Railyard Emissions in Portland Area

With Particular Consideration for the Brooklyn Yard[1]

Diesel engines, because of their power, durability and economy of use, are the predominant engine of choice when moving freight. Over 94 percent of freight moved in the United States is by a locomotive, truck or ship powered by a diesel engine. However, the exhaust from a diesel engine represents a significant source of pollution with adverse impacts on public health and the environment. Over 95 percent of Oregonians live where exposures to diesel exceed an Oregon public health benchmark. Oregon DEQ estimates that the annual direct and indirect costs from exposure in Oregon to diesel may be valued as much as $2 billion annually. While railroad activity is a relatively small contributor to the overall burden, these emissions can be locally significant in areas adjacent to railyards and railroad right of way.

<u>Fine Particulates from Diesel</u>

Diesel exhaust is a complex mixture of gases and particles, including those that have contributed to historic air pollution problems like ozone (commonly referred to as smog). Diesel engines are relatively low emitters of carbon monoxide and hydrocarbons, major constituents of traditional air quality issues. Diesel engines, however, are disproportionate emitters of fine (<2.5 microns) and ultrafine (<0.1 microns) particulate aerosols. Heavy duty diesels for instance represent 7 percent of the total motor vehicle fleet but emit about 65 percent of all particulates from motor vehicles. As compared to gaseous pollutants commonly found in vehicle exhaust, researchers[2] have concluded that human health impacts associated with fine particulate may be ten times greater than for nitrogen oxides, 150 times greater than hydrocarbons and 2,000 times greater than carbon monoxide on an equivalent mass basis.

Fine particulates are very small, about 1/25th the diameter of a human hair. Although these particles are small they have a large surface area relative to their mass, making them an excellent medium for adsorbing other toxic organics like formaldehyde, acetaldehyde, benzene, 1-3 butadiene and trace metals of toxicological significance like chromium, manganese, mercury and nickel. The small size also makes them highly respirable, able to penetrate into the deepest parts of the lungs and evade the body’s normal mechanisms for protection against aerosols. Although a solid material, the particulates can also act like a gas passing through the lungs transporting the particles and adsorbed toxics directly into the bloodstream.

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[1] This paper is intended as a background briefing on air quality issues associated with the Brooklyn train yard in support of efforts by the Eastmoreland and Sellwood-Moreland Neighborhood Associations. Prepared by Kevin Downing July 2011.

[2] McCubbin, Donald and Mark Delucchi (1999), *The Health Costs of Motor-Vehicle-Related Air Pollution*, Journal of Transport Economics and Policy, September, Vol. 33, Part 3, pp. 253-86

Diesel particulates have been associated with a number of chronic and acute health effects including premature mortality, aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions, emergency room visits, school absences, lost work days and restricted activity days), changes in lung function with an increase in respiratory symptoms, altered respiratory defense mechanisms and chronic bronchitis and asthma. For instance, the California Office of Environmental Health Hazard Assessment[3] listed diesel exhaust among the five most hazardous substances to children because of its potent contribution to asthma and other respiratory illnesses among children.

Several international, federal and state public health agencies, including the Oregon Environmental Quality Commission, have also determined that diesel exhaust particulates are a likely or probable human carcinogen at environmental levels of exposure.[4] Retrospective studies of occupational exposures, including railroad workers, have supported these findings[5].

In addition to the public health impacts associated with diesel exhaust, there are additional environmental impacts. Perhaps the most significant of these is the contribution to climate change from black carbon, estimated at 75 percent of total diesel particulate. Black carbon is the soot that results from the incomplete combustion of fossil fuels and biomass. Black carbon may be the second largest human contributor to climate change impacts with an impact up to 2000 times that of carbon dioxide compared on an equivalent basis[6]. Sixty percent of black carbon emissions in the United States are from diesel engines, about 4 percent from locomotives[7]. Since black carbon particles have a much shorter atmospheric residence time

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[3] http://oehha.ca.gov/air/toxic_contaminants/pdf_zip/diesel_final.pdf

[4] International Agency for Research on Cancer (1989), *Diesel and Gasoline Engine Exhausts and Some Nitroarenes,* No. 46, http://monographs.iarc.fr/ENG/Monographs/vol46/volume46.pdf;

U.S. Dept. of Health and Human Services, National Toxicology Program (2005), *11th Report on Carcinogens.* http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s069dies.pdf;

U.S. EPA. *Health Assessment Document for Diesel Engine Exhaust (Final 2002)*. U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Washington Office, Washington, DC, EPA/600/8-90/057F, 2002. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060

California Environmental Protection Agency, (2002), *Chemicals known to the State to Cause Cancer or Reproductive Toxicity*, 2002, http://www.oehha.ca.gov/prop65/prop65_list/files/singlelist060906.xls;

Oregon Department of Environmental Quality, (2006), *Oregon Air Toxics Program: Benchmark,* http://www.deq.state.or.us/about/eqc/agendas/attachments/2006aug/H-AirToxicsBenchmarksStaffRpt.pdf.

[5] Garshick, E; Schenker, MB; Munoz,A; et al. (1988) *A retrospective cohort study of lung cancer and diesel exhaust exposure in railroad workers*. Am Rev Respir Dis 137; 820-825.

Swanson, GM; Lin, CS; Burn, PB. (1993) *Diversity in the association between occupation and lung cancer among black and white men*. Cancer Epidemiol Biomarkers Prev 2:313-320.

Woskie, SR; Smith, TJ; Hammond, SK; et al. (1988) *Estimation of the diesel exhaust exposures of railroad workers: I. Current exposures*. Am J Ind Med 13:381-394; *II National and historical exposures*. Am J Ind Med 13:395-404.

