

4. Modeling Results

4.1 Overview of Modeling Results

The PATS 2017 model allows DEQ and stakeholders to understand the regional distribution of air toxic concentrations, the significant source categories responsible for these concentrations, and ways to estimate emission reduction targets and plan emission reduction strategies. Using GIS to map pollutant concentrations, DEQ has described various spatial patterns, identified risk drivers, and analyzed contributions from source categories. Table 7 summarizes spatial distribution of the modeled PATS pollutants. In general, the modeling showed that the majority of PATS pollutants are present both regionally and in zones of higher concentration corresponding to roadways and development. Several pollutants were modeled at levels of concern for the entire region, and several pollutants are strictly limited to localized impact areas.

Table 7 : Spatial Distribution of the Modeled PATS Pollutants

Region wide	Region wide with higher concentrations in defined zones	Limited to localized impact areas
Acetaldehyde Formaldehyde 15 PAH	Benzene 1,3 Butadiene Diesel Particulate Arsenic Chromium VI Naphthalene Acrolein Dichlorobenzene	Manganese Nickel Cadmium Lead (one receptor)

PATS pollutants can be categorized by their primary sources. Table 8 shows pollutants organized in this way. Even though PATS pollutants are associated with a primary source, most of them also come from a variety of other sources as well. For example, the largest source of benzene is motor vehicles but it is also produced by residential wood burning and some industrial facilities. However, the metals in the localized impact area category are produced almost exclusively by industrial processes. Pollutants in the Secondary Formation category come overwhelmingly from atmospheric chemical reactions.

Table 8: Primary Source of PATS Pollutants

Predominant Source of Emissions	PATS Pollutant
Mobile Sources	1,3 Butadiene Benzene Ethyl benzene Diesel particulate Arsenic Chromium VI
Residential Wood Combustion	15 PAH Naphthalene
Industry	Cadmium Manganese Nickel Lead
Solvents	Dichlorobenzene Methylene Chloride Perchloroethylene Trichloroethylene
Secondary Formation	Acetaldehyde Formaldehyde Acrolein

4.1.1 Pollutants above Benchmarks

For all receptors with values above DEQ benchmarks, PATS 2017 modeling estimated seven pollutants at levels more than ten times the benchmarks. Seven other pollutants were between one and 10 times above DEQ benchmarks. Table 9 summarizes PATS modeling results including times above the benchmarks, regional, zonal or localized impacts, and is also color coded based on predominant contributing source category. Three pollutants not included in this table were below benchmarks: perchloroethylene and trichloroethylene and ethylbenzene. Lead is not included because it exceeded the benchmark only at one receptor and needs further verification. Methylene chloride is not included because while levels were modeled above benchmarks, DEQ has extremely low confidence in the data quality and will follow-up by improving the emissions inventory. Table 10 summarizes average reductions needed to reach benchmarks.

Table 9: Summary of PATS 2017 Modeling Results

Pollutant	Region wide	Region wide and zonal	Localized impact areas
More than 10 X ABC			
1,3 Butadiene		●	
Benzene		●	
Diesel particulate		●	
15 PAH	●		
Naphthalene		●	
Cadmium			●
Formaldehyde	●		
Acrolein		●	
Between 1 and 10 x ABC			
Arsenic		●	
Manganese			●
Nickel			●
Chromium VI		●	
Dichlorobenzene		●	
Acetaldehyde	●		

Table 10: Average Reductions Needed to Meet Benchmark

Pollutant	Region wide	Region wide and zonal	Localized impact areas
Average Reduction Needed to Reach Benchmark – More than 10 X Ambient Benchmark Concentration			
1,3 Butadiene		85%	
Benzene		88%	
Diesel particulate		86%	
15 PAH	94%		
Naphthalene		77%	
Cadmium			70%
Acrolein		88%	
Formaldehyde	10%		

Average Reduction Needed to Reach Benchmark – Between 1 and 10 x Ambient Benchmark Concentration			
Arsenic		66%	
Chromium VI		37%	
Manganese			84%
Nickel			90%
Dichlorobenzene		45%	
Acetaldehyde	81%		

4.1.2 Secondary Formation and Background Pollutants

During the PATS modeling study and PATSAC advisory committee process, DEQ further investigated the role and importance of background and secondary pollutants. For three pollutants, acrolein, acetaldehyde and formaldehyde, the primary source is atmospheric formation from precursors such as 1,3 butadiene, toluene and xylene. For other pollutants, such as benzene, background sources from other locations and undocumented regional emissions make up a significant percentage of the total emissions. Figure 35 illustrates the sources of background and secondary air toxics concentrations. The PATS emissions inventory is composed of direct emissions. Because CALPUFF does not include estimates from atmospheric formation or chemical reactions, DEQ added secondary pollutant concentrations to the modeled concentrations to the extent information was available from EPA's 2005 National Air Toxics Assessment (NATA). Also, to form a complete estimate of concentrations in the Portland area, DEQ added the NATA levels of background concentrations when available. EPA has not yet been able to develop background concentrations for all air toxics.

Figure 35 Sources of Background and Secondary Air Toxics

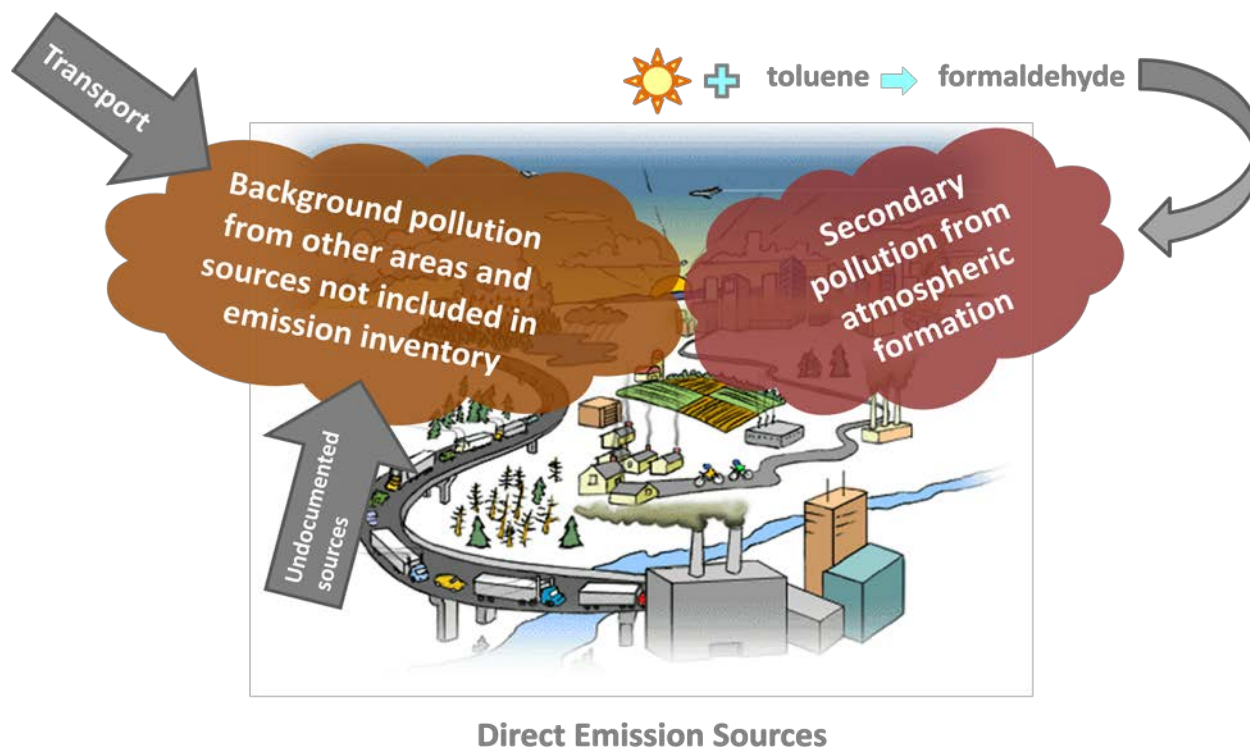


Table 11 shows the pollutants for which DEQ added background concentrations to the PATS model. Table 12 shows pollutants for which DEQ added secondary concentrations to the PATS model and also chief associated precursors.

Table 11 Background Concentration Included in Modeling

Background Concentration Data Included	Background Concentration Data Not Included
1,3 Butadiene	Diesel Particulate
Benzene	Ethylbenzene
Dichlorobenzene	15 PAH
Naphthalene	
Arsenic	
Chromium VI	
Cadmium	
Manganese	
Nickel	

Table 12: Secondary Concentrations Included in Modeling

Secondary Concentration Data Included	Chief Precursors
Acetaldehyde	Toluene and xylene from auto exhaust and vegetation
Formaldehyde	Toluene and xylene from auto exhaust and vegetation
Acrolein	1,3 Butadiene from auto exhaust

4.2 Concentrations vs. Exposures as Emission Reduction Targets

The PATS model estimates concentrations at block group centroids. In many modeled air toxics risk assessments, concentration estimates are followed by further estimates of exposure based on assumptions about how various population cohorts spend time in different locations. These exposure assumptions and estimates provide an understanding of how much of a particular modeled pollutant people are likely to breathe. In DEQ's previous air toxics model, Portland Air Toxics Assessment (PATA), exposure analysis generally decreased concentrations for individuals living in denser or more developed block groups and increased concentrations for individuals living in less populated and less developed block groups. These results come from assumptions that many people move daily out of their home block groups for work, school and other activities. In contrast,

inclusion of assumptions about time spent traveling on roadways will increase exposure to mobile source air toxics.

Despite the availability of exposure analysis, DEQ opted to use modeled concentrations instead of exposure concentrations to characterize air toxics problems in the PATS study area. This simplifying assumption provides a starting point to understand air toxics problems and would likely be most protective for individuals or sensitive populations that do not move out of higher concentration areas. Using modeled concentrations rather than exposure concentrations is generally consistent with the method of reasonable worst case analysis that DEQ used to analyze modeling data. In addition, DEQ regulations in OAR 340-246-0170 indicate that local emission reduction plans will use modeled concentrations as targets. However, when air toxics rules were drafted in 2003, DEQ and others lacked experience modeling and estimating air toxics at a geographic level, and were not fully aware of the value of or potential role for exposure analysis. In emission reduction efforts that follow PATS, exposure concentrations can be used to further understand air toxics risk and to inform and fine-tune strategies. Exposure analysis may also lead to a more detailed understanding of environmental justice issues.

4.3 Summary of Concentration Results

4.3.1 Mobile Source Pollutants

There are six pollutants associated primarily with mobile sources: 1,3 butadiene, benzene, ethylbenzene, diesel particulate, arsenic and chromium VI. Benzene, 1,3 butadiene and diesel particulate are more than ten times above their benchmarks, arsenic and chromium VI are between one and ten times above their benchmarks. The sources associated with mobile source pollutants fall into two basic categories: on-road mobile and non road mobile. On-road mobile categories include gasoline and diesel fueled cars, trucks and busses. Non road mobile categories include diesel construction equipment, rail and marine engines.

4.3.1.1 1,3 Butadiene

1,3 butadiene is a colorless gas with a mild gasoline-like odor. It is a probable human carcinogen, possibly associated with heart diseases. Within the PATS area, it comes from incomplete combustion of fuels from cars and trucks, and off-road engines like lawn mowers and boats. Additional sources include production of rubber and plastics and forest fires. Figure 36 and Figure 37 are maps showing region-wide 1,3 butadiene modeled concentrations without and including background contributions compared to Oregon's 1,3 butadiene ambient benchmark concentration.

Figure 36: 1,3 Butadiene 2017 Modeled Concentrations without Background Contributions

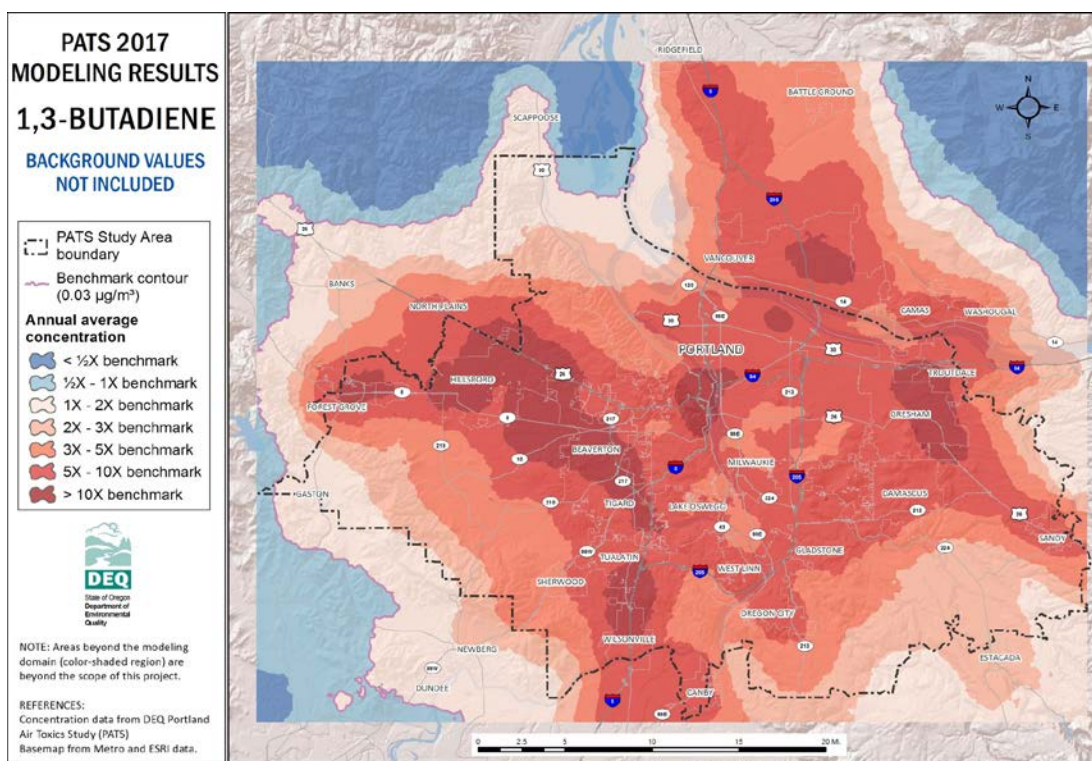
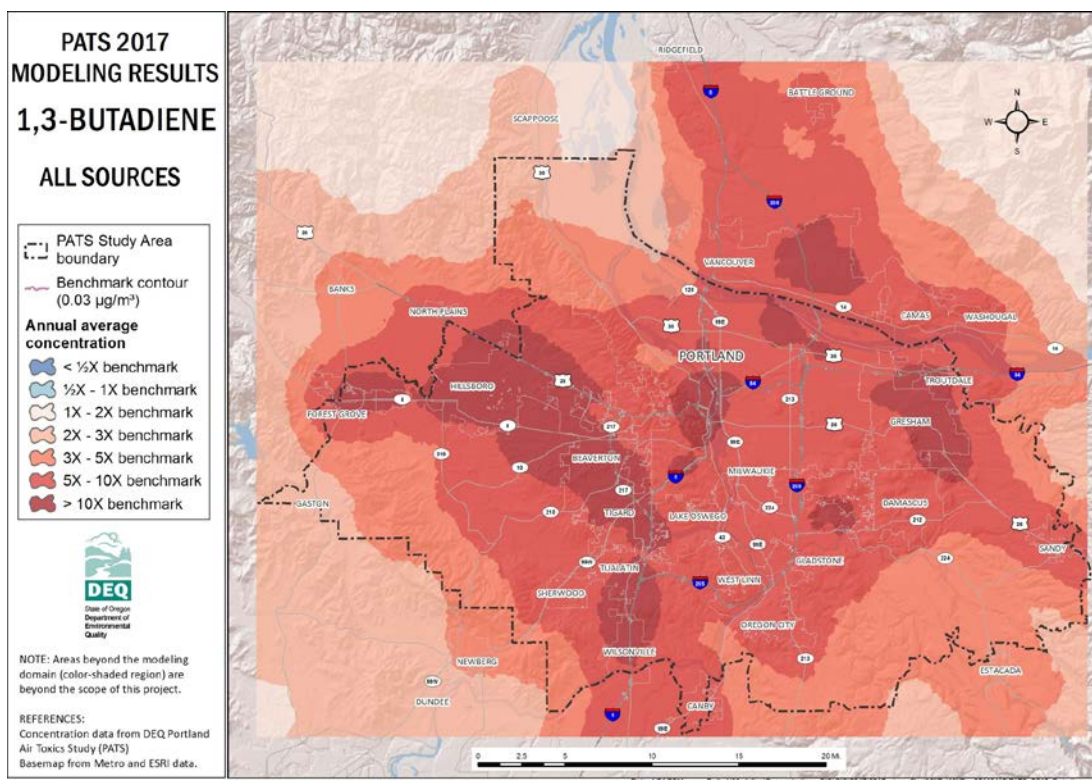


Figure 37: 1,3 Butadiene 2017 Modeled Concentrations Including Background Contributions



1,3 butadiene is a regional pollutant with higher concentrations in areas with high volume roadways. Figure 38 is a pie chart showing percentages of modeled contributions for 1,3 butadiene.

Figure 38: Modeled 2017 Sources of 1,3 Butadiene

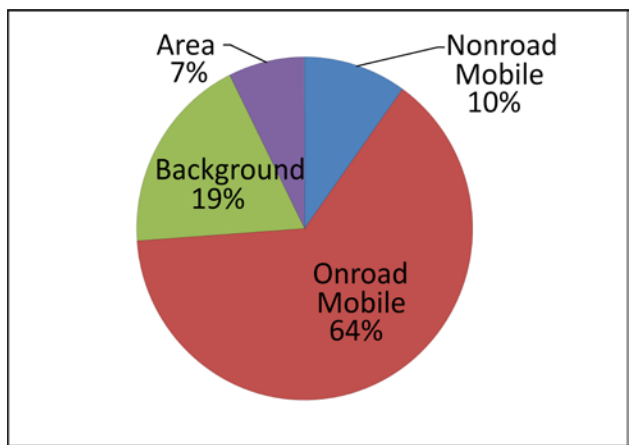
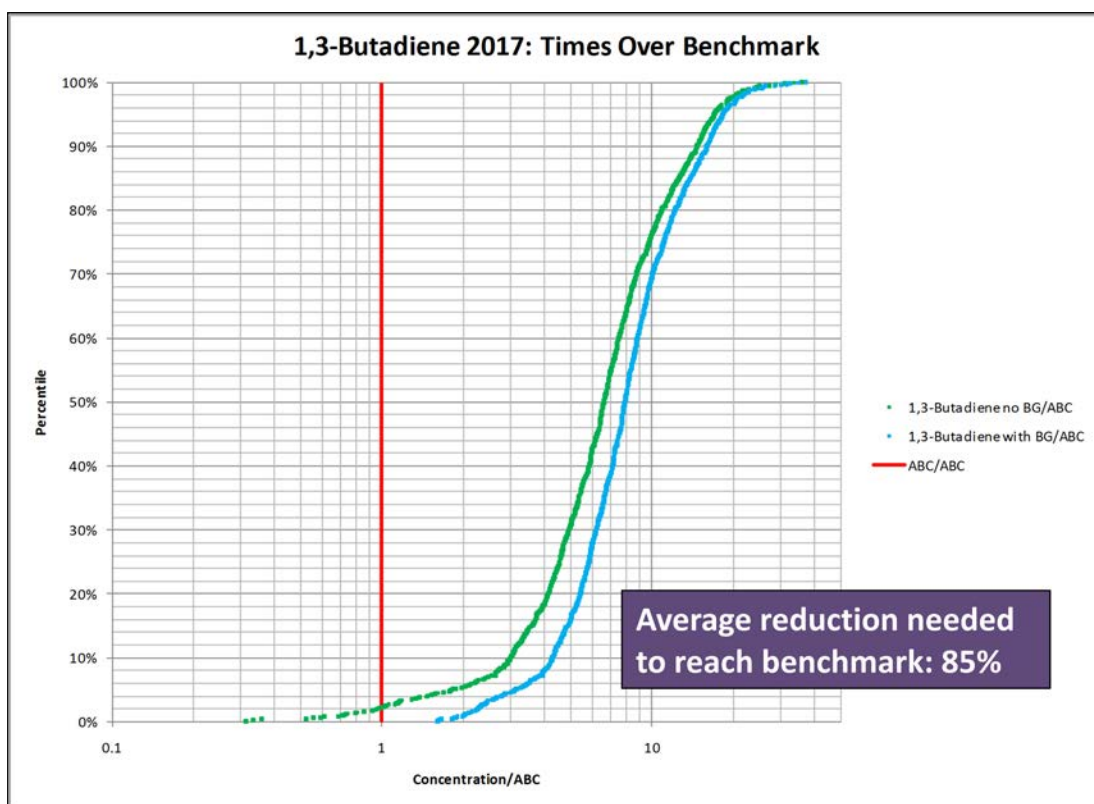


Figure 39 plots a distribution of modeled values for 1,3 butadiene with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the background concentration. This graph, known as an S-curve, shows that most modeled 1,3 butadiene values are above the benchmark. The average reduction needed for 1,3 butadiene in order to reach the benchmark is 85%. This means that for those receptors whose modeled concentrations are greater than benchmark, the average reduction in concentration needed to meet the reduction target is 85%. Note that the 85% reduction is of the average concentration above the benchmark, not the highest modeled value. As a result, for 1,3 butadiene, an 85% reduction will still leave receptors with the highest modeled concentrations above the benchmark.

