>	<b>71,018,763</b>	-	-	<b>2,214,288</b>	<b>827</b>	-	<b>68,803,649</b>	-

**Notes:**

Pollutant discharges reported in EPA's Water Pollution Search database (Discharge Monitoring Report [DMR] and Toxic Release Inventory [TRI] reporting programs) and queried only for the toxic pollutants of the Willamette River Basin, at the 8-digit fourth-level USGS Hydrologic Unit Code (HUC) (EPA, 2017b; OSDL, 2017). Facility coordinates (latitude/longitude) were geospatially referenced in ArcGIS Version 10.5.1 to determine their subbasin location (ESRI, 2017). NAICS = North American Industry Classification System.

**Table 27. Toxic Pollutant Loads from EPA DMR- and TRI-Reporting Facilities in the Willamette Basin by Subbasin**

Subbasin	Total Pollutants Discharged (pounds) – 2007 to 2016														
	Total Pollutants	Total Average Daily Flow (MGD)	Metals								PAHs		VOCs		
			Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Silver	Zinc	Benzo(g,h,i)perylene	Naphthalene	Ammonia	Cyanide	Trichloroethylene
Coast Fork Willamette	29,014	2.2x10 <sup>-5</sup>	-	-	-	-	-	-	-	-	-	-	29,014	-	-
Middle Fork Willamette	1,055	-	-	-	-	-	-	-	-	-	-	-	1,055	-	-
McKenzie	57,500	-	-	-	68	-	273	2	-	-	-	-	57,157	-	-
South Santiam	10,431,772	3.3x10 <sup>-3</sup>	-	-	-	-	-	-	-	-	-	-	10,431,772	-	-
Upper Willamette	8,967,202	1.0x10 <sup>-3</sup>	127	-	514	994	623	-	-	1,776	-	-	8,962,130	1,023	15
North Santiam	37,030	3.6x10 <sup>-5</sup>	-	-	-	-	-	-	-	-	-	-	37,030	-	-
Clackamas	2,129,073	1.5x10 <sup>-4</sup>	20	4	53	121	17	-	16	1,409	-	-	2,127,246	187	-
Molalla-Pudding	183,087	1.0x10 <sup>-3</sup>	-	-	-	27	8	-	-	-	-	-	183,052	-	-
Middle Willamette	15,904,571	1.3x10 <sup>-3</sup>	-	16	-	2,643	1,291	3	-	128,386	8	22	15,772,201	-	-
Yamhill	610,570	4.9x10 <sup>-5</sup>	-	-	17	-	53	-	-	445	-	-	610,055	-	-
Tualatin	16,098,473	1.0x10 <sup>-2</sup>	-	-	-	435	159	-	-	-	-	-	16,097,880	-	-
Lower Willamette	16,569,416	1.1x10 <sup>-3</sup>	-	-	284	17,696	160	-	-	10,263	-	2	16,541,002	10	-
<b>TOTAL</b>	<b>71,018,763</b>	<b>1.8x10<sup>-2</sup></b>	<b>147</b>	<b>20</b>	<b>936</b>	<b>21,916</b>	<b>2,585</b>	<b>5</b>	<b>16</b>	<b>142,279</b>	<b>8</b>	<b>24</b>	<b>70,849,594</b>	<b>1,219</b>	<b>15</b>

**Notes:**

Pollutant discharges reported in EPA's Water Pollution Search database (EPA's DMR and TRI reporting programs) and queried only for the toxic pollutants of the Willamette River Basin, at the 8-digit fourth-level USGS Hydrologic Unit Code (HUC) (EPA, 2017b; OSDL, 2017). Facility coordinates (latitude/longitude) were geospatially referenced in ArcGIS Version 10.5.1 to determine their subbasin location (ESRI, 2017). MGD = million gallons per day.