Figure 39: Distribution of 2017 Modeled Concentrations for 1, 3 Butadiene



4.3.1.2 Benzene

Benzene is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities. Benzene is a known human carcinogen that causes blood disorders, and may cause anemia and genetic damage. Within the PATS area, Benzene is found in emissions from cars and trucks, wood smoke, evaporation from service stations, and industrial solvents. Figure 40 and Figure 41 are maps showing region wide benzene modeled concentrations without and including background contributions compared to Oregon's benzene benchmark.

Figure 40: Benzene 2017 Modeled Concentrations without Background Contributions

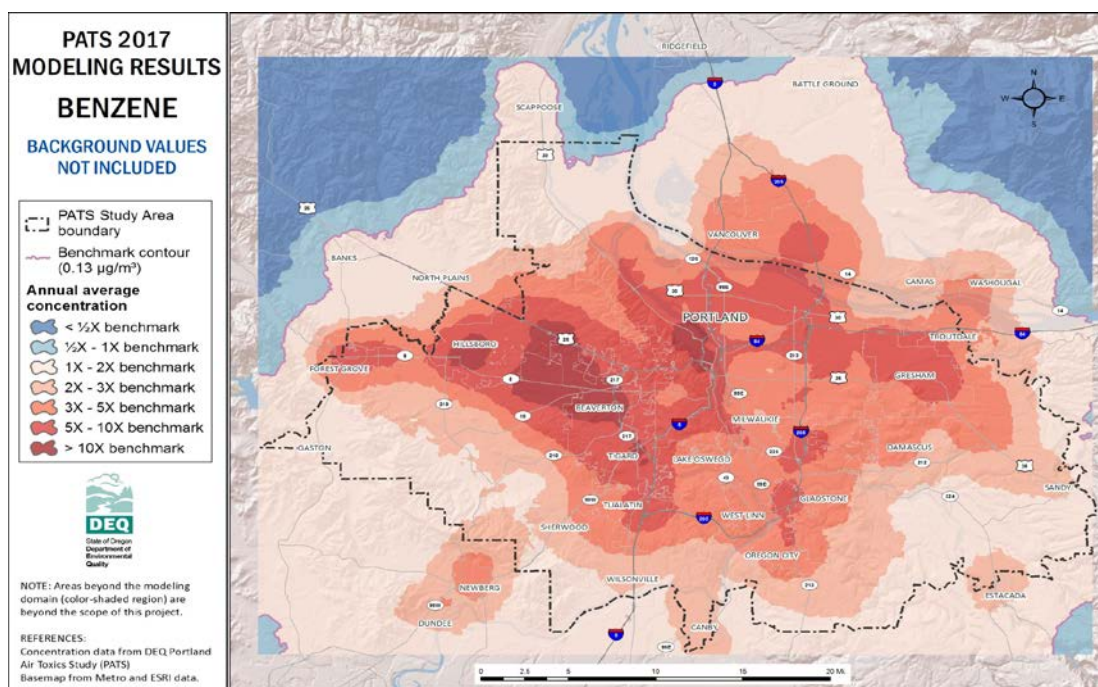
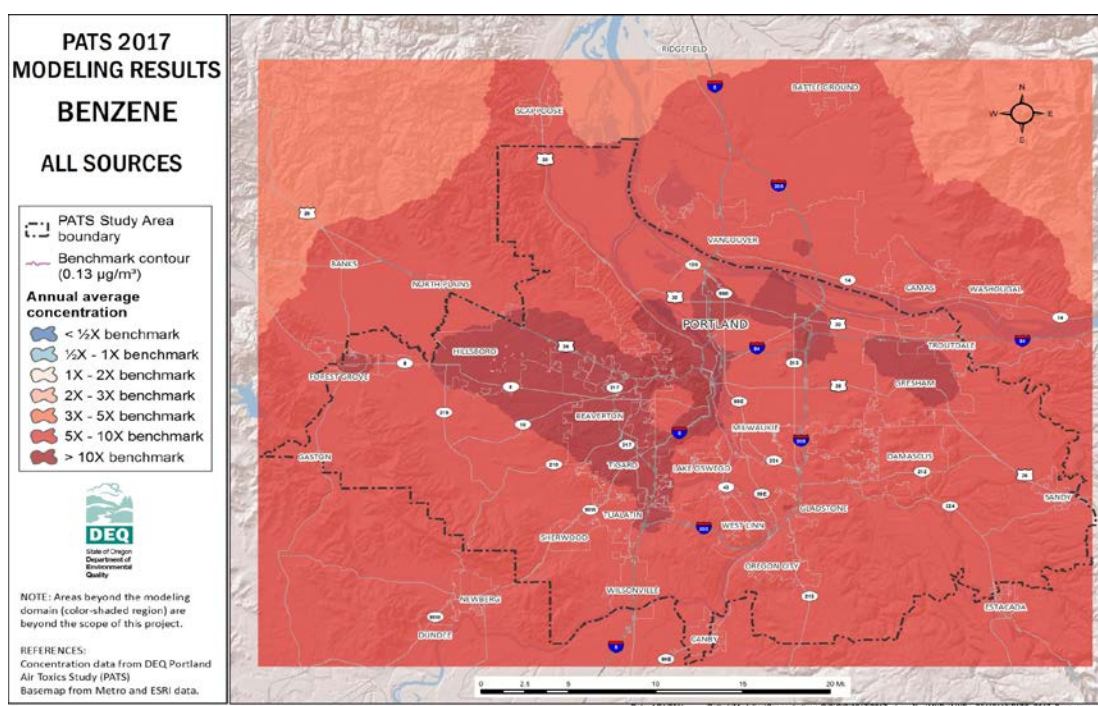


Figure 41: Benzene 2017 Modeled Concentrations Including Background Contributions



Benzene is a regional pollutant with higher concentrations in areas with high volume roadways. The benzene background contribution is significant. Figure 42 is a pie chart showing percentages of modeled contributions for benzene.

Figure 42: Modeled 2017 Sources of Benzene

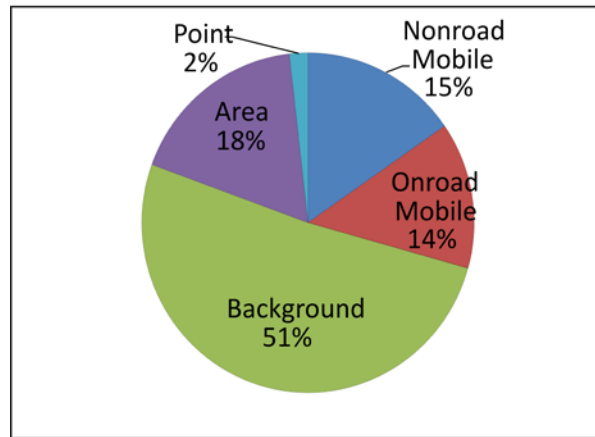
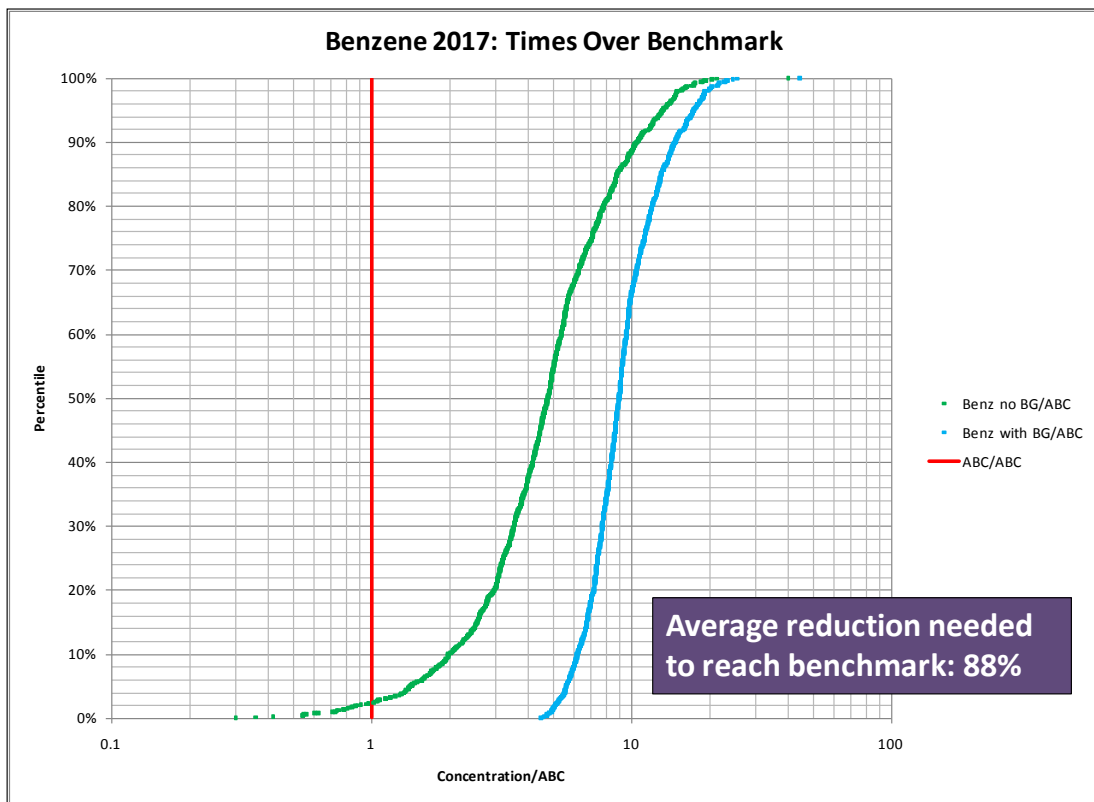


Figure 43 plots a distribution of modeled values for benzene with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the background concentration. This graph, known as an S-curve, shows that most modeled benzene values are above the benchmark. The reduction in benzene concentration needed to reach the target is 88%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, an 88% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

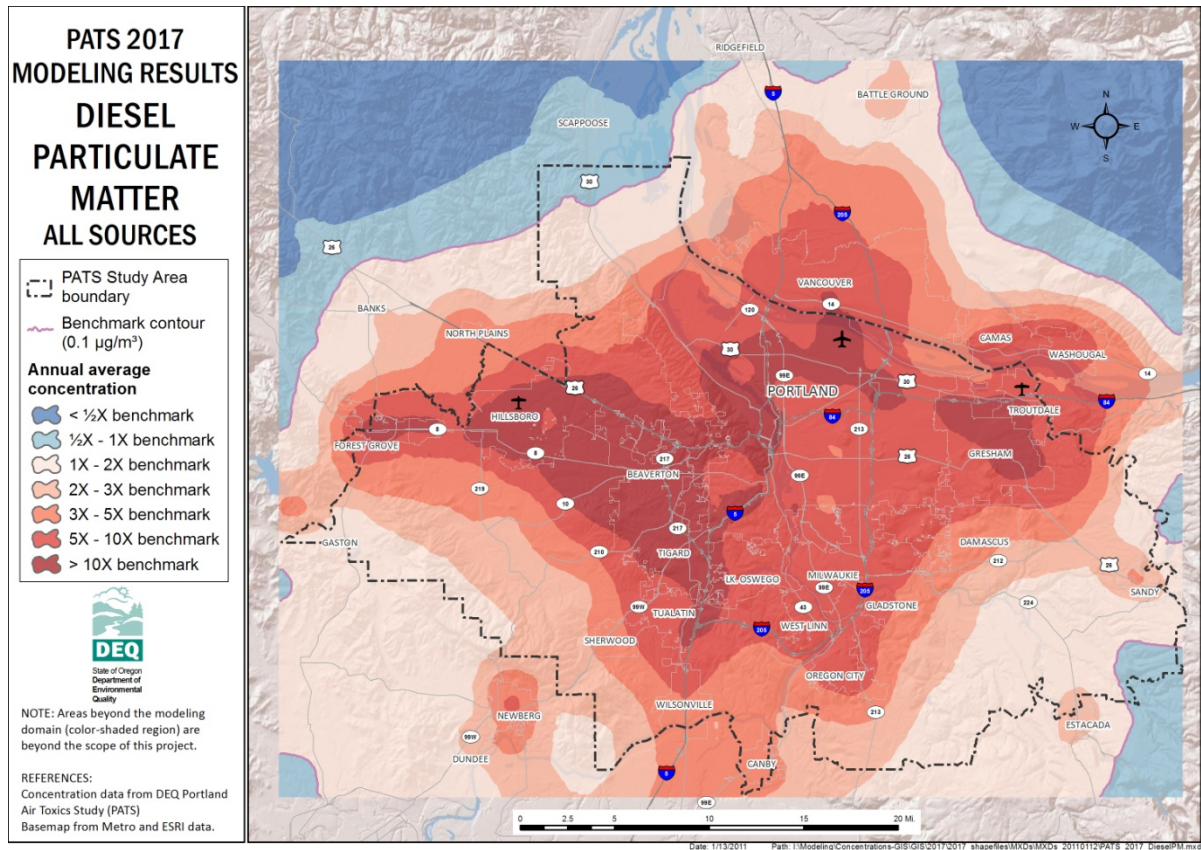
Figure 43: Distribution of 2017 Modeled Concentrations for Benzene



4.3.1.3 Diesel Particulate

Diesel particulate matter is not a specific chemical. It is a complex mixture of particles and various chemical compounds in, on, or around the particles. Diesel particulate matter is associated with increased lung cancer, breathing and heart problems. Within the PATS area, it comes mainly from on and off road diesel engines, including cars and trucks, construction equipment, ships, and rail sources. Figure 44 is a map showing region-wide diesel particulate modeled concentrations compared to the Oregon benchmark.

Figure 44: Diesel Particulate Matter 2017 Modeled Concentrations



Diesel particulate is a regional pollutant with higher concentrations in areas with high volume roadways and estimated construction activity. Figure 45 is a pie chart showing percentages of modeled contributions for diesel particulate.

Figure 45: Modeled 2017 Sources of Diesel Particulate

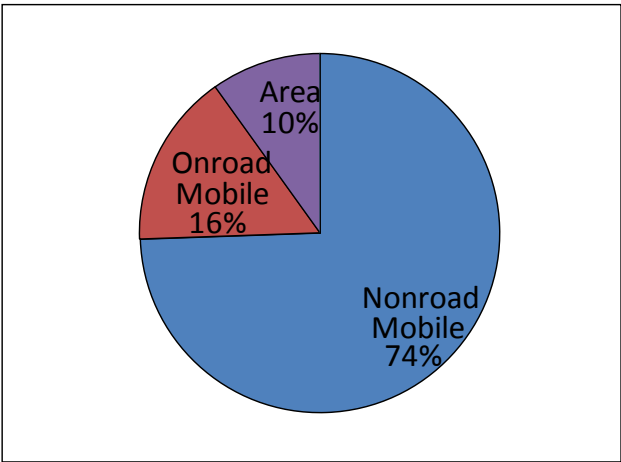
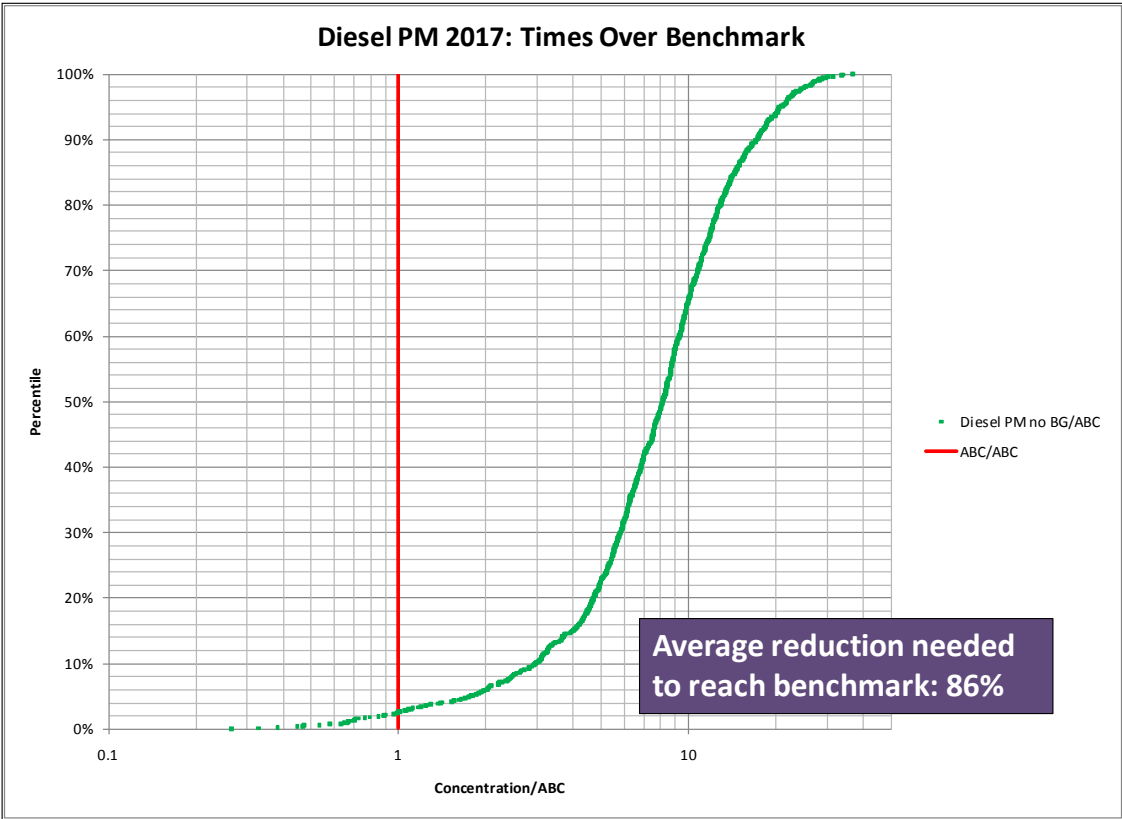


Figure 46 plots a distribution of modeled values for diesel particulate with the y-axis showing the percentile value, the x-axis showing times above the benchmark value, and the red vertical line representing the benchmark value. The green line is composed of all the modeled values. This graph, known as an S-curve, shows that most modeled diesel values are above the benchmark. There is no estimated background for diesel particulate at this time. The reduction in diesel particulate concentration needed to reach the target is 86%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, an 86% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 46: Distribution of 2017 Modeled Concentrations for Diesel Particulate Matter



4.3.1.4 Arsenic

Sources of arsenic are both human caused and natural. Our soils in the Pacific Northwest are naturally high in arsenic because of their volcanic origins. Arsenic is a known human carcinogen. In the PATS area, motor vehicle exhaust, oil and natural gas combustion, metal processing, agricultural pesticides, and soil dust are sources of arsenic. Figure 47 and Figure 48 are maps showing region-wide arsenic modeled concentrations without and including background contributions.

Figure 47: Arsenic 2017 Modeled Concentrations without Background Contributions

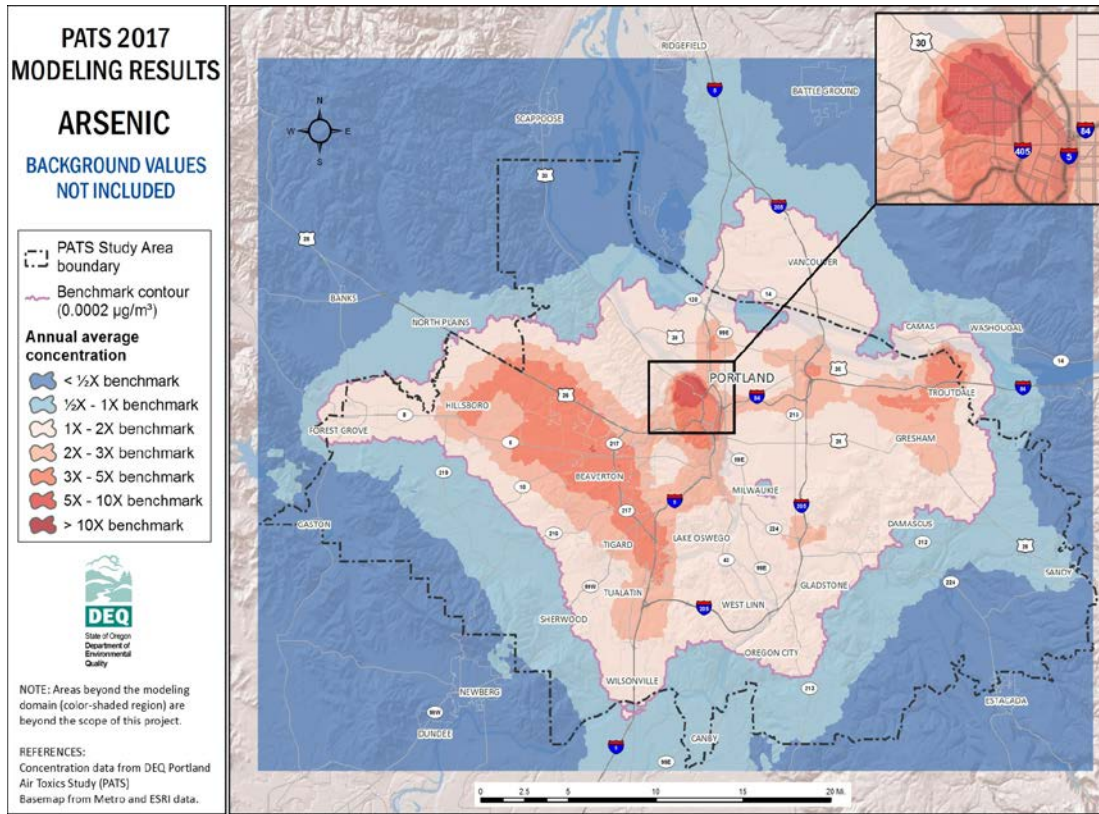
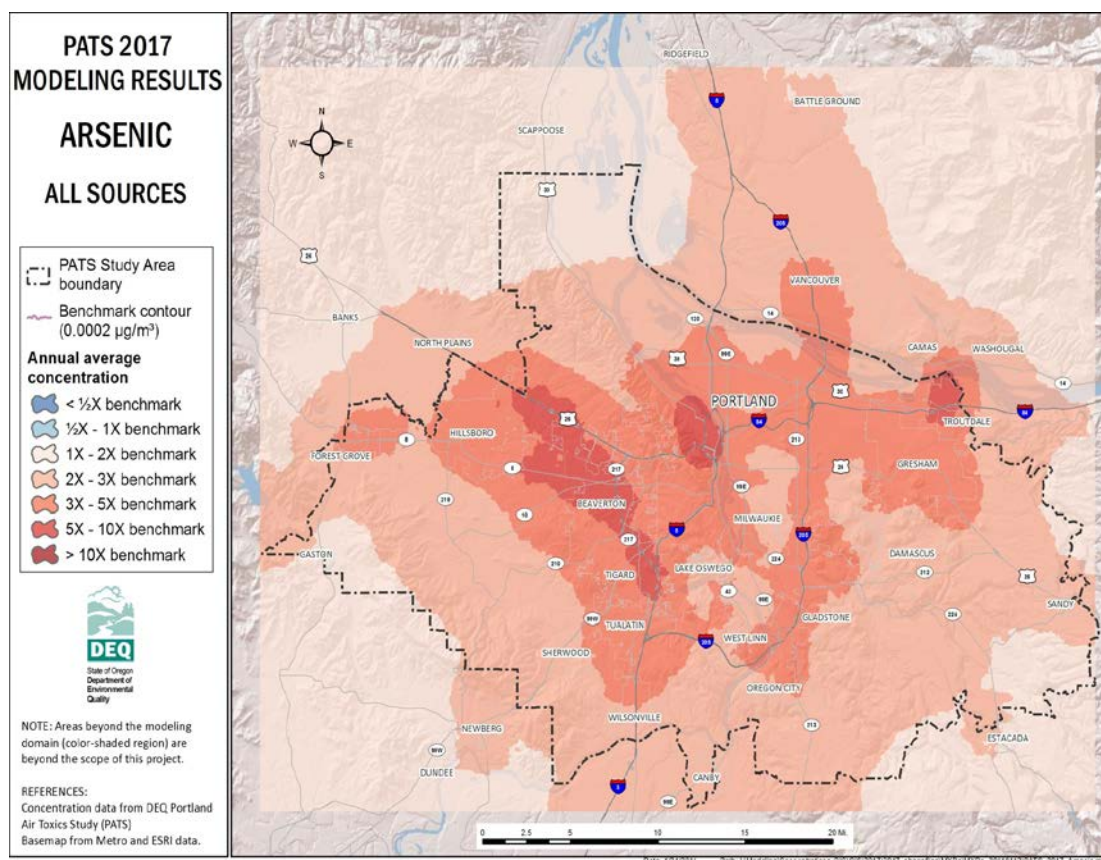


Figure 48: Arsenic 2017 Modeled Concentrations Including Background Contributions



Arsenic is a regional pollutant with higher concentrations in areas with high volume roadways and significant background contributions. Figure 49 is a pie chart showing percentages of modeled contributions for arsenic.

Figure 49: Modeled 2017 Sources of Arsenic

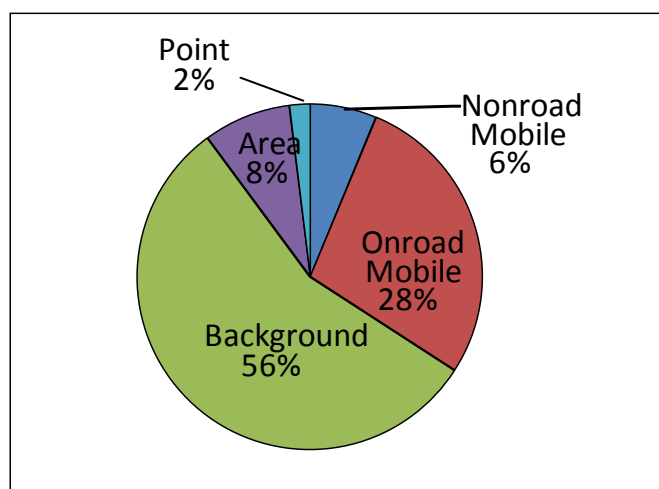
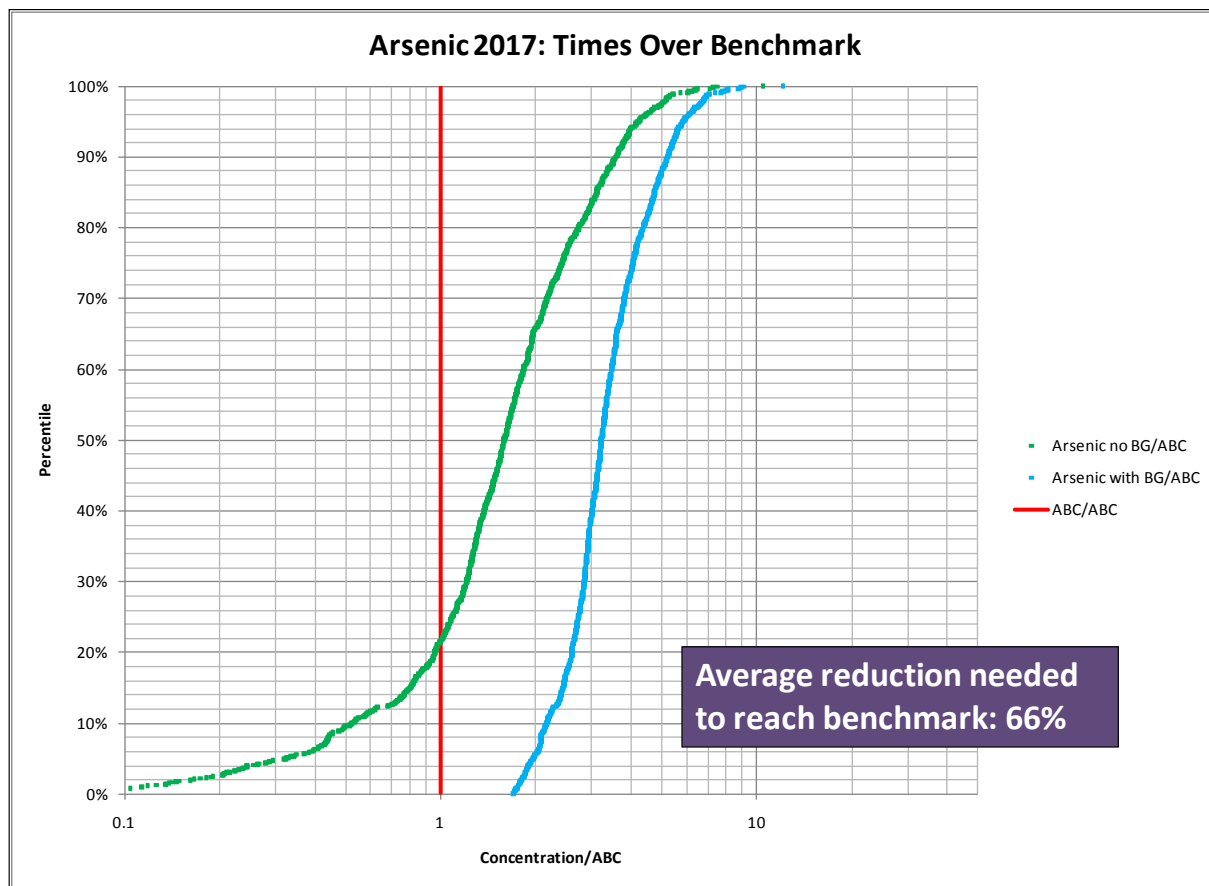


Figure 50 plots a distribution of modeled values for arsenic with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the background concentration. This graph, known as an S-curve, shows that adding background concentrations puts all modeled arsenic values above the benchmark. The reduction in arsenic concentration

needed to reach the target is 66%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, a 66% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 50: Distribution of 2017 Modeled Concentrations for Arsenic



4.3.1.5 Chromium VI

Hexavalent chromium – also called chromium VI – is a naturally occurring metal found in rocks, animals, plants, soil, and volcanic dust and gases. Chromium comes in several forms. Chromium VI is a form of chromium that can occur naturally but is most commonly produced by industrial processes and vehicle exhaust. Chromium VI is a known human carcinogen that causes damage to the respiratory tract. Figure 51 and Figure 52 are maps showing region wide chromium VI modeled concentrations without and including background contributions. Chromium is a regional pollutant with higher concentrations in areas with high volume roadways and industrial emissions.

Figure 51: Chromium VI 2017 Modeled Concentrations without Background Contributions

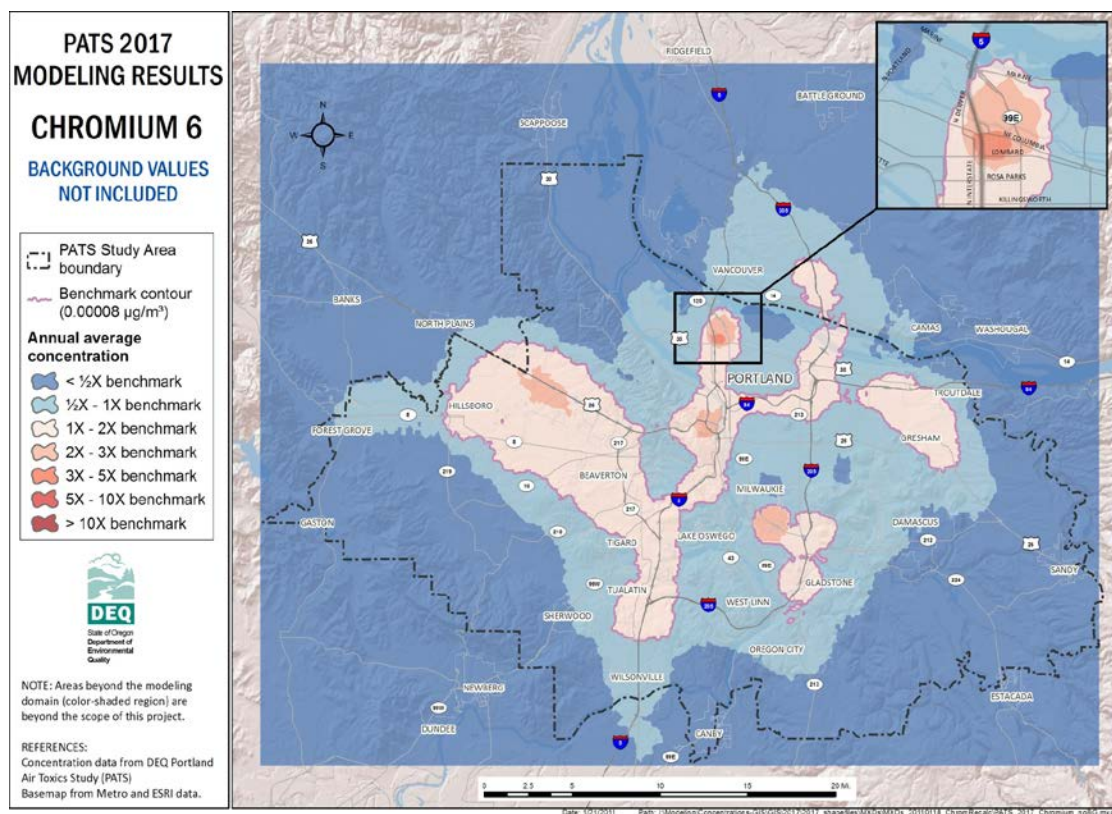


Figure 52: Chromium VI 2017 Modeled Concentrations Including Background Contributions

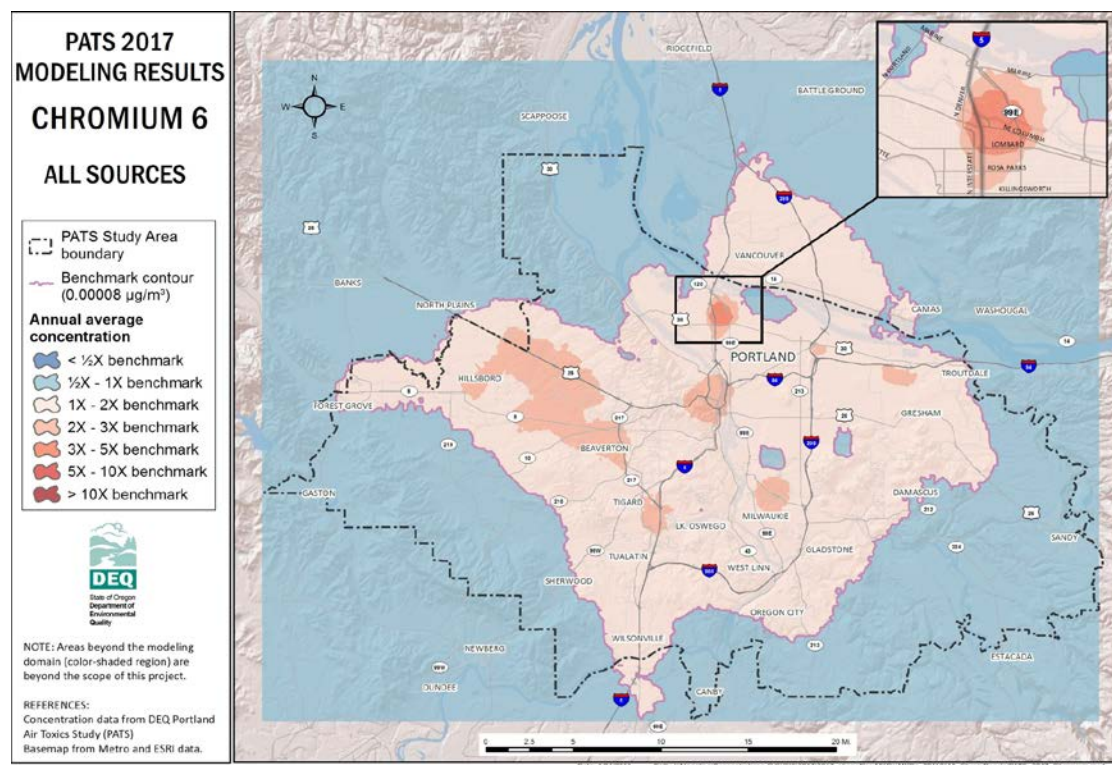


Figure 53 is a pie chart showing percentages of modeled contributions for chromium VI.