**Table 28. DOGAMI Mining Sites by Subbasin in the Willamette Basin**

Subbasin	Total Sites	Permit Type		
		NPDES 1200-A (offsite discharge)	WPCF 1000 (no offsite discharge)	Unidentified
Coast Fork Willamette	31	2	2	27
Middle Fork Willamette	26	2	-	24
McKenzie	19	1	-	18
South Santiam	60	4	-	56
Upper Willamette	147	16	4	127
North Santiam	41	4	1	36
Clackamas	41	2	4	35
Molalla-Pudding	92	9	2	81
Middle Willamette	113	22	5	86
Yamhill	36	9	1	26
Tualatin	55	7	-	48
Lower Willamette	54	3	3	48
<b>TOTAL</b>	<b>715</b>	<b>81</b>	<b>22</b>	<b>612</b>

Notes:

Mine sites reported in DOGAMI's Mining Permit Viewer (DOGAMI, 2017). Facility coordinates (latitude/longitude) were plotted in ArcGIS to determine their subbasin location, at the 8-digit fourth-level USGS Hydrologic Unit Code (HUC) (ESRI, 2017; OSDL, 2017).

**Table 29. ODOT Outfalls by Subbasin in the Willamette Basin**

Subbasin	Total Outfalls	Discharge Endpoint								
		Ditch	Unknown	Open Field	Pond	River	Sough	Storm Drain System	Stream	Wetland
Coast Fork Willamette	0	-	-	-	-	-	-	-	-	-
Middle Fork Willamette	11	-	11	-	-	-	-	-	-	-
McKenzie	5	-	1	-	-	2	2	-	-	-
South Santiam	0	-	-	-	-	-	-	-	-	-
Upper Willamette	112	-	83	-	-	9	16	-	4	-
North Santiam	0	-	-	-	-	-	-	-	-	-
Clackamas	21	-	3	3	-	8	-	2	5	-
Molalla-Pudding	7	1	-	4	-	-	-	-	-	2
Middle Willamette	65	5	5	3	-	17	-	4	31	-
Yamhill	0	-	-	-	-	-	-	-	-	-
Tualatin	173	9	24	67	1	5	-	6	48	13
Lower Willamette	128	4	1	39	5	28	13	1	35	2
<b>TOTAL</b>	<b>522</b>	<b>19</b>	<b>128</b>	<b>116</b>	<b>6</b>	<b>69</b>	<b>31</b>	<b>13</b>	<b>123</b>	<b>17</b>

**Notes:**

ODOT outfalls reported in ODOT's Stormwater Inventory. Facility coordinates (latitude/longitude) were plotted in ArcGIS to determine their subbasin location, at the 8-digit fourth-level USGS Hydrologic Unit Code (HUC) (ESRI, 2017; OSDL, 2017).