Figure 53: Modeled 2017 Sources of Chromium VI

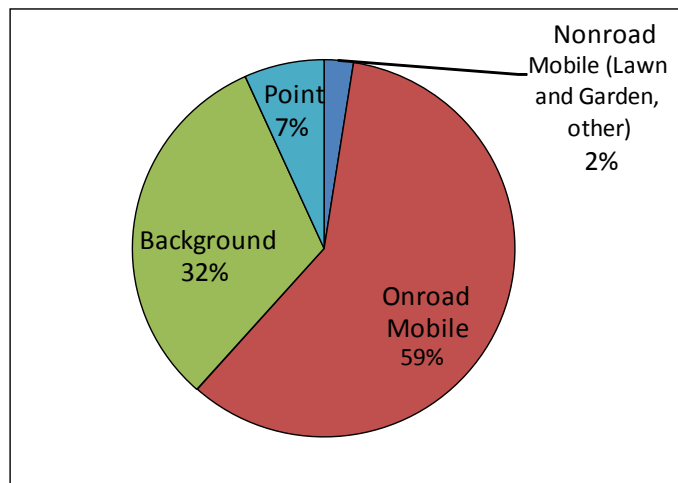
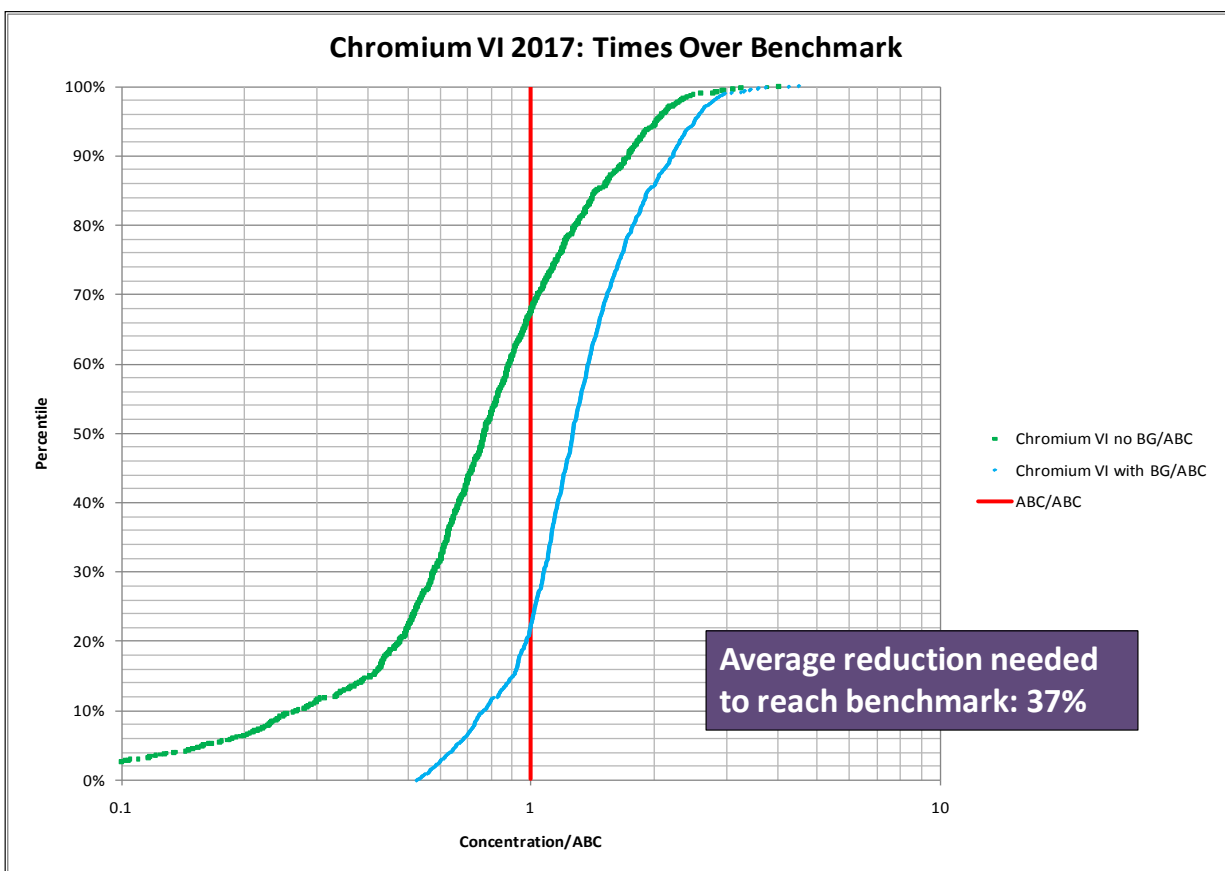


Figure 54 plots a distribution of modeled values for chromium VI with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the modeled values. This graph, known as an S-curve, shows that most modeled chromium VI values are above the benchmark. The reduction in chromium VI concentration needed to reach the target is 37%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, a 37% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 54: Distribution of 2017 Modeled Concentrations for Chromium VI



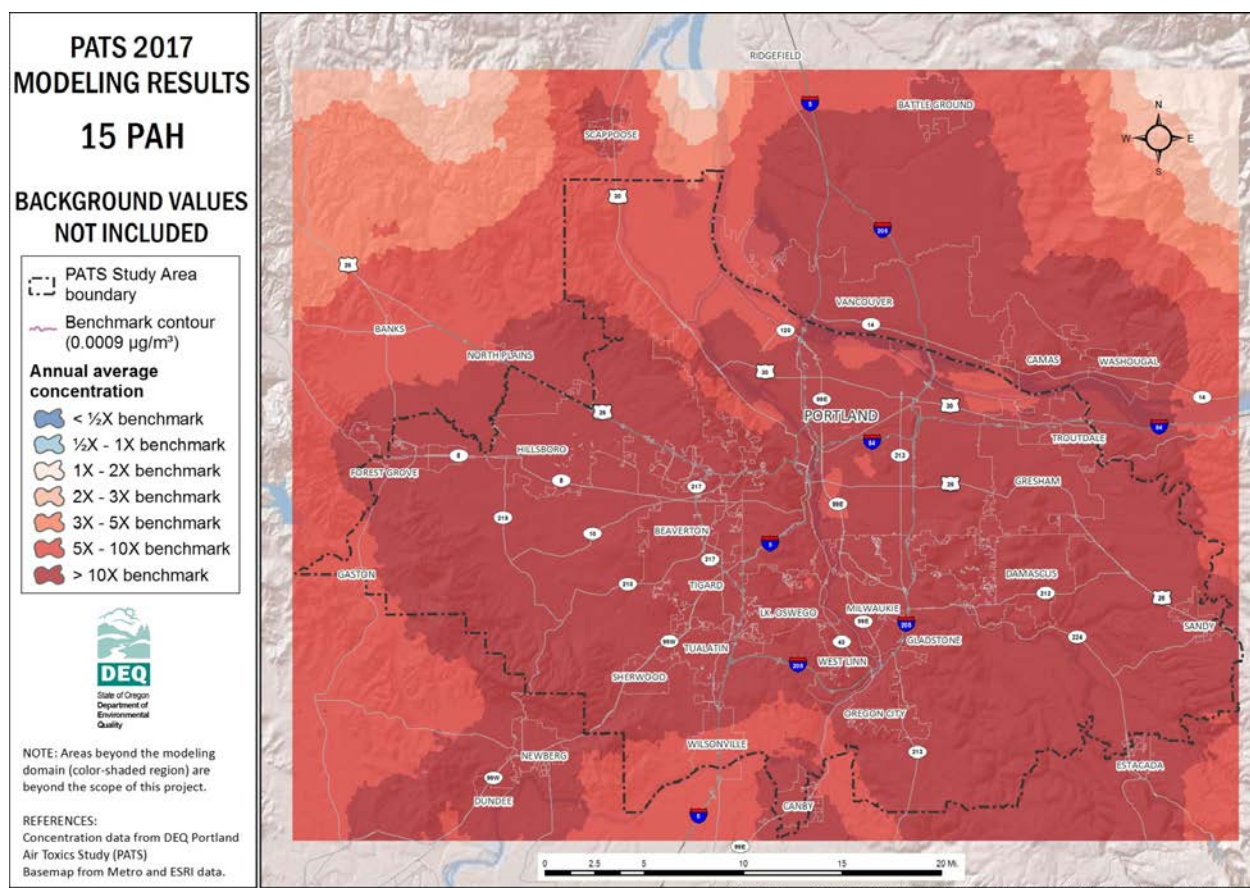
4.3.2 Area Source Pollutants

There are three pollutants associated primarily with area sources: 15 PAH, naphthalene and dichlorobenzene. Area sources emit many of the PATS pollutants, but these three drive the risk levels for area source categories. 15 PAH and naphthalene are more than ten times above the benchmarks and dichlorobenzene is between one and ten times above its benchmark. The source categories associated with area source pollutants fall into basic categories: residential wood combustion, industrial fuel use, consumer products, solvent and coating use, asphalt production and use, and several miscellaneous categories including publicly owned treatment works, landfills, and restaurants.

4.3.2.1 15 PAH

Polycyclic aromatic hydrocarbons, also called PAHs, are a group of chemicals that are formed during the incomplete burning of carbon-containing substances: wood, coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs, which are 4,000 or more individual chemical compounds, are usually found as a mixture containing two or more of these compounds. Figure 55 is a map showing region-wide 15 PAH modeled concentrations without and including background contributions compared to Oregon's 15 PAH benchmark concentration.

Figure 55: 15 PAH 2017 Modeled Concentrations without Background Contributions



15 PAH is a regional pollutant with higher concentrations in some areas. Figure 56 contains a pie chart showing percentages of modeled contributions for 15 PAH. Figure 56 also plots a distribution of modeled values for 15 PAH with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration. This graph, known as an S-curve, shows that most modeled 15 PAH values are above the benchmark. At this time, there is no background estimate of 15 PAH. The reduction in 15 PAH concentration needed to reach the target is 94%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, a 94% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

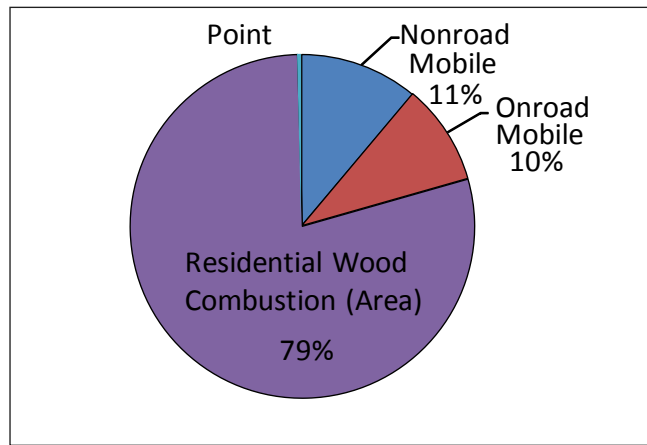


Figure 56: Distribution of 2017 Modeled Concentrations and Modeled 2017 Sources of 15 PAH

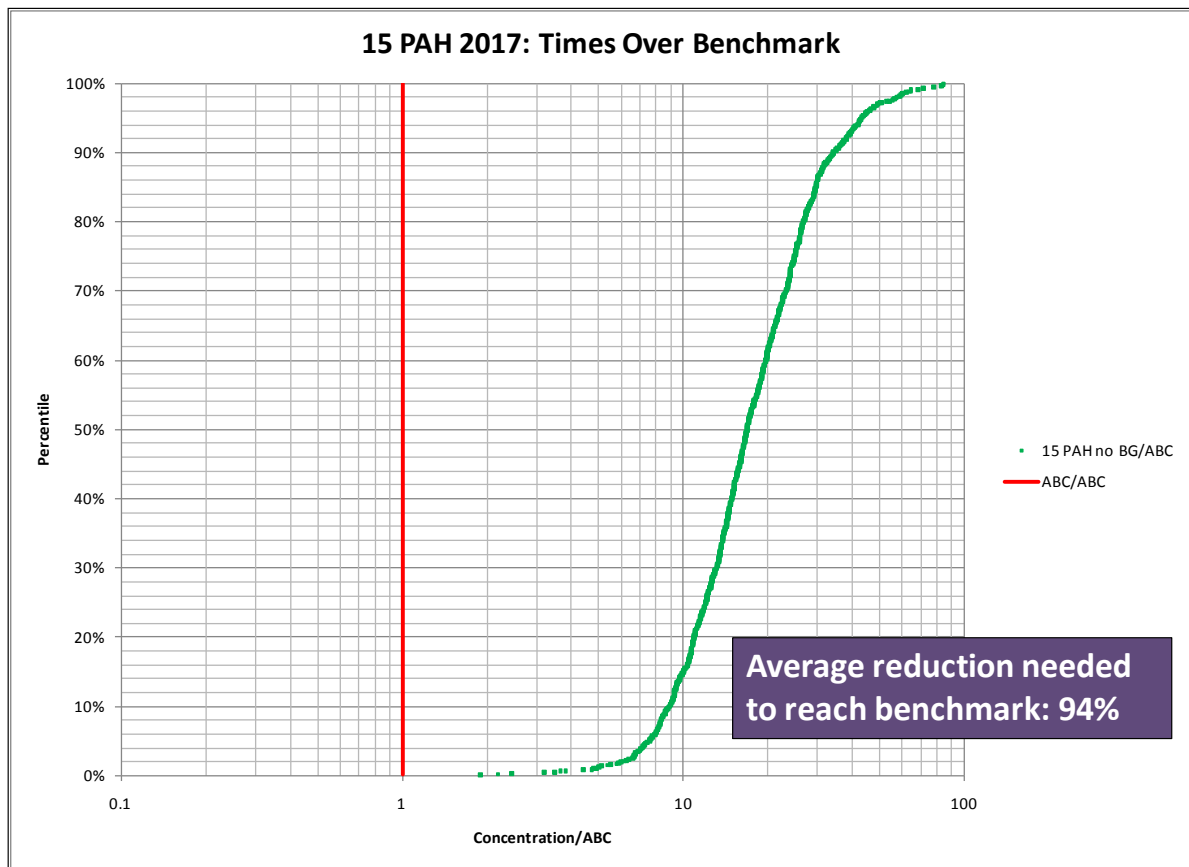


Figure 57: Distribution of 2017 Modeled Concentrations for 15 PAH

4.3.2.2 Naphthalene

Naphthalene is a white solid that evaporates easily and has a strong odor. Fuels such as petroleum and coal contain naphthalene. Burning tobacco or wood produces naphthalene. The major *commercial* use of naphthalene is in the manufacture of polyvinyl chloride (PVC) plastics. Its major *consumer* use is in moth repellents and toilet deodorant blocks. In the PATS area, naphthalene is released to the air from the burning of oil and from the use of mothballs. Figure 58 and Figure 59 are maps showing region-wide naphthalene modeled concentrations without and including background contributions compared to Oregon's naphthalene benchmark concentration.

Figure 58: Naphthalene 2017 Modeled Concentrations without Background Contributions

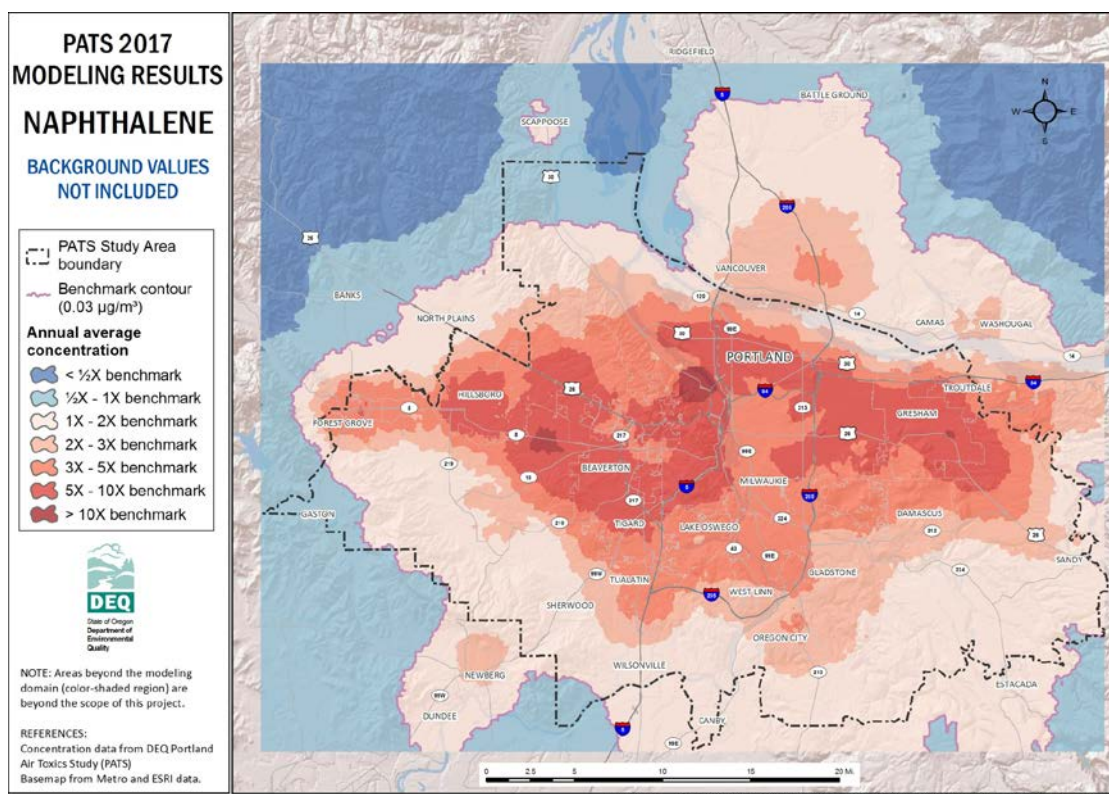
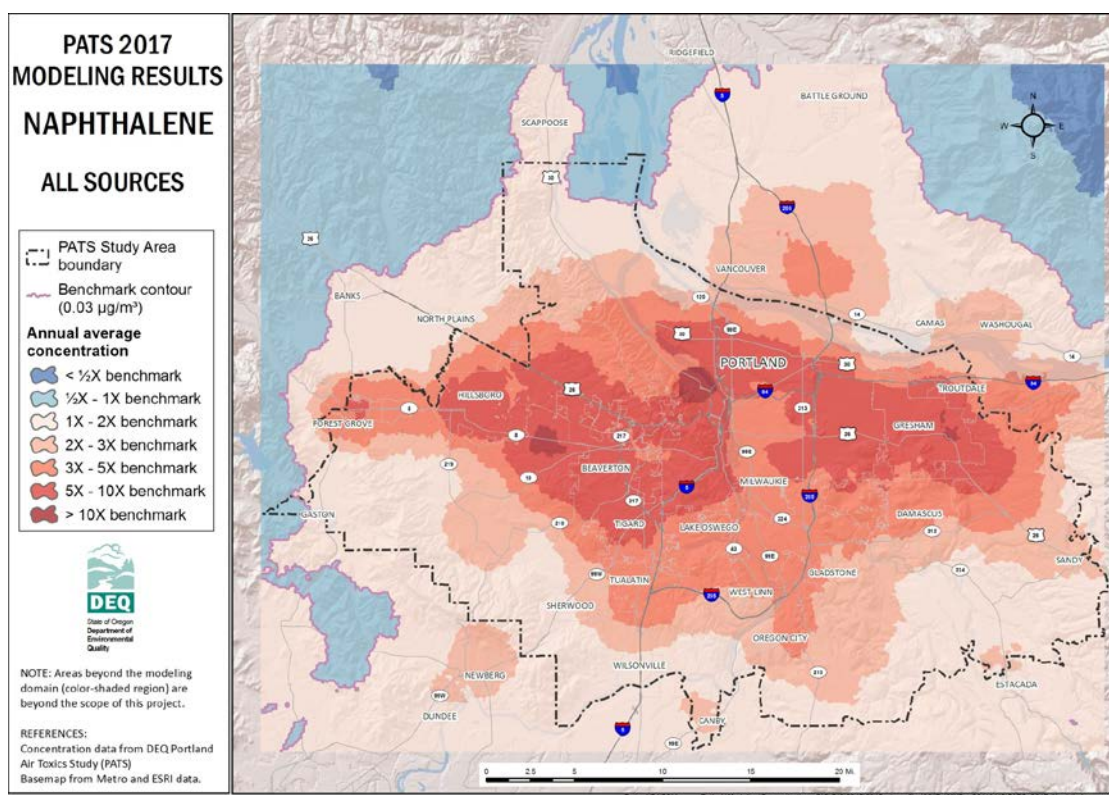
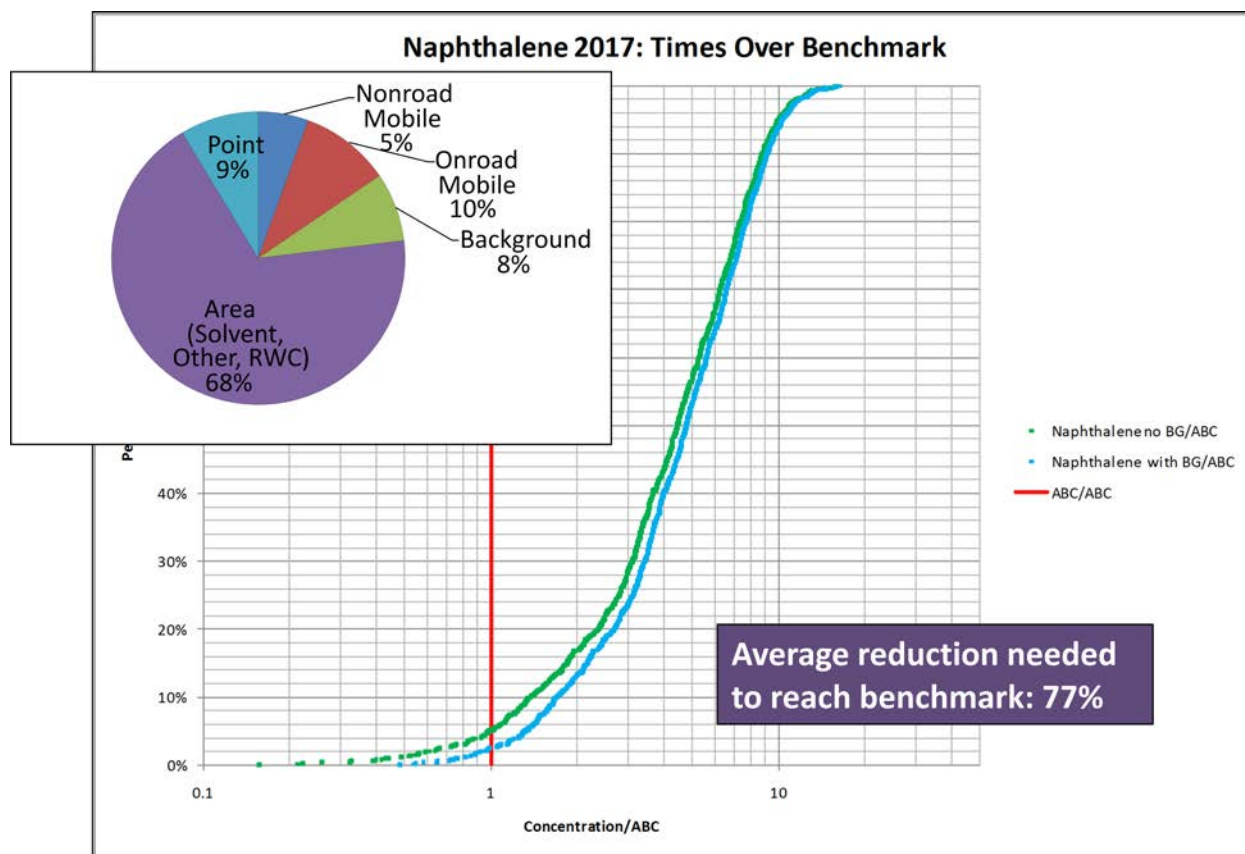


Figure 59: Naphthalene 2017 Modeled Concentrations Including Background Contributions



Naphthalene is a regional pollutant with higher concentrations in some areas. Figure 60 contains a pie chart showing percentages of modeled contributions for naphthalene. Figure 60 also plots a distribution of modeled values for naphthalene with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the background concentration. This graph, known as an S-curve, shows that most modeled naphthalene values are above the benchmark. The reduction in naphthalene concentration needed to reach the target is 77%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, a 77% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 60: Distribution of 2017 Modeled Concentrations and Modeled 2017 Sources of Naphthalene



4.3.2.3 Dichlorobenzene

1,4-Dichlorobenzene, also called para-dichlorobenzene, is a colorless solid with a strong, distinctive smell. 1,4-Dichlorobenzene is used as a fumigant to control moths, molds and mildew. It is also used as a disinfectant in waste containers and restrooms and is the characteristic smell associated with urinal cakes. Figure 61 and Figure 62 are maps showing region-wide dichlorobenzene modeled concentrations without and including background contributions compared to Oregon's dichlorobenzene benchmark concentration.

Figure 61: Dichlorobenzene 2017 Modeled Concentrations without Background Contributions

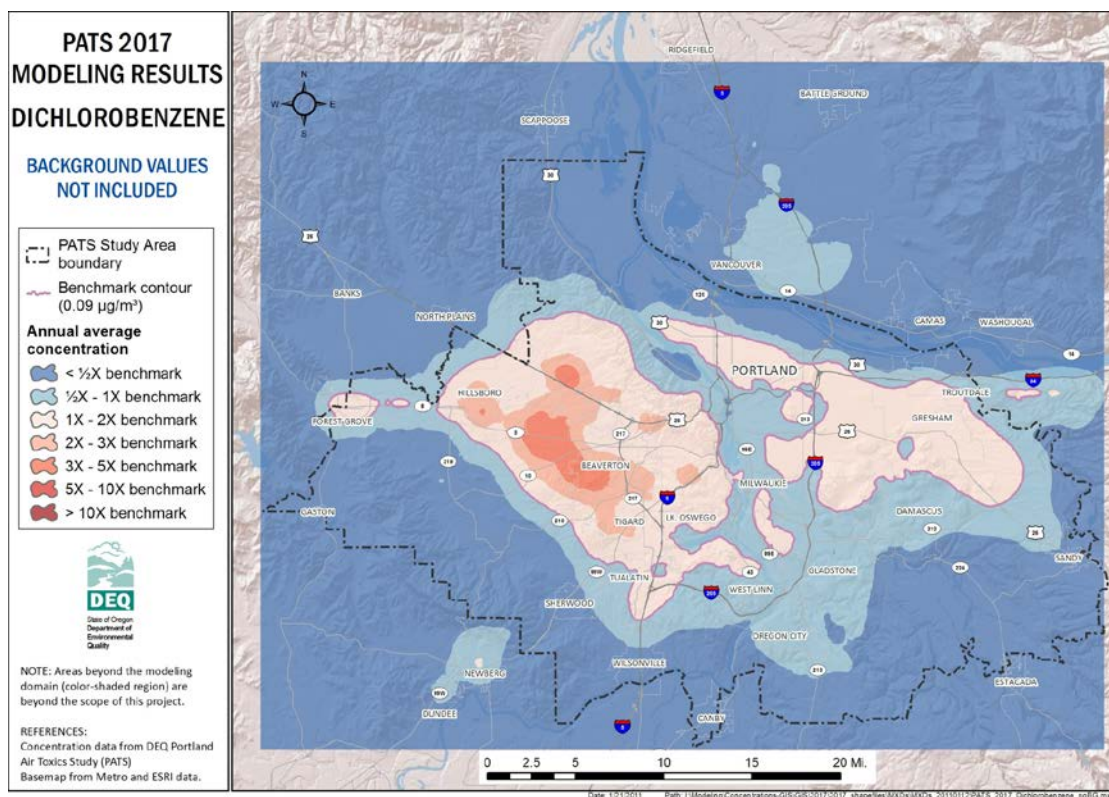
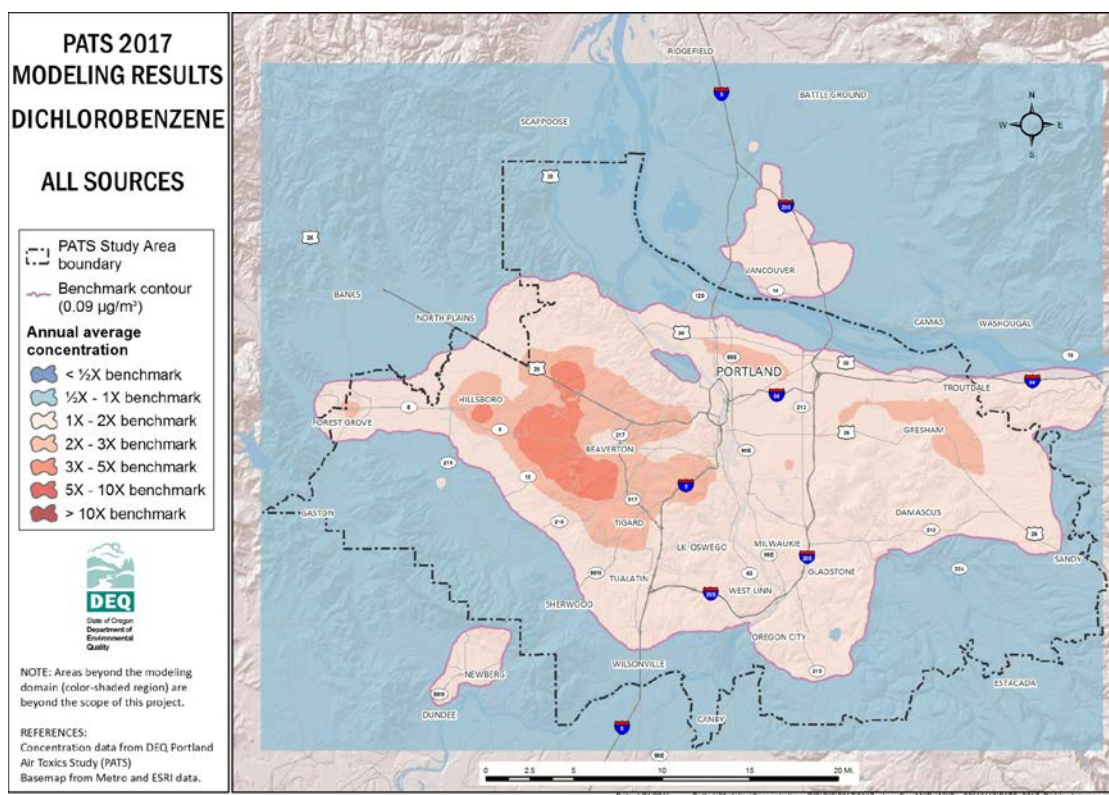
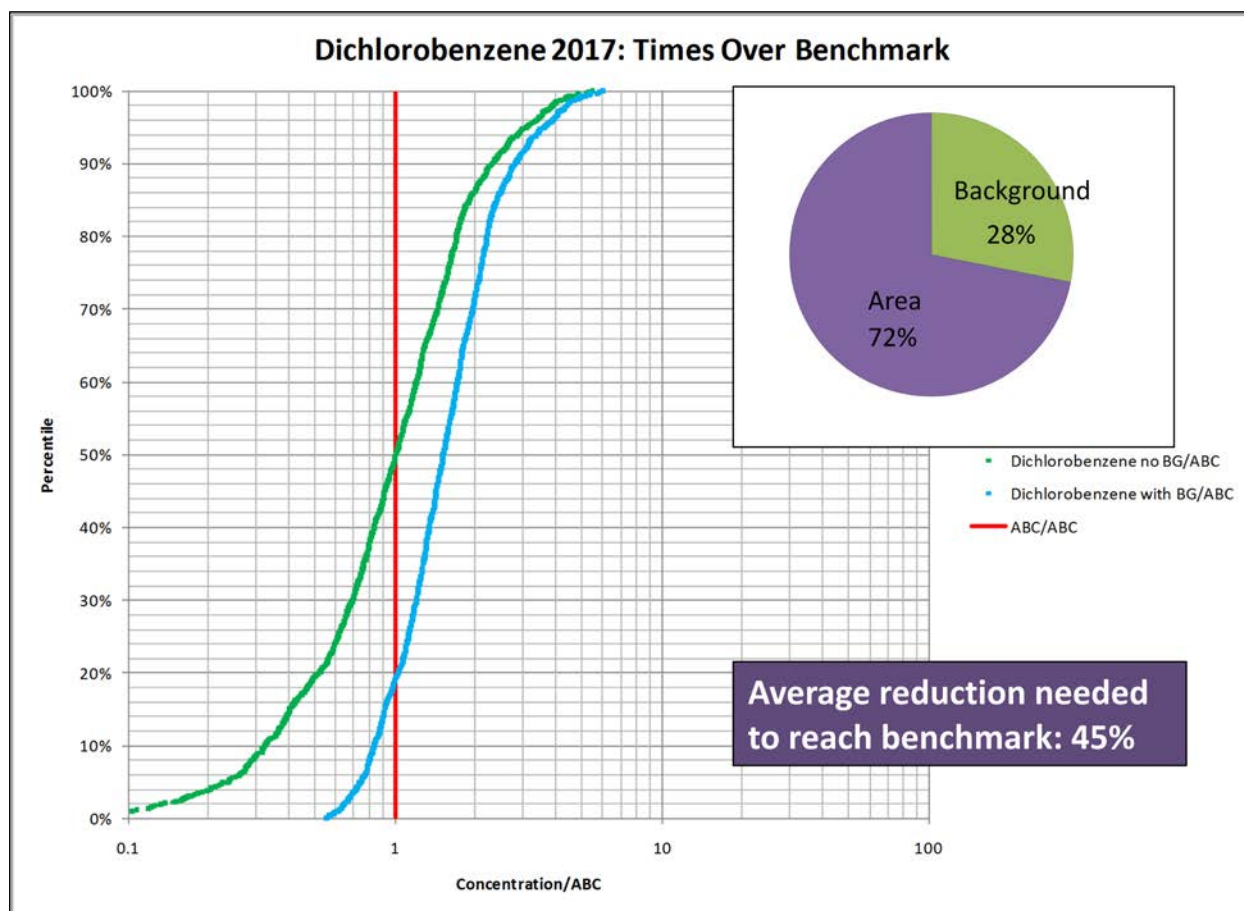


Figure 62: Dichlorobenzene 2017 Modeled Concentrations Including Background Contributions



Dichlorobenzene is a regional pollutant with higher concentrations in areas with high volume roadways. Figure 63 contains a pie chart showing percentages of modeled contributions for dichlorobenzene. Figure 63 also plots a distribution of modeled values for dichlorobenzene with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the background concentration. This graph, known as an S-curve, shows that in general, about half of the modeled dichlorobenzene values are above the benchmark. The reduction in dichlorobenzene concentration needed to reach the target is 45%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, a 45% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 63: Distribution of 2017 Modeled Concentrations and Modeled 2017 Sources of Dichlorobenzene



4.3.3 Point Source Pollutants

There are three pollutants associated primarily with point sources: cadmium, manganese, and nickel. Cadmium is more than ten times above their benchmarks and manganese and nickel are between one and ten times above their benchmarks. The source categories associated with point source pollutants are industrial.

4.3.3.1 Cadmium

Cadmium is a relatively abundant soft, bluish-white metal. It is usually found as a mineral combined with other elements. Metals processing and burning fossil fuels for both residential and industrial use are major sources of cadmium in Portland's air. Cadmium is also used to make batteries, pigments, metal coatings, and plastic.

Figure 64 and Figure 65 are maps showing region wide cadmium modeled concentrations without and including background contributions compared to Oregon’s cadmium benchmark concentration.

Figure 64: Cadmium 2017 Modeled Concentrations without Background Contributions

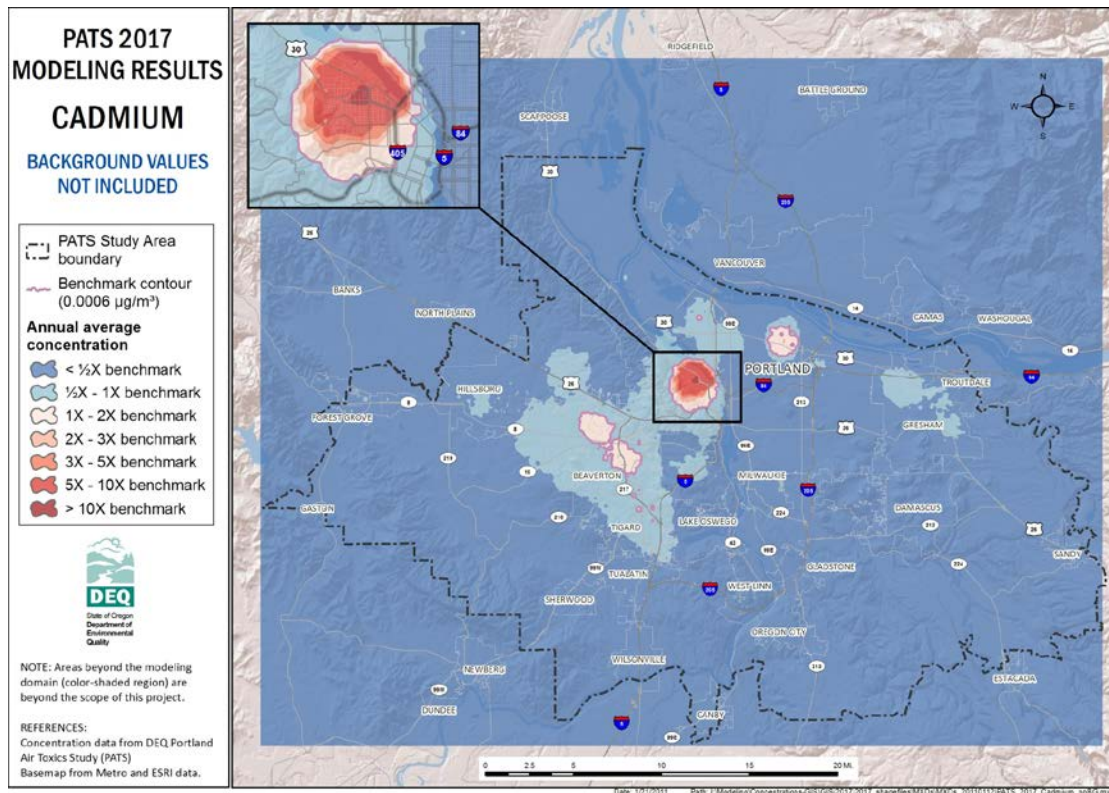
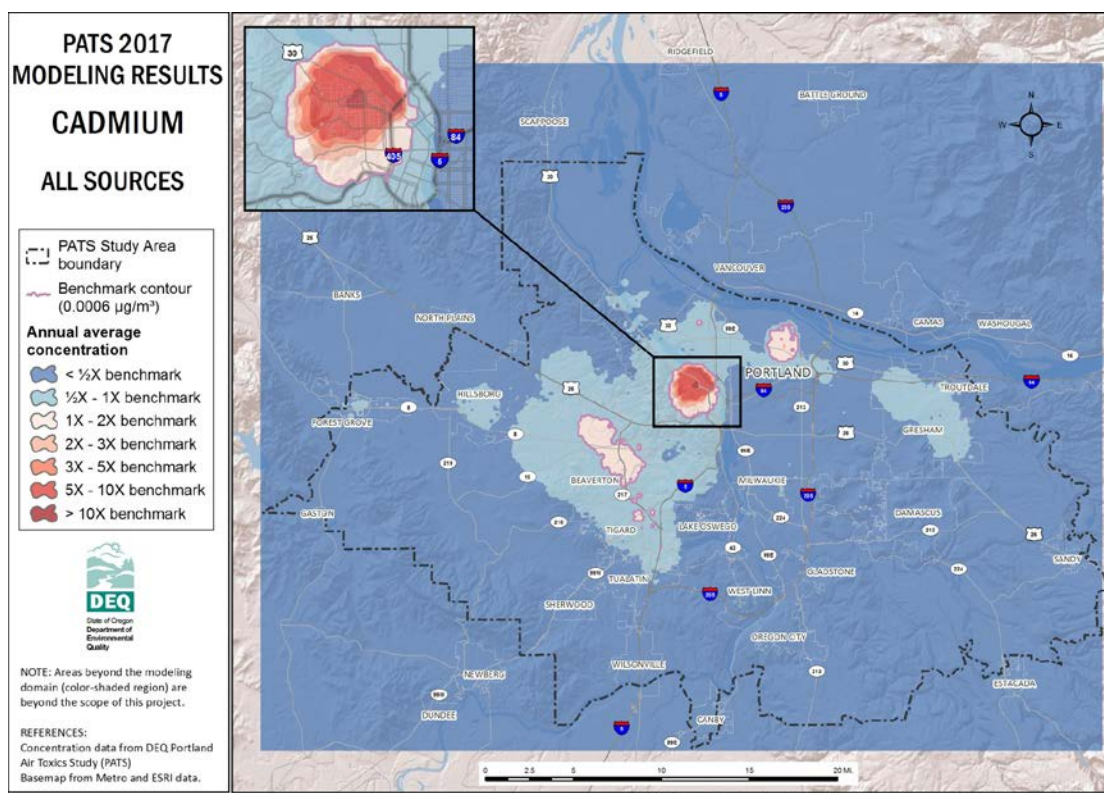
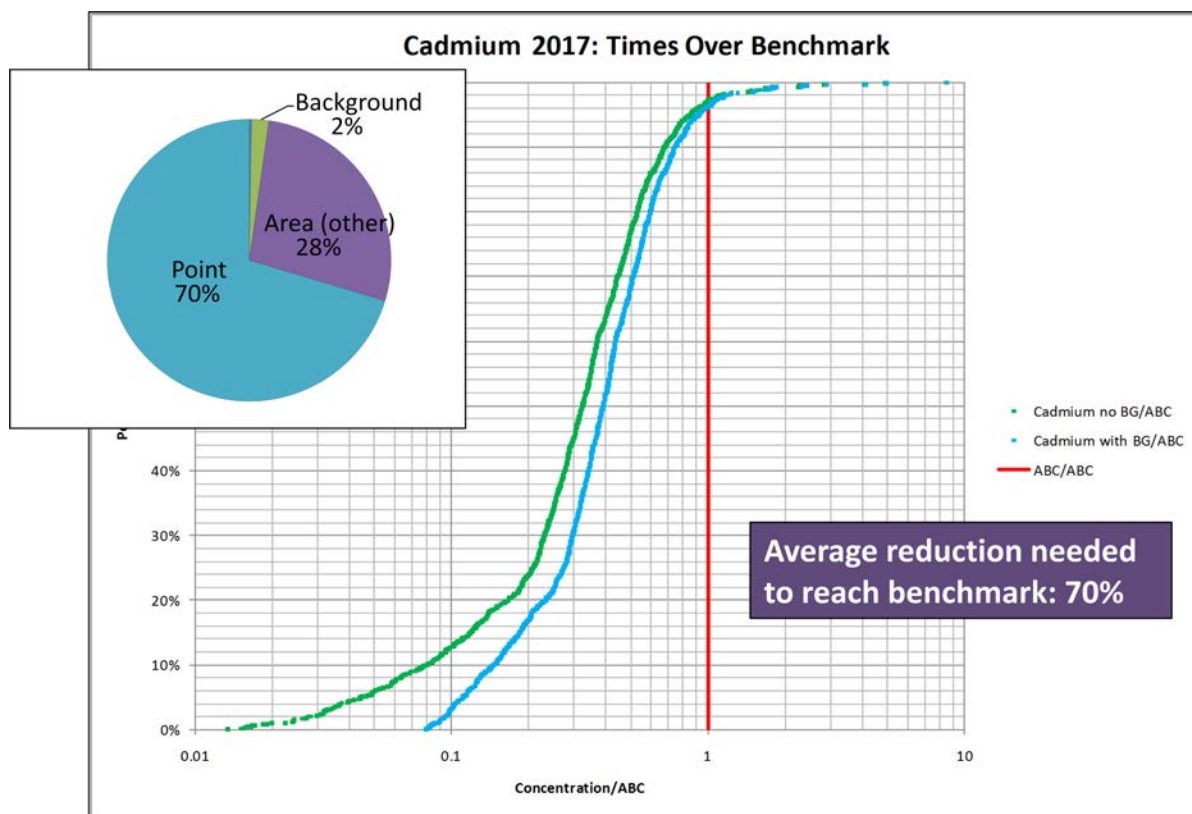