**Table 30. DEQ ECSI Sites by Subbasin in the Willamette Basin**

*Provided in electronic format*

**Table 31. Chemical Characteristics of Toxic Pollutants in the Willamette Basin**

Chemical Characteristic	Value	Toxic Pollutant Class					
		Metals	Organochlorine Insecticides	Organophosphorus Insecticides	PAHs	PCBs	VOCs
Water solubility (mg/L)	Minimum	6x10-02	6.2x10-03	2	2.6x10-04	7.4x10-06	206
	Median	70,480	8.3x10-02	15	6.2x10-02	1.4x10-02	4,010
	Maximum	623,500	5.3x10-01	28	31	5	482,000
	Behavior	<b>Negligible to very soluble</b>	<i>Negligible solubility</i>	<i>Negligible solubility</i>	<i>Negligible solubility</i>	<i>Negligible solubility</i>	<b>Moderately to very soluble</b>
Vapor Pressure (mmHg)	Minimum	3.9x10-09	3.7x10-08	2.2x10-07	9.6x10-11	7.6x10-09	19
	Median	4.2x10-09	4.4x10-06	9.5x10-06	6.3x10-07	8.5x10-06	266
	Maximum	1.8	3.0x10-04	1.9x10-05	8.5x10-02	1.1x10-02	7,508
	Behavior	<i>Less to very volatile</i>	<i>Slow volatility to volatile</i>	<i>Slow volatility to volatile</i>	<i>Less to very volatile</i>	<i>Less to very volatile</i>	<b>Very volatile</b>
Henry's Law (atm-m <sup>3</sup> /mol)	Minimum	8.6x10-03	3.7x10-08	3.7x10-09	7.3x10-08	1.3x10-06	1.6x10-05
	Median	2.5x10-02	1.5x10-05	6.2x10-06	7.0x10-06	9.2x10-05	9.6x10-03
	Maximum	7.7x10-01	1.7x10-03	1.2x10-05	1.5x10-03	9.4x10-03	1.9x10-01
	Behavior	<i>Volatile</i>	<i>Nonvolatile to volatile</i>	<i>Nonvolatile to moderately volatile</i>	<i>Nonvolatile to volatile</i>	<i>Slightly to volatile</i>	<b>Moderately to volatile</b>
Octanol-Water Partition Coefficient (log K <sub>OW</sub> )	Minimum	-7.7x10-01	3.8	2.8	3.3	4.5	2.3x10-01
	Median	2.3x10-01	5.7	3.8	5.2	6.8	2.0
	Maximum	7.3x10-01	6.9	4.8	6.8	9.6	3.4
	Behavior	<i>Highly lipophilic</i>	<i>Moderate to super hydrophobic</i>	<i>Moderate to highly hydrophobic</i>	<i>Moderate to super hydrophobic</i>	<b>Highly to super hydrophobic</b>	<i>Highly lipophilic to moderately hydrophobic</i>

Chemical Characteristic	Value	Toxic Pollutant Class					
		Metals	Organochlorine Insecticides	Organophosphorus Insecticides	PAHs	PCBs	VOCs
Organic carbon-water distribution coefficient (log K <sub>OC</sub> )	Minimum	-6.7x10-01	3.9x10-07	2.5	1.4	3.5	-1.2
	Median	0.20	4.0	3.2	4.8	4.8	1.7
	Maximum	0.63	6.0	3.9	6.7	6.2	2.4
	<i>Behavior</i>	Negligible sorption (rapid gw migration)	Negligible to very strong sorption (rapid to negligible gw migration)	Moderate to strong sorption (slow gw migration)	Negligible to very strong sorption (moderate to negligible gw migration)	<b>Moderate to very strong sorption (slow to negligible gw migration)</b>	Negligible to low sorption (rapid to moderate gw migration)

Notes:

Chemical characteristics of the Basin's 48 toxic pollutants, identified as Category 5 in DEQ's 2012 Integrated Report, where: metals (n = 9), Organophosphorus Insecticides (n = 2), Organochlorine Insecticides (n = 11), PAHs (n = 17), PCBs (n = 209), and VOCs (n = 8)(DEQ, 2012). Refer to **Table 10** for raw data and sources. **Bold text** indicates the predominant chemical characteristic (i.e., behavior) differentiating the toxic pollutant classes (EPA, 2012; Rand, 1995). GW = groundwater.

**Table 32. ANOSIM Pair-wise Test Statistics of Cluster Significance**

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Cluster 1				
Cluster 2	p=0.003 R=0.93			
Cluster 3	p=0.001 R=1	p=0.001 R=0.802		
Cluster 4	p=0.001 R=1	p=0.001 R=0.82	p=0.001 R=0.784	

Notes:

Pair-wise analysis of similarity (ANOSIM) testing conducted on six cluster pairs using the Bonferroni-corrected significance level ( $\alpha_{\text{altered}} p = 0.05/6 = 0.01$ ) to evaluate significant differences. Red text indicates significant differences ( $p < 0.01$ ). R test statistic is an index of relative within-group dissimilarity where an R equal to 1 indicates all toxic pollutants within the cluster are similar to each other than to toxic pollutants in other clusters. Grey shading indicates no pair-wise test conducted. Clusters are the four clusters generated from the cluster analysis of the Willamette River Basin's 48 toxic pollutants based on five chemical characteristics. Statistical analyses conducted in R (R Development Core Team, 2016).



**Table 33. ANOVA Test Statistics of Chemical Characteristic Significance**

Variable	Df	Sum Square	Mean Square	F-value	p-value (>F-value)
<b>Solubility</b>					
Cluster	1	19.634	19.6343	30.884	0.00000133***
Residuals	46	29.244	0.6358		
<b>Organic carbon-water distribution coefficient (<math>K_{oc}</math>)</b>					
Cluster	1	10.343	10.3433	12.308	0.00102**
Residuals	46	38.656	0.8403		
<b>Vapor Pressure</b>					
Cluster	1	5.170	5.1703	5.4306	0.0242*
Residuals	46	43.795	0.9521		
<b>Henry's Law Constant</b>					
Cluster	1	2.406	2.4056	2.3777	0.129
Residuals	46	46.541	1.0117		
<b>Octanol-water partition coefficient (<math>K_{ow}</math>)</b>					
Cluster	1	1.595	1.5950	1.5484	0.219
Residuals	46	47.385	1.0301		

Notes:

Analysis of variance (ANOVA) conducted on clusters using the Bonferroni-corrected significance level ( $\alpha_{\text{adjusted}} = p = 0.05/4 = 0.0125$ ) to evaluate significant differences. Variables in order of p-values from most significant to least significant. Red text indicates significant differences ( $p < 0.0125$ ). Variables refer to the five chemical characteristics associated with the Willamette River Basin's 48 toxic pollutants. Statistical analyses conducted in R (R Development Core Team, 2016).

**Table 34. Results of Environmental Vectors Fitting in NMDS Plot**

Variables	NMDS1	NMDS2	r <sup>2</sup>	p-value
Solubility	-0.86108	0.50847	0.3530	0.000999***
Organic carbon-water distribution coefficient (K <sub>OC</sub> )	0.44038	0.89781	0.4202	0.000999***
Henry's Law Constant	-0.67260	0.74000	0.1485	0.018981*
Vapor pressure	-0.81246	0.58302	0.1237	0.033966*
Octanol-water partition coefficient (K <sub>OW</sub> )	0.03347	0.99944	0.0465	0.285714

**Notes:**

Variables refer to the five chemical characteristics associated with the toxic pollutants evaluated in the Willamette River Basin. Statistical analysis conducted in R (R Development Core Team, 2016).

Variable scores of the two ordination axes (NMDS 1 and 2), goodness of fit statistic r<sup>2</sup>, and its significance (p-value).

Variables in order of p-values from most significant to least significant.

Significance codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Significance level (α) = 0.05 compared to the p-values (based on 1,000 permutations).

**Table 35. Chemical Characteristics of Toxic Pollutant Clusters in the Willamette Basin**

Chemical Characteristic	Value	Toxic Pollutant Clusters			
		Cluster 1 (n=4; 8%)	Cluster 2 (n=13; 27%)	Cluster 3 (n=17; 35%)	Cluster 4 (n=14; 29%)
Toxic Pollutant Class		VOCs Metals	VOCs Metals	PAHs OC Insecticides OP Insecticides	PAHs OC Insecticides PCBs
Water Solubility (mg/L)	Minimum	343,700	6.0x10-02	6.2x10-03	2.6x10-04
	Median	451,400	6,410	5.1x10-01	1.1x10-02
	Maximum	623,500	95,400	31	4.8
	Standard Deviation	102,535	33,600	9.3	1.2
	Behavior	Very soluble	Negligible to very soluble	Negligible solubility	Negligible solubility
Vapor Pressure (mmHg)	Minimum	3.9x10-09	4.2x10-09	1.5x10-08	9.6x10-11
	Median	4.2x10-09	19	5.9x10-06	3.3x10-07
	Maximum	7,508	630	8.5x10-02	1.1x10-02
	Standard Deviation	3,251	220	2.1x10-02	2.7x10-03
	Behavior	Less to very volatile	Less to very volatile	Less to very volatile	Less to very volatile
Henry's Law (atm-m³/mol)	Minimum	1.6x10-05	4.1x10-03	3.7x10-09	7.3x10-08
	Median	0.025	0.025	1.2x10-05	7.6x10-06
	Maximum	2.5x10-02	7.7x10-01	1.7x10-03	9.4x10-03
	Standard Deviation	1.1x10-02	2.0x10-01	5.0x10-04	2.4x10-03
	Behavior	Moderately volatile to volatile	Volatile	Nonvolatile to volatile	Nonvolatile to volatile
Octanol-Water Partition Coefficient (log K <sub>OW</sub> )	Minimum	-7.7x10-01	2.3x10-01	2.8	5.2
	Median	-0.52	7.3x10-01	4.4	6.3
	Maximum	2.3x10-01	3.4	6.2	10
	Standard Deviation	3.8x10-01	1.01	0.93	9.9x10-01
	Behavior	Highly lipophilic	Highly lipophilic to moderately hydrophobic	Moderately to super hydrophobic	Highly to super hydrophobic