Figure 65: Cadmium 2017 Modeled Concentrations Including Background Contributions



Cadmium impacts are limited to some zonal areas and also localized impacts with higher concentrations in smaller areas. Figure 66 contains a pie chart showing percentages of modeled contributions for cadmium. Figure 66 also plots a distribution of modeled values for cadmium with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the background concentration. This graph, known as an S-curve, shows that in general, most of the receptors in the PATS study area are below the benchmark and a few in the localized impact areas are above the benchmark. The reduction in cadmium concentration needed to reach the target is 70%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, a 70% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 66: Distribution of 2017 Modeled Concentrations for Cadmium, and Modeled 2017 Sources of Cadmium



4.3.3.1 Manganese

Manganese is a metal used primarily in steel production to improve hardness, stiffness, and strength. Manganese dioxide is used in the production of dry-cell batteries, matches, fireworks, and the production of other manganese compounds. The main source of manganese pollution in Portland comes from metals production containing steel and iron. Manganese is also a component of some pesticides and is used as a fuel additive in some gasoline. Figure 67 and Figure 68 are maps showing region-wide manganese modeled concentrations without and including background contributions compared to Oregon's manganese benchmark concentration.

Figure 67: Manganese 2017 Modeled Concentrations without Background Contributions

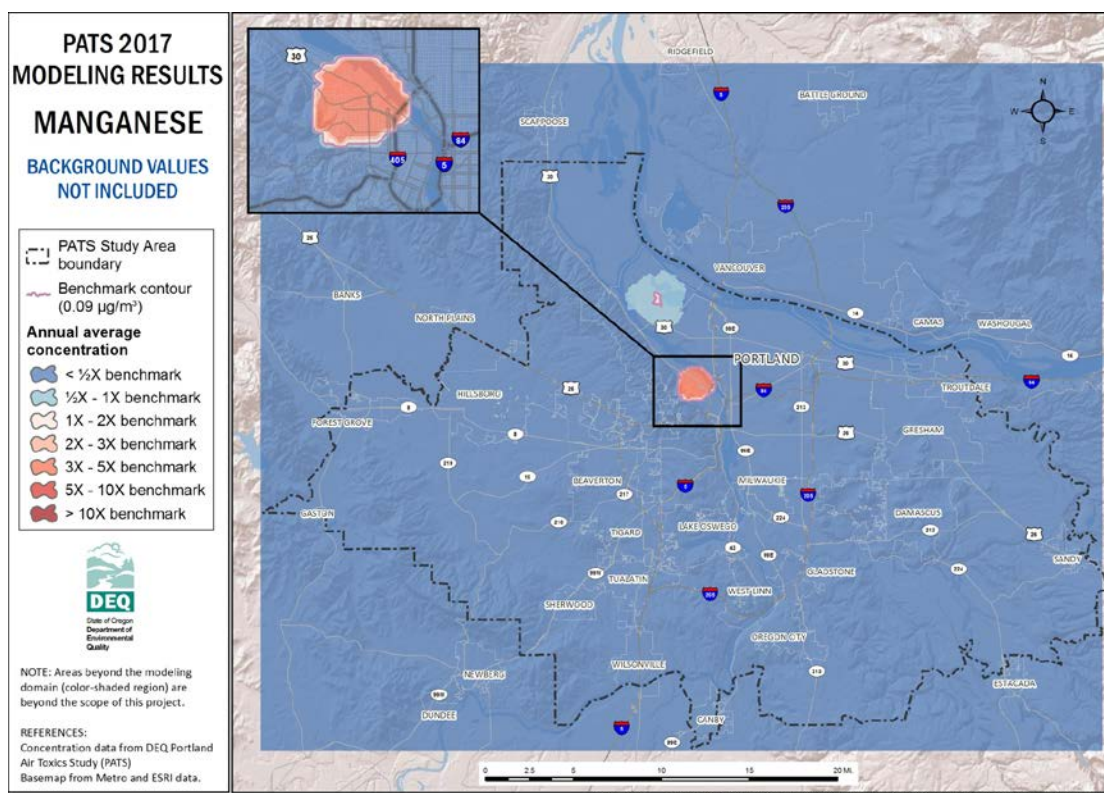
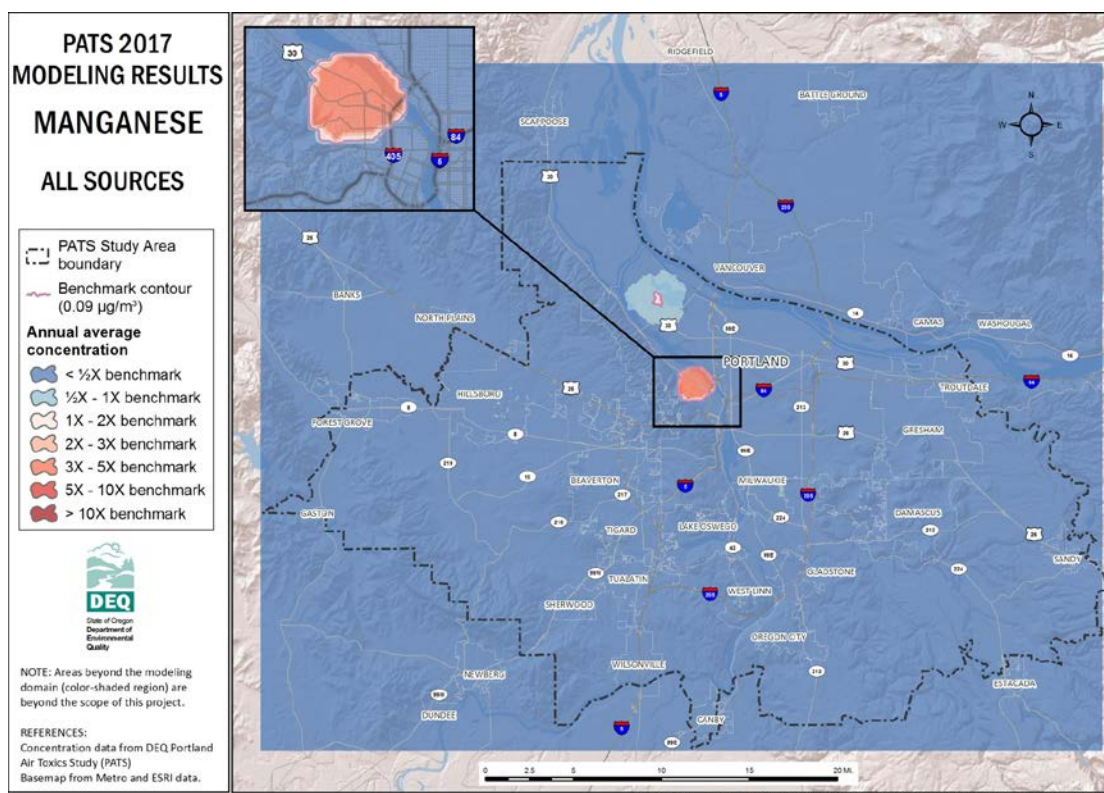
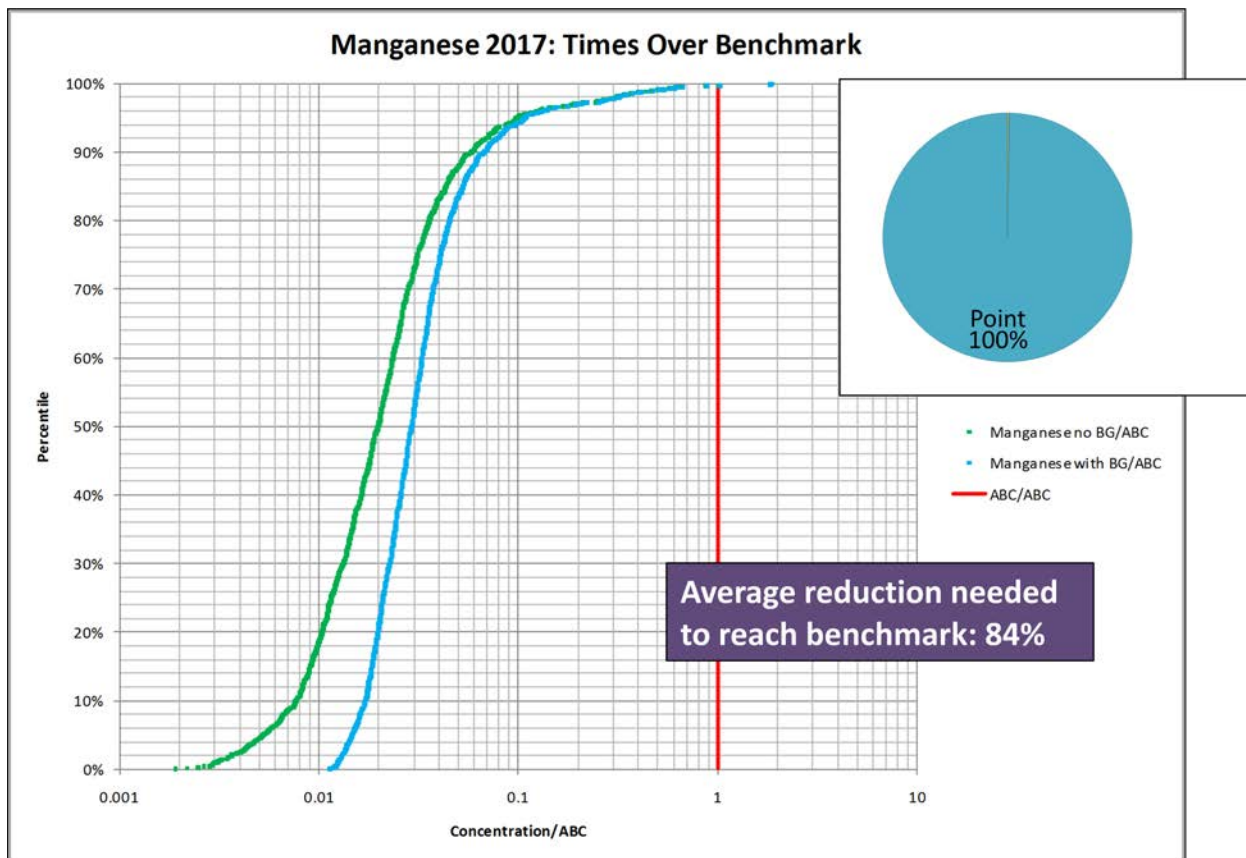


Figure 68: Manganese 2017 Modeled Concentrations Including Background Contributions



Manganese impacts are limited to localized impact areas. Figure 69 contains a pie chart showing percentages of modeled contributions for manganese. Figure 69 also plots a distribution of modeled values for manganese with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the background concentration. This graph, known as an S-curve, shows that most of the modeled manganese values in our study area are below the benchmark and a few in the localized impact areas are above the benchmark. The reduction in manganese concentration needed to reach the target is 84%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, an 84% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 69: Distribution of 2017 Modeled Concentrations for Manganese, and Modeled 2017 Sources of Manganese



4.3.3.1 Nickel

Nickel is an abundant natural element found in soil and emitted from volcanoes. Nickel is most often used to make stainless steel and nickel compounds are used for nickel plating, to make some batteries, and as catalysts. Nickel is released into the air by industries that make or use nickel or nickel compounds. It is also released by oil- and coal-burning power plants and trash incinerators. Figure 70 and Figure 71 are maps showing region-wide nickel modeled concentrations without and including background contributions compared to Oregon’s nickel benchmark concentration.

Figure 70: Nickel 2017 Modeled Concentrations without Background Contributions

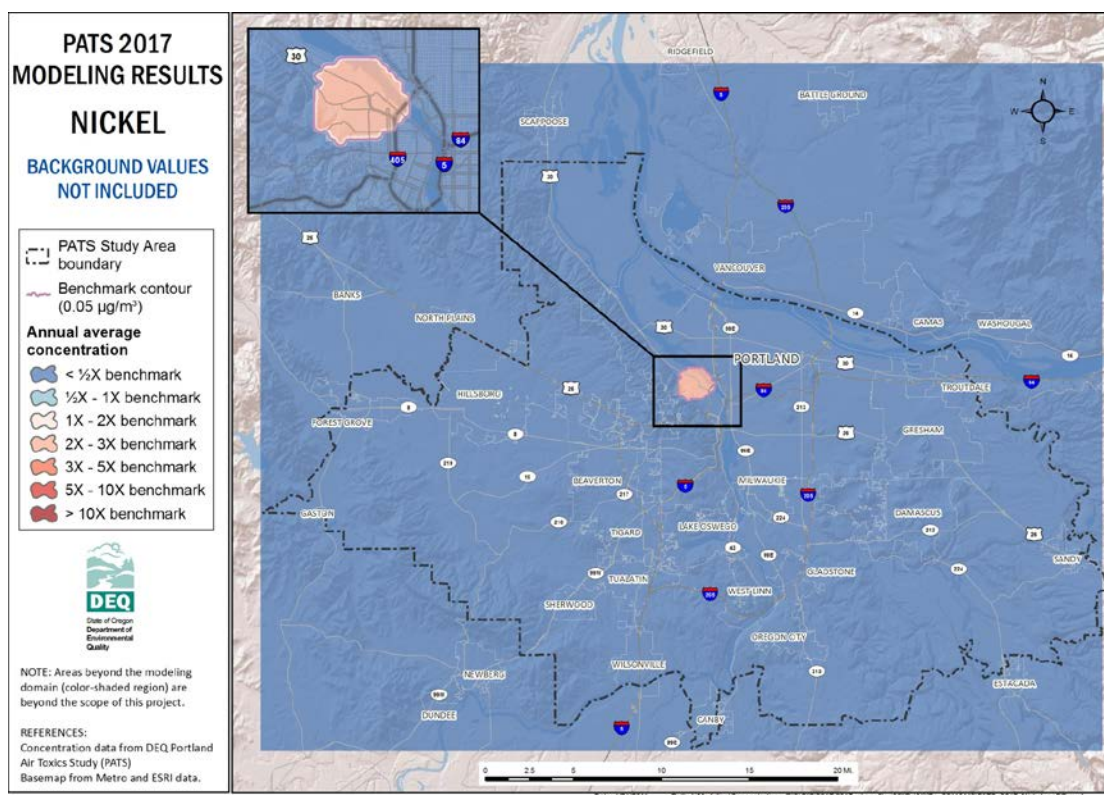
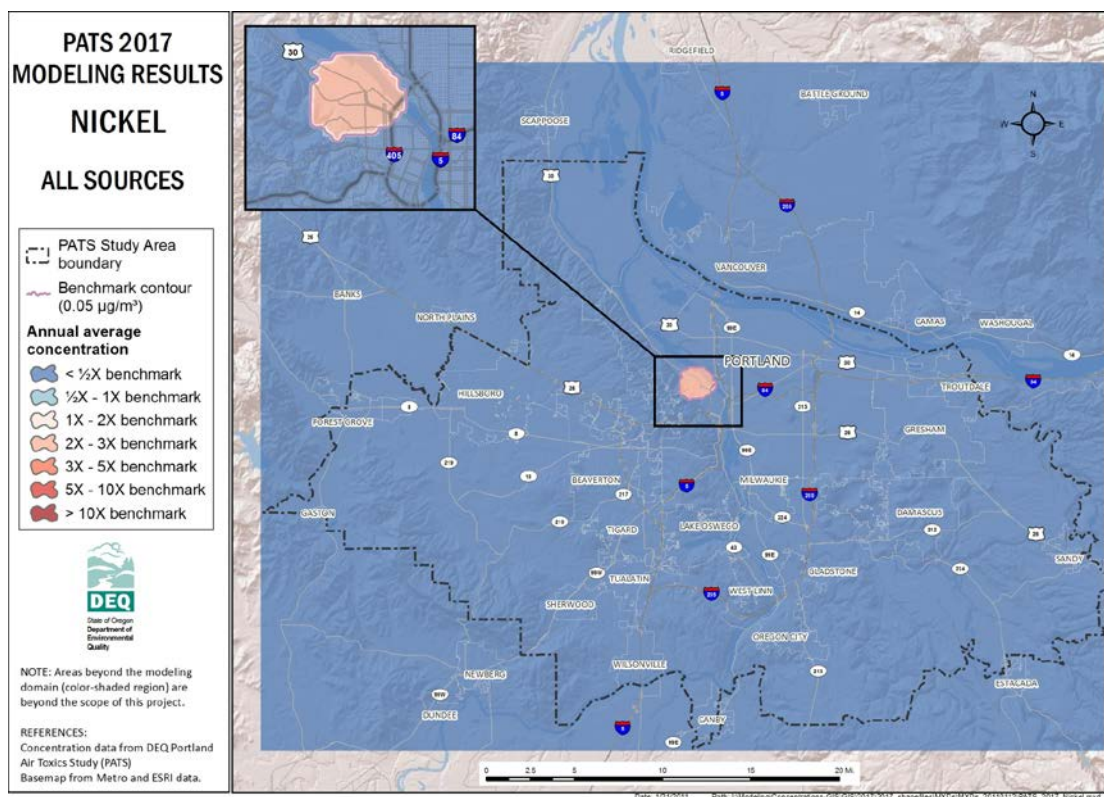
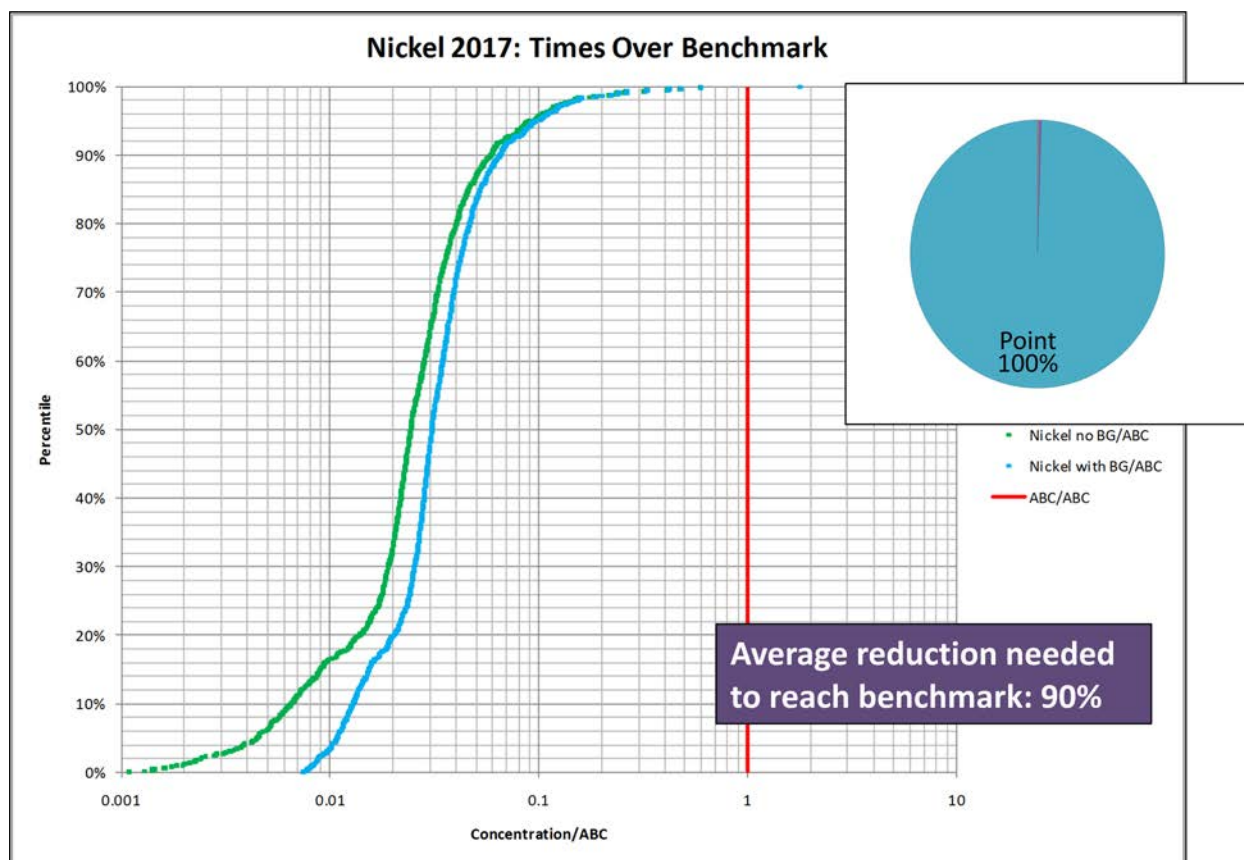