Chemical Characteristic	Value	Toxic Pollutant Clusters			
		Cluster 1 (n=4; 8%)	Cluster 2 (n=13; 27%)	Cluster 3 (n=17; 35%)	Cluster 4 (n=14; 29%)
Toxic Pollutant Class		VOCs Metals	VOCs Metals	PAHs OC Insecticides OP Insecticides	PAHs OC Insecticides PCBs
Organic Carbon-Water Distribution Coefficient (log K <sub>OC</sub> )	Minimum	-1.2	2.0x10-01	3.9x10-07	5.3
	Median	-0.58	0.94	3.8	5.7
	Maximum	-4.3x10-01	2.4	4.8	6.7
	Standard Deviation	3.0x10-01	7.5x10-01	1.4	4.5x10-01
	Behavior	Negligible sorption (rapid gw migration)	Negligible to low sorption (rapid to slow gw migration)	Negligible to very strong sorption (rapid to negligible gw migration)	Very strong sorption (negligible gw migration)

**Notes:**

Chemical characteristics of the Basin's 48 toxic pollutants identified as Category 5 in DEQ's 2012 Integrated Report, evaluated from the cluster analysis performed in R, where: Cluster 1 (n = 4), Cluster 2 (n = 13), Cluster 3 (n = 17), and Cluster 4 (n = 14) (DEQ, 2012; R Development Core Team, 2016). Refer to **Table 10** for raw data and sources. **Bold text** indicates the predominant chemical characteristic (i.e., behavior) differentiating toxic pollutant classes in each cluster (EPA, 2012; Rand, 1995). GW = groundwater; VOCs = volatile organic compounds; PAHs = polycyclic aromatic hydrocarbons; OC = organochlorine; OP = organophosphorus; PCBs = polychlorinated biphenyls.

**Table 36. Data Gaps of Toxic Pollutant Point and Nonpoint Sources Identified in the Willamette Basin**

Toxic Pollutant <sup>1</sup>	Identified in Point Source Discharges <sup>2</sup>	Identified in Nonpoint Discharges <sup>3</sup>
<b>Metals</b>		
Arsenic	X (limited)	
Chromium	X (limited)	
Chromium III	X (limited)	
Chromium VI		
Copper	X (limited)	X (mass applied to land)
Iron		
Lead	X (limited)	
Mercury	X (limited)	
Silver	X (limited)	
Thallium		
Zinc	X (limited)	X (mass applied to land)
<b>Organochlorine Insecticides</b>		
4,4-DDE		
4,4-DDT		
Aldrin		
Chlordane		
Dieldrin		
Endrin		
Endrin Aldehyde		
Endosulfan		
Endosulfan I (alpha)		X (mass applied to land)
Endosulfan I (beta)		X (mass applied to land)
Heptachlor		
Hexachlorobenzene		
<b>Organophosphorus Insecticides</b>		
Chlorpyrifos		X (mass applied to land)
Guthion (azinphos-methyl)		X (mass applied to land)
<b>PAHs</b>		
Acenaphthene		
Acenaphthylene		
Anthracene		
Benzo(a)anthracene		
Benzo(a)pyrene		
Benzo(b)fluoranthene		
Benzo(j)fluoranthene		
Benzo(k)fluoranthene		
Benzo(g,h,i)perylene	X (limited)	
Chrysene		
Dibenzo(a,h)anthracene		
Fluoranthene		
Fluorene		

Toxic Pollutant <sup>1</sup>	Identified in Point Source Discharges <sup>2</sup>	Identified in Nonpoint Discharges <sup>3</sup>
Indeno(1,2,3-cd)pyrene		
Naphthalene	X (limited)	
Phenanthrene		
Pyrene		
<b>VOCs</b>		
Ammonia	X	
1,1-Dichloroethylene		
1,2-Dichloroethylene		
cis-1,2-Dichloroethylene		
trans-1,2-Dichloroethylene		
Cyanide	X (limited)	
Tetrachloroethylene		
Trichloroethylene	X (limited)	
<b>PCBs</b>		
PCBs		

**Notes:**

X = toxic pollutant was identified for that source.

<sup>1</sup> DEQ's 2012 *Integrated Report Assessment Database and 303(d) List*. (DEQ, 2017b)

<sup>2</sup> Point sources = NPDES-permitted discharge facilities reporting pollutant discharges in EPA's Water Pollutant Loading Search database (2006 to 2017) (EPA, 2017b).

<sup>3</sup> Nonpoint sources = DEQ ECI Sites, EPA Superfund Sites, and USGS NWQA PNSP (2000-2016). Nonpoint sources of toxic pollutants identified for pesticide applications as total mass (pounds) (USGS, 2017).

**Abbreviations:**

DEQ – (Oregon) Department of Environmental Quality  
 ECSI – Environmental Cleanup Site Information  
 EPA – (United States) Environmental Protection Agency  
 NWQA – National Water Quality Assessment  
 PAHs – polycyclic aromatic hydrocarbons  
 PCBs – polychlorinated biphenyls  
 PNSP – Pesticide National Synthesis Project  
 USGS – United States Geological Survey  
 VOCs – volatile organic compounds

**Table 37. Recommendations Toxic Pollutant TMDL Prioritization in the Willamette Basin**

Toxic Pollutant	Cluster	Coast Fork Willamette	Middle Fork Willamette	McKenzie	South Santiam	Upper Willamette	North Santiam	Clackamas	Molalla-Pudding	Middle Willamette	Yamhill	Tualatin	Lower Willamette
<b>Metals</b>													
Arsenic	2	-	-	-	-	P	-	-	P	-	-	P	-
Chromium	2	-	-	-	-	-	-	-	-	-	-	P	-
Copper	1	P	-	-	-	P	-	-	-	P	P	P	P
Iron	1	P	-	P	-	P	-	-	P	P	P	P	P
Lead	2	P	-	-	-	P	-	P	P	P	P	P	P
Mercury	2	HP	HP	HP	-	HP	HP	HP	-	-	HP	HP	HP
Silver	2	-	-	-	-	-	-	-	-	-	-	P	-
Thallium	2	-	-	-	-	-	-	-	-	-	-	P	-
Zinc	1	-	-	-	-	-	-	-	-	P	-	P	-
<b>Organochlorine Insecticides</b>													
4,4-DDE	4	-	-	-	-	-	-	-	HP	HP	-	-	HP
4,4-DDT	4	-	-	-	-	-	-	-	-	HP	-	-	HP
Aldrin	4	-	-	-	-	-	-	-	-	P	-	-	P
Chlordane	4	-	-	-	-	-	-	-	-	-	-	-	P
Dieldrin	3	-	-	-	-	-	-	P	-	P	-	P	P
Endrin Aldehyde	3	-	-	-	-	-	-	-	-	-	-	-	P
Endosulfan	3	-	-	-	-	-	-	-	P	-	-	-	P
Endosulfan I (alpha)	3	-	-	-	-	-	-	-	P	-	-	-	P
Endosulfan I (beta)	3	-	-	-	-	-	-	-	P	-	-	-	P
Heptachlor	4	-	-	-	-	-	-	-	-	P	-	-	-
Hexachlorobenzene	3	-	-	-	-	-	-	-	-	-	-	-	P
<b>Organophosphorus Insecticides</b>													
Chlorpyrifos	3	-	-	-	-	-	-	P	P	-	P	-	-
Guthion (azinphos-methyl)	3	-	-	-	-	-	-	P	P	-	-	-	-