Figure 71: Nickel 2017 Modeled Concentrations Including Background Contributions



Nickel impacts are limited to one localized impact area as shown in the pollutant concentration maps. Figure 72 contains a pie chart showing percentages of modeled contributions for nickel. Figure 72 also plots a distribution of modeled values for nickel with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the background concentration. This graph, known as an S-curve, shows that most of the modeled nickel values are below the benchmark a few in the localized impact areas are above the benchmark. The reduction in nickel concentration needed to reach the target is 90%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, a 90% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 72: Distribution of 2017 Modeled Concentrations and Sources of Nickel



4.3.3.1 Point Source Emission Reduction Targets

4.3.4 Secondary Source Pollutants

There are three pollutants associated primarily with secondary sources: Formaldehyde, acrolein, and acetaldehyde. Formaldehyde and acrolein are more than ten times above their benchmarks and acetaldehyde is between one and ten times above their benchmarks.

4.3.4.1 Formaldehyde

Formaldehyde comes from incomplete fuel combustion from industry, on and off-road engines, construction equipment, diesel fuel combustion, railroads, and airports, as well as from wood burning. It is used as a concrete and plaster additive, as a disinfectant, and as a wood preservative. The highest levels of airborne formaldehyde have been detected in indoor air, where it is released from various consumer products including paneling and

carpets. Figure 73 and Figure 74 are maps showing region-wide formaldehyde modeled concentrations without and including secondary contributions compared to Oregon’s formaldehyde benchmark concentration.

Figure 73: Formaldehyde 2017 Modeled Concentrations without Secondary Contributions

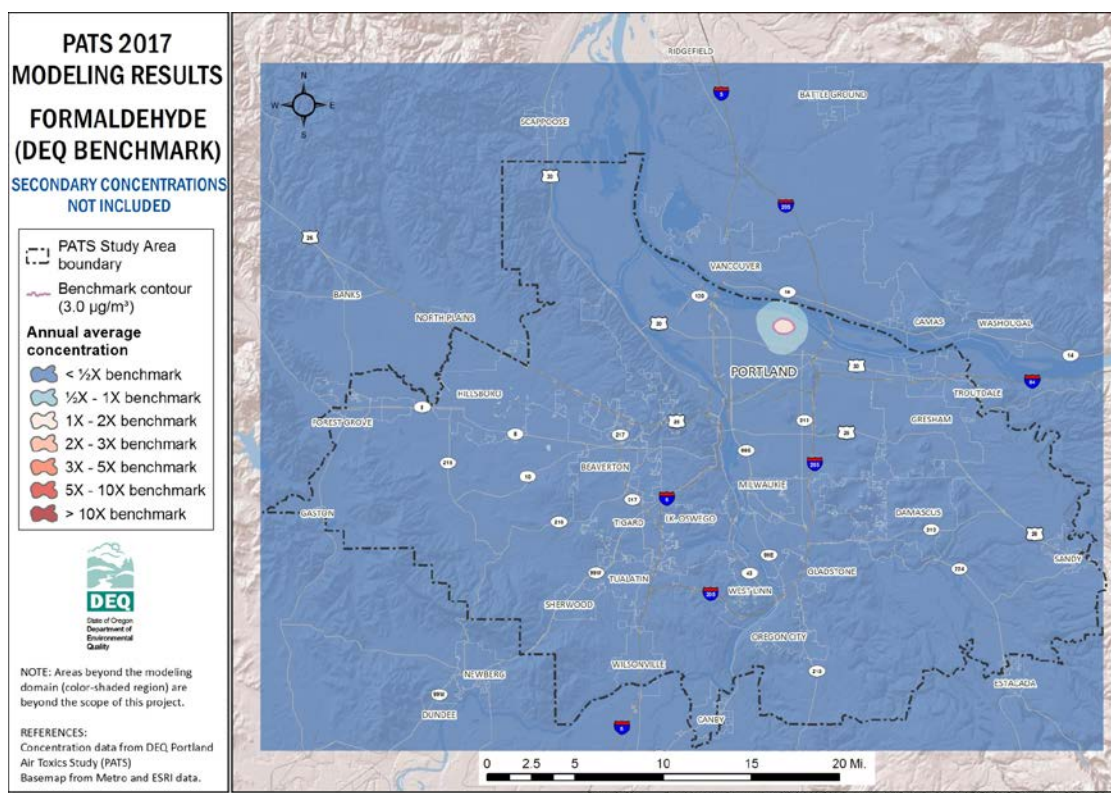


Figure 74: Formaldehyde 2017 Modeled Concentrations Including Secondary Contributions

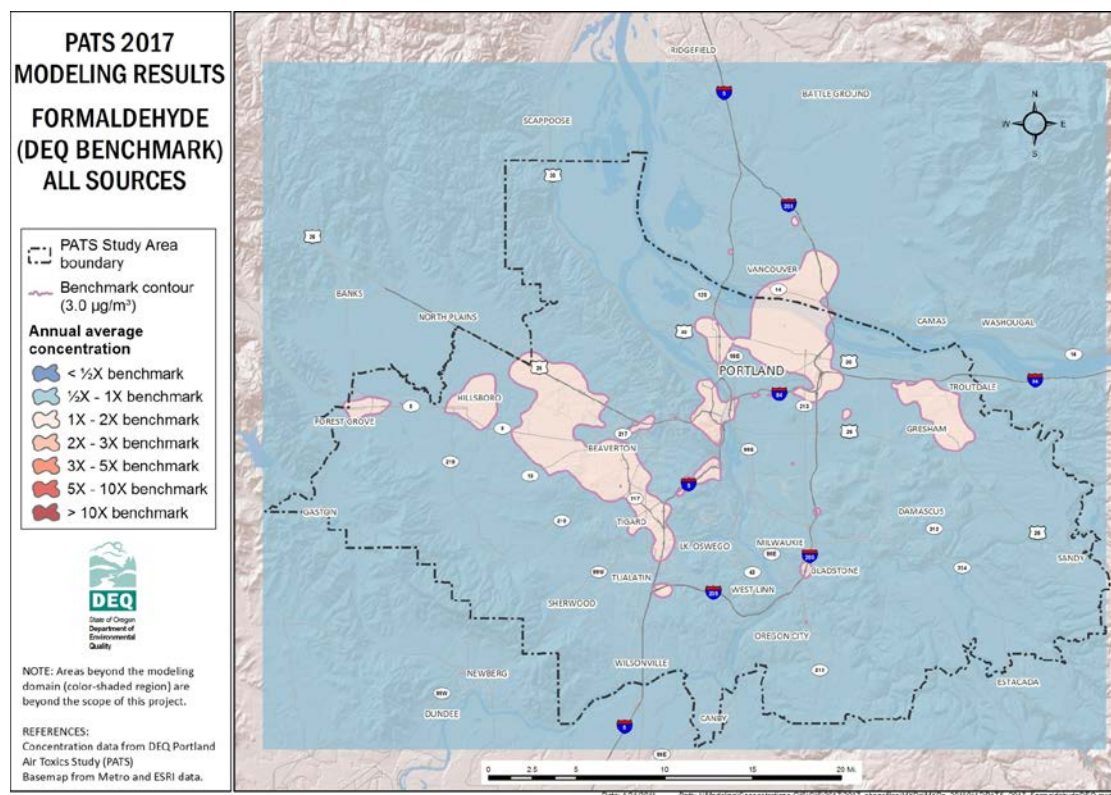


Figure 75 and Figure 76 are maps showing region-wide formaldehyde modeled concentrations without and including secondary contributions compared to EPA’s formaldehyde benchmark.

Figure 75: Formaldehyde 2017 Modeled Concentrations without Secondary Contributions

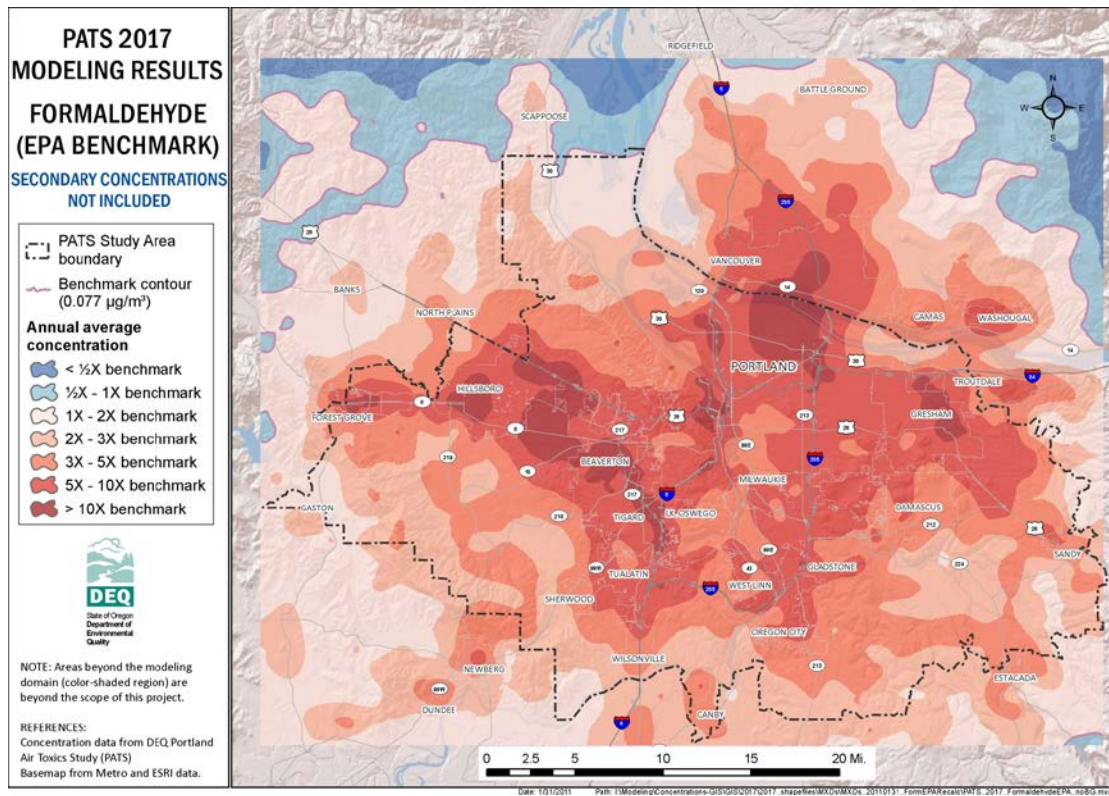
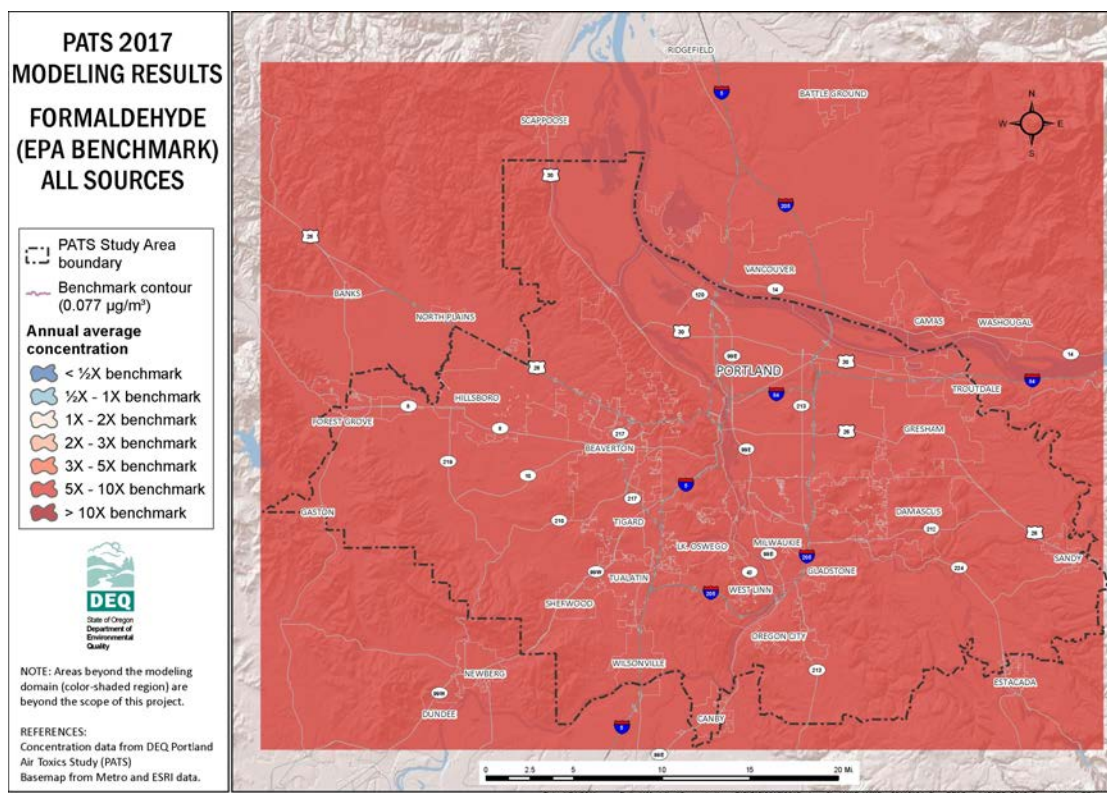
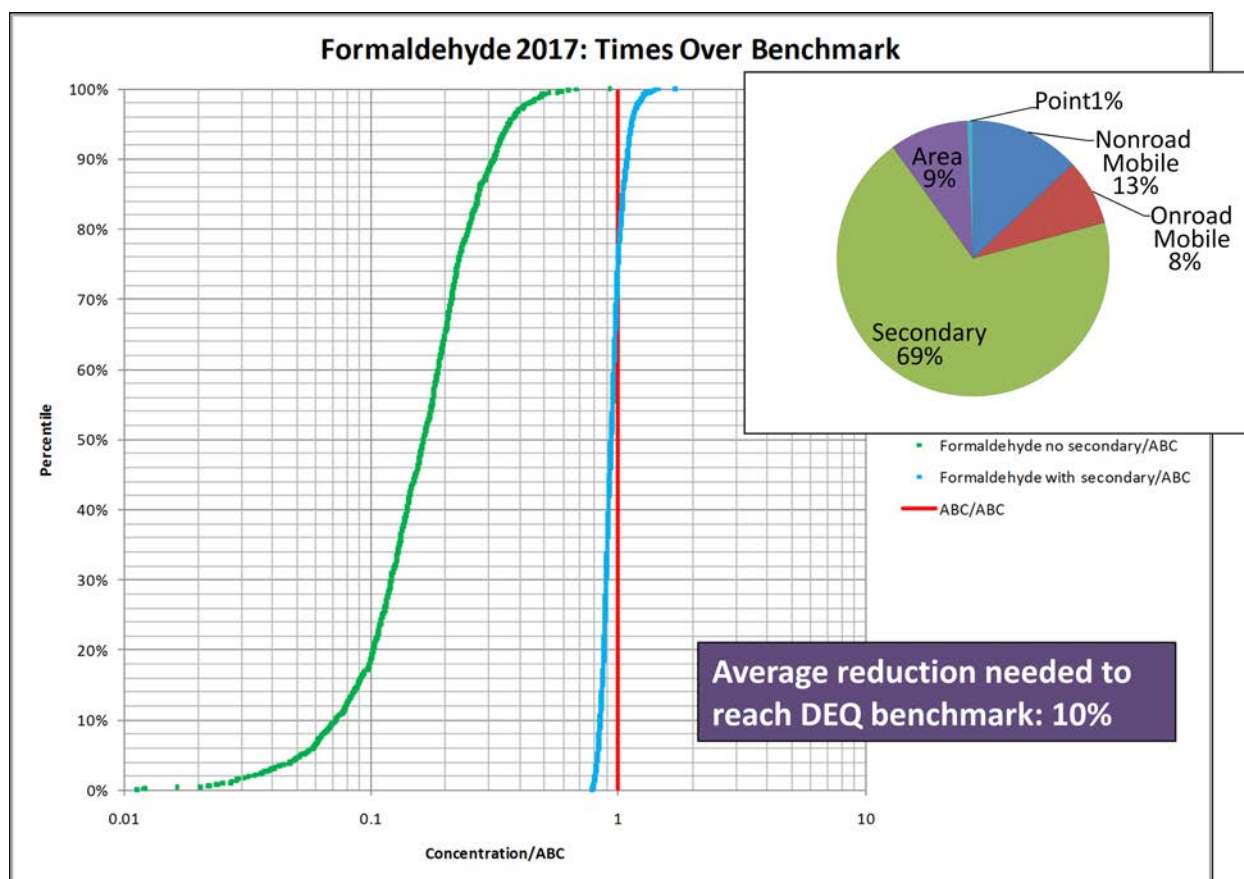


Figure 76: Formaldehyde 2017 Modeled Concentrations Including Secondary Contributions



Formaldehyde is a regional pollutant. Figure 77 contains a pie chart showing percentages of modeled contributions for formaldehyde. Figure 77 also plots a distribution of modeled values for formaldehyde compared to the DEQ benchmark, with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the secondary concentration. This graph, known as an S-curve, shows that in general, most of the receptors in the PATS study area are below the benchmark and a few in the localized impact areas are above the benchmark. The reduction in formaldehyde concentration needed to reach the target is 10%. This represents the reduction of the average concentration above the DEQ benchmark to meet the DEQ benchmark, not the reduction of the highest modeled concentration to meet the DEQ benchmark. As a result, a 10% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 77: Distribution of 2017 Modeled Concentrations and Sources of Formaldehyde



4.3.4.2 Acrolein

Acrolein is a colorless or yellow liquid that evaporates quickly and burns easily. Acrolein has a strong, unpleasant odor. It reacts quickly when exposed to other substances. In the PATS area, acrolein enters the air mainly from wood burning, structural (house and building) fires and construction. Tobacco smoke is another source of acrolein. Figure 78 and Figure 79 are maps showing region wide acrolein modeled concentrations without and including secondary contributions compared to Oregon's acrolein benchmark concentration.

Figure 78: Acrolein 2017 Modeled Concentrations without Secondary Contributions

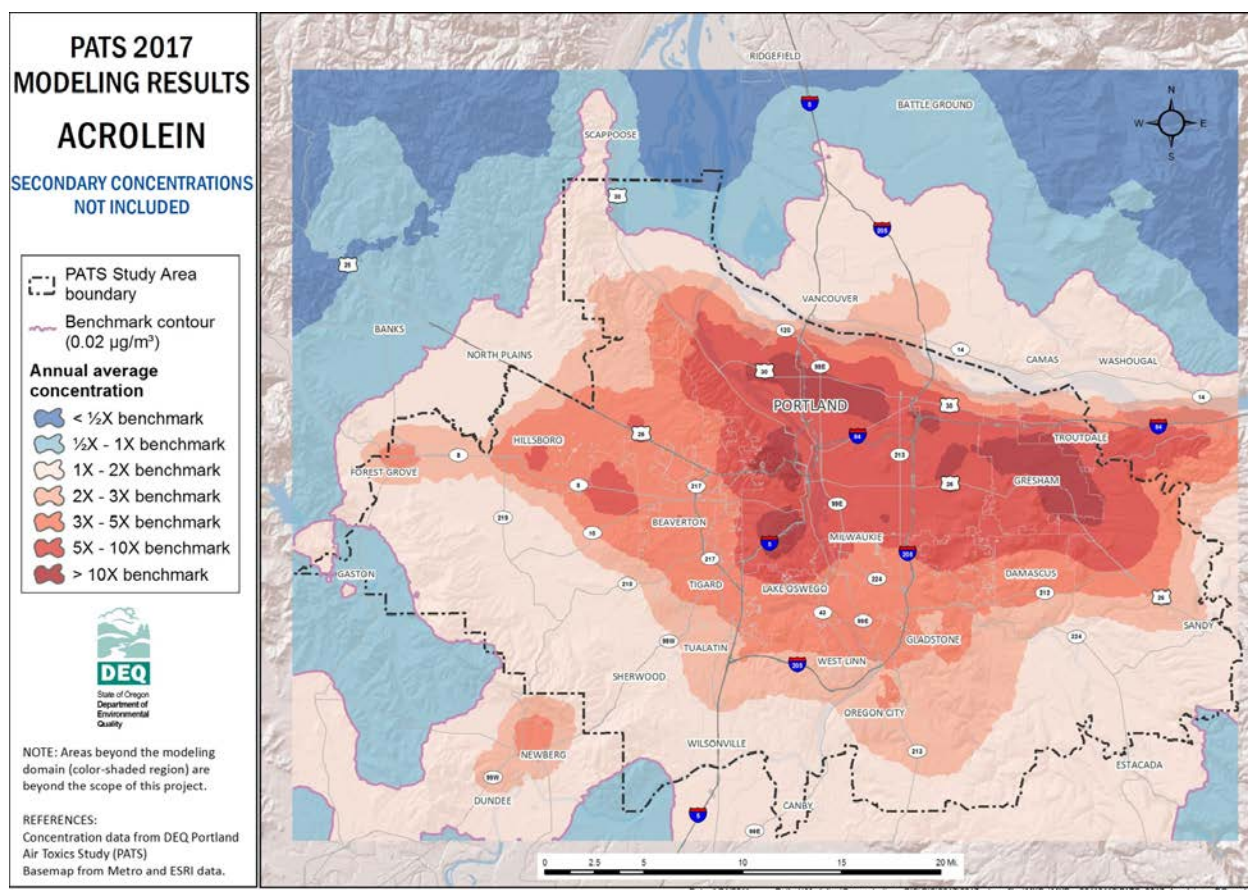
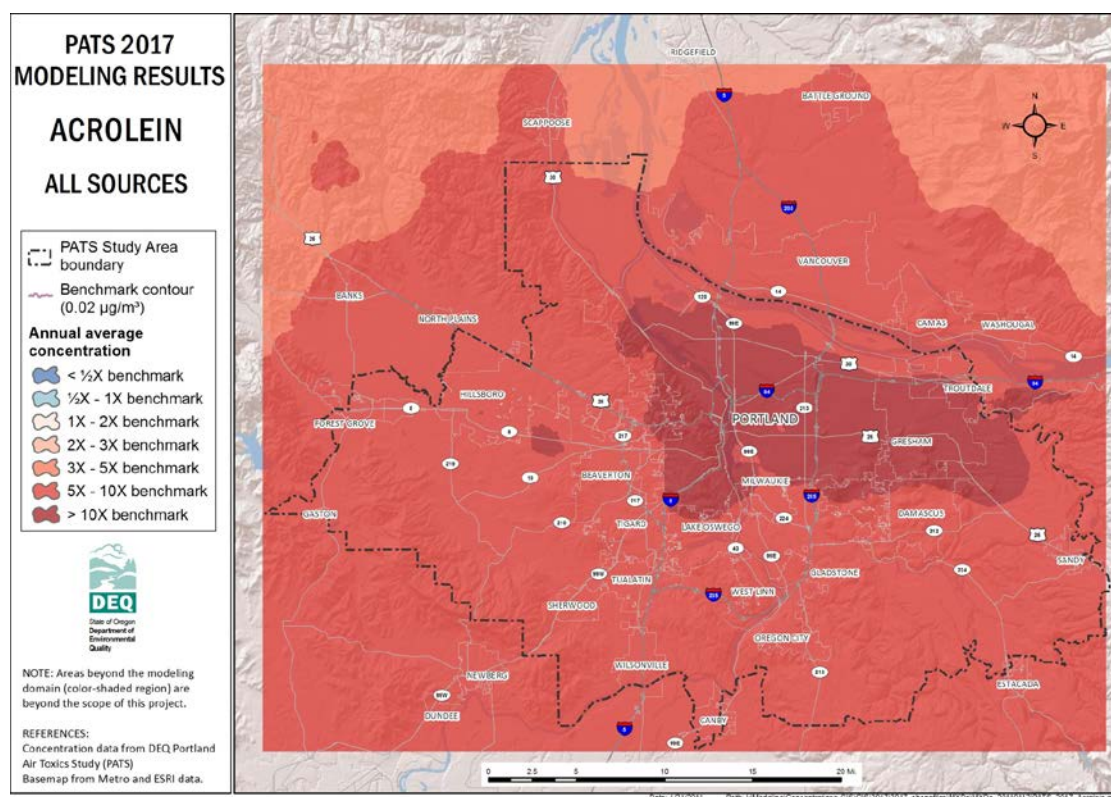
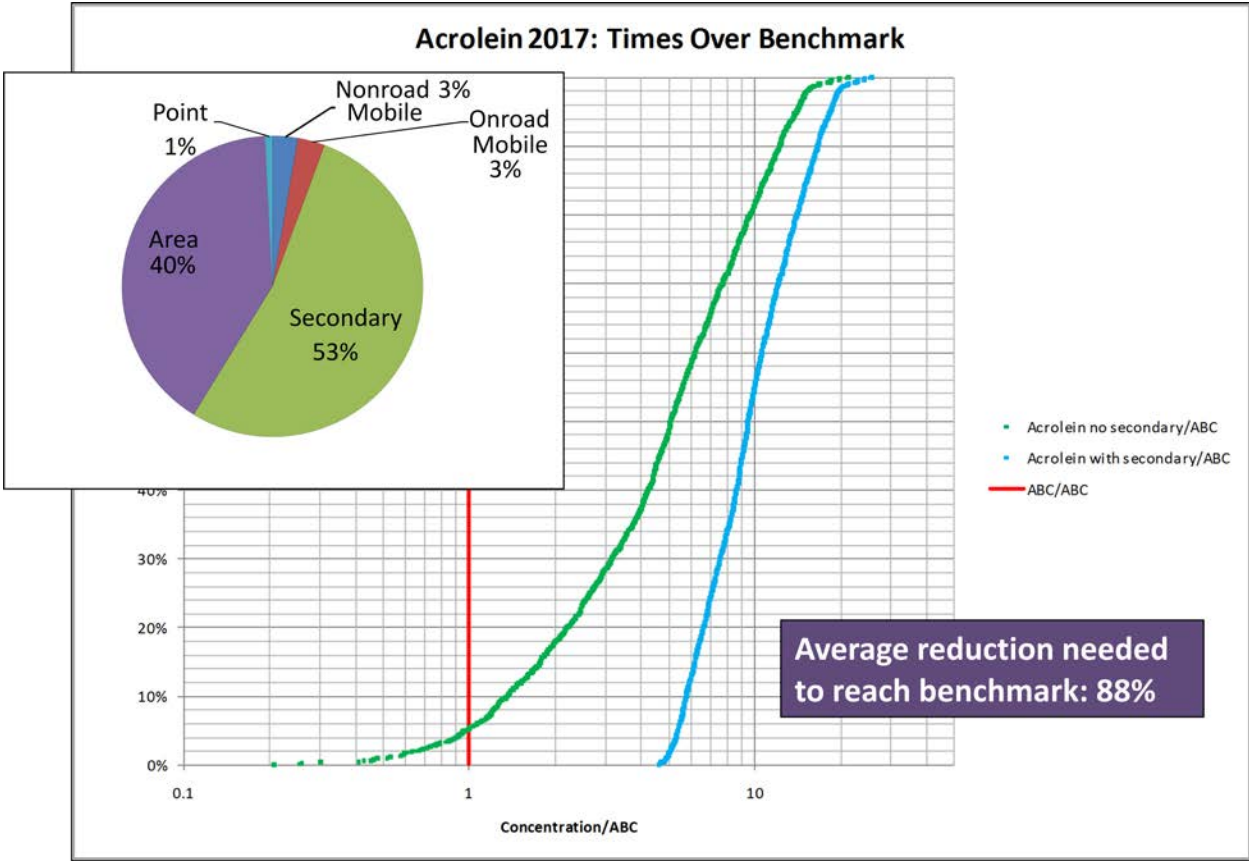


Figure 79: Acrolein 2017 Modeled Concentrations Including Secondary Contributions



Acrolein exists throughout the study area with higher concentrations in defined zones. The secondary concentration is 53 percent of the total for receptors above the benchmark. Figure 80 contains a pie chart showing percentages of modeled contributions for acrolein. Figure 80 also plots a distribution of modeled values for acrolein with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without secondary concentration and the blue line is composed of all values including the secondary concentration. This graph, known as an S-curve, shows that in general, most of the receptors in the PATS study area are above the benchmark. The reduction in acrolein concentration needed to reach the target is 88%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, an 88% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 80: Distribution of 2017 Modeled Concentrations and Sources of Acrolein



4.3.4.3 Acetaldehyde

Acetaldehyde is a colorless, flammable liquid that evaporates easily into the air. It is a product of incomplete combustion of fuels and wood, and is also used in the manufacture of other chemicals and products including perfumes and dyes. The dominant source of acetaldehyde in the Portland area is smoke from residential wood stoves and fireplaces, but much is also produced by engines. Figure 81 and Figure 82 are maps showing region-wide acetaldehyde modeled concentrations without and including secondary contributions compared to Oregon’s acetaldehyde benchmark concentration.

Figure 81: Acetaldehyde 2017 Modeled Concentrations without Secondary Contributions

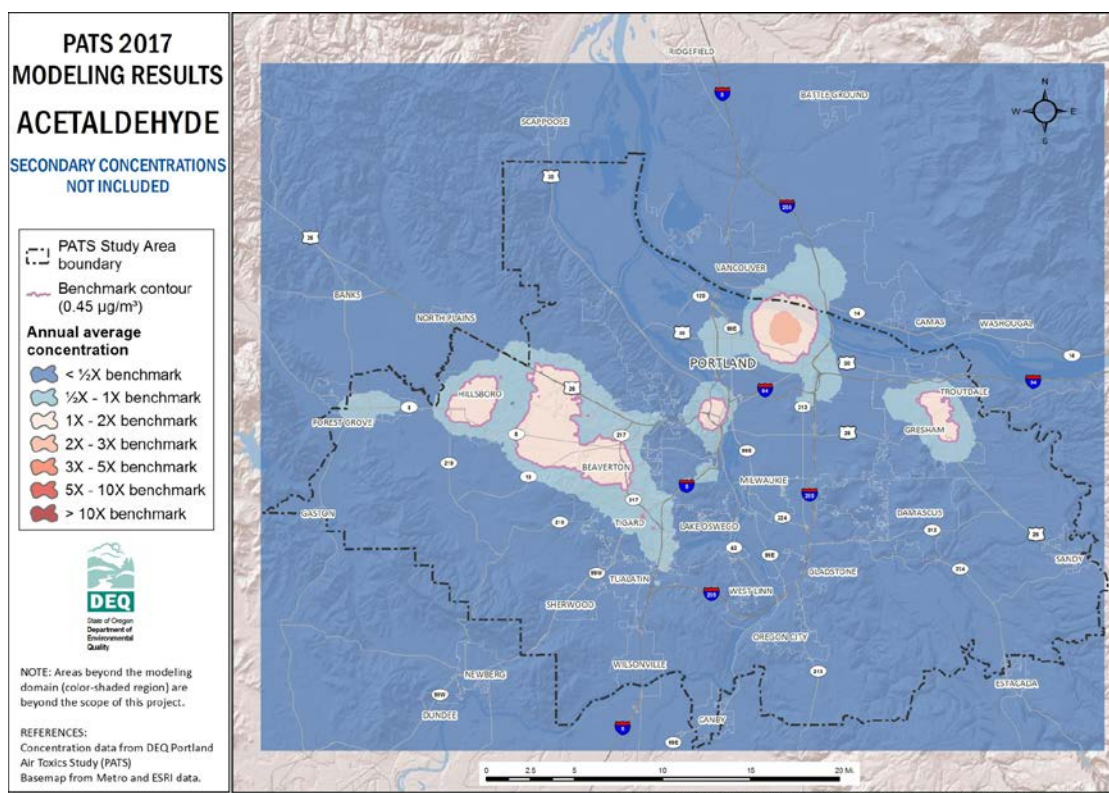
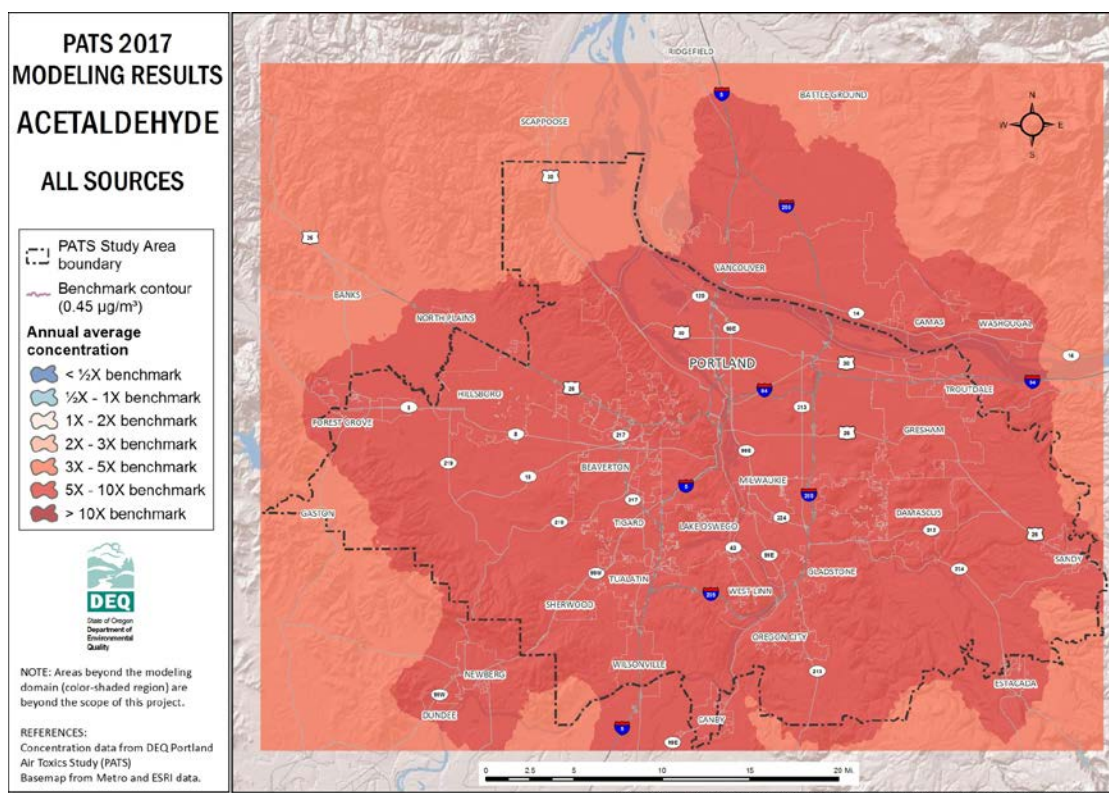


Figure 82: 2017 Acetaldehyde Modeled Concentrations Including Secondary Contributions



Acetaldehyde is a regional pollutant. There is a high secondary concentration of acetaldehyde, so including secondary sources brings levels up across the region. The secondary concentration is 91 percent of the total for receptors above the benchmark. Figure 83 contains a pie chart showing percentages of modeled contributions for cadmium. Figure 83 also plots a distribution of modeled values for cadmium with the y-axis showing the percentile value, the x-axis showing times above the benchmark, and the red vertical line representing the benchmark value. The green line is composed of all the values without background concentration and the blue line is composed of all values including the background concentration. This graph, known as an S-curve, shows that in general, most of the receptors in the PATS study area are below the benchmark and a few in the localized impact areas are above the benchmark. The reduction in acetaldehyde concentration needed to reach the target is 81%. This represents the reduction of the average concentration above the benchmark to meet the benchmark, not the reduction of the highest modeled concentration to meet the benchmark. As a result, an 81% reduction still leaves receptors with the highest modeled concentrations above the benchmark.

Figure 83: Distribution of 2017 Modeled Concentrations and Sources of Acetaldehyde