Toxic Pollutant	Cluster	Coast Fork Willamette	Middle Fork Willamette	McKenzie	South Santiam	Upper Willamette	North Santiam	Clackamas	Molalla-Pudding	Middle Willamette	Yamhill	Tualatin	Lower Willamette
<b>PAHs</b>													
Acenaphthene	3	-	-	-	-	-	-	-	-	-	-	-	P
Acenaphthylene	3	-	-	-	-	-	-	-	-	-	-	-	P
Anthracene	3	-	-	-	-	-	-	-	-	-	-	-	P
Benzo(a)anthracene	4	-	-	-	-	-	-	-	-	-	-	-	HP
Benzo(a)pyrene	4	-	-	-	-	-	-	-	-	-	-	-	HP
Benzo(b)fluoranthene	4	-	-	-	-	-	-	-	-	-	-	-	HP
Benzo(j)fluoranthene	3	-	-	-	-	-	-	-	-	-	-	-	P
Benzo(k)fluoranthene	4	-	-	-	-	-	-	-	-	-	-	-	HP
Benzo(g,h,i)perylene	4	-	-	-	-	-	-	-	-	-	-	-	P
Chrysene	4	-	-	-	-	-	-	-	-	-	-	-	HP
Dibenzo(a,h)anthracene	4	-	-	-	-	-	-	-	-	-	-	-	HP
Fluoranthene	3	-	-	-	-	-	-	-	-	-	-	-	P
Fluorene	3	-	-	-	-	-	-	-	-	-	-	-	P
Indeno(1,2,3-cd)pyrene	4	-	-	-	-	-	-	-	-	-	-	-	HP
Naphthalene	3	-	-	-	-	-	-	-	-	-	-	-	P
Phenanthrene	3	-	-	-	-	-	-	-	-	-	-	-	P
Pyrene	3	-	-	-	-	-	-	-	-	-	-	-	P
<b>VOCs</b>													
Ammonia	1	-	-	-	-	-	-	-	-	-	-	P	P
1,1-Dichloroethylene	2	-	-	-	-	P	-	-	-	-	-	-	-
1,2-Dichloroethylene	2	-	-	-	-	P	-	-	-	-	-	-	-
cis-1,2-Dichloroethylene	2	-	-	-	-	P	-	-	-	-	-	-	-
trans-1,2-Dichloroethylene	2	-	-	-	-	P	-	-	-	-	-	-	-
Cyanide	2	-	-	-	-	-	-	-	-	-	-	-	P
Tetrachloroethylene	2	-	-	-	-	-	-	-	-	-	-	P	P
Trichloroethylene	2	-	-	-	-	P	-	-	-	-	-	-	-
<b>PCBs</b>													
PCBs	4	-	-	-	-	-	-	-	-	HP	-	-	HP

Notes:

P = priority; HP = high priority.

Grey shading and a dash (-) indicates the particular subbasin is not impaired by the toxic pollutant (DEQ, 2017b).

PAHs listed in red text are carcinogenic PAHs and should be prioritized in TMDL development (ATSDR, 1996c).

Subbasin names in red text have toxic-pollutant impacted Superfund Sites located in the subbasin.

Cluster # based on cluster analysis of chemical characteristics conducted in R (R Development Core Team, 2016).

Abbreviations:

PAHs – polycyclic aromatic hydrocarbons

PCBs – polychlorinated biphenyls

VOCs – volatile organic compounds



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