[6] Bond, T.C. and H. Sun, (2005) *Can reducing black carbon emissions counteract global warming?*, Environmental Science and Technology 39, 5921-5926.

[7] Sarofim, M.C.; B.J. DeAngelo, R.H. Reach, K.A. Weitz, M.A. Bahner and A.M. Zapata Figueroa. (2009), *Marginal Abatement Cost Curves for U.S. Black Carbon Emissions.* Presentation to the Fifth International Symposium on Non-

(weeks and months as compared to 60 to 100 years for carbon dioxide) reductions of black carbon are identified as a priority first step to buy time while more challenging reductions of carbon dioxide are secured.

Emission Regulations for Railyards

The federal Clean Air Act reserves authority solely to the Environmental Protection Agency to establish emission standards for new and in-use locomotives. Emission control requirements for locomotives have lagged behind comparable standards for diesel trucks by 15 to 20 years. The most recent adoption in 2008 will phase in over four years beginning in 2011. Since locomotives have a replacement cycle of 30 to 40 years, emission equipment upgrades are also required in some cases when locomotives are remanufactured, possibly every 6 to 10 years. When fully phased in, EPA estimates a reduction in particulate emissions by 88 percent as compared to the standards in place at the time of adoption. EPA estimated the value of the direct and indirect public health and environmental benefits associated with reducing one ton of diesel particulate from locomotives at up to $862,000.

Despite the restriction on state and local government regulation of locomotives, the state of California secured a pollution reduction agreement in 2005 with Union Pacific Railroad and Burlington Northern Railway. The agreement, expected to achieve a 20 percent reduction in particulate emissions, has five major elements:

- Phase out nonessential idling within six months of signing and install idle reduction devices on California based locomotives by 2008.
- Identify and expeditiously repair excessively smoking locomotives.
- Maximize use of highway grade diesel fuel by January 1, 2007, six years before national requirements.
- Conduct health risk assessments for 17 major railyards and use these studies to identify risk reduction measures.
- By January 2006 prepare a progress report on plans to implement feasible mitigation measures at the 17 major railyards.

Emissions from railyard activity can come from a variety of sources in addition to locomotives, depending on the type of activity in the railyard. In an intermodal railyard emissions also come from cargo handling equipment, yard tractors and drayage trucks. In this case, EPA establishes emission standards for new highway and nonroad equipment but not currently operating, so called in-use, vehicles. The state of California is singularly authorized to establish standards for new and in-use highway vehicles and nonroad equipment. The Air Resources Board currently has requirements in place for in-use vehicles and equipment, including those that operate in railyards, to upgrade with highly effective emission controls. The Clean Air Act limits other state's authority to adoption of the California requirements if they demonstrate a need. In Oregon, any action to further reduce emissions associated with railyard activity is limited by a lack of state statutory authority.

Emission Sources in Railyards

The mix of emission sources from a railyard depends upon the type of activity that occurs there. For instance in a classification yard, trains are assembled and disassembled by individual railcars (e.g., box car, tanker car, flatbed car) requiring movement by switch locomotives. In an intermodal yard freight is transferred between rail and trucks by container or truck trailer without individually handling the contents any freight container when changing modes. The difference in impacts between classification and intermodal facilities can vary considerably and is illustrated in a generic example presented in Table 1. Locomotives can represent a larger portion of emissions from classification yards while intermodal facilities can show significant impacts from equipment and vehicles that service the yard in support of the intermodal functionality.

Table 1 Emissions from Railyard with Existing Equipment, 2005 Baseline[8]

$PM_{2.5}$, tons/year	Very Large Intermodal Yard	Very Large Classification Yard
Locomotive Servicing	0.0	9.8
Switch Engines	1.8	5.5
Cargo Handling Equipment		
Yard Tractors	12.5	0.0
Cranes	7.5	0.0
Forklifts	4.9	0.0
Main Line Train Operations	3.5	11.8
Estimated Truck Drayage	28	0.0
Total	58.2	27.1

Railyards, from an air quality perspective, can be a collection of older, high emitting equipment and vehicles in each emission source category. As mentioned earlier with locomotives, turnover to new cargo handling equipment can also take a long time, up to 16 years. Trucks used in drayage service to intermodal facilities tend towards the oldest trucks on the road[9].

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[8] Mark Stehly (2006), Vice President of Environmental and Hazardous Materials Engineering, presentation at Faster Freight/Cleaner Air

[9] Wilbur Smith Associates (2010), *SCAPA Truck Survey Summary Report*.

Table 2 presents more a specific emission inventory for intermodal railyards from the Health Risk Assessment completed under the California Memorandum of Agreement. These were selected for potential comparability to the Brooklyn railyard in SE Portland. The current report of container lift activity at the Brooklyn Yard is about 145,000 per year but projected to increase to 209,000 by 2015. The California assessment not only developed emission inventories but also completed a risk assessment. Focusing solely on diesel particulate, each assessment also included an estimate of excess risk for cancer over a lifetime exposure solely from railyard activity, as opposed to other background sources. In the case of these three railyards, for the estimated cancer risk to drop to 10 in a million (1 in a million cancer risk is considered a public health benchmark) a resident would have to live at least 2 to 4 miles from the facility.

Table 2 Select California Intermodal Railyards with Health Risk Assessments

	Commerce Railyard	Los Angeles Transportation Center	Oakland Railyard
Container Lifts – per year	350,000	250,000	350,000
Diesel PM Emissions – per year (tons)			
Locomotive	4.9	3.19	3.9
Line haul	3.0	0.73	1.6
Switch	1.9	2.46	1.9
Trailer Refrigeration Units, Reefer cars	0.4	0.46	3.2
Cargo Handling Equipment	4.8	2.67	2.2
On-Road Trucks	2.0	0.99	1.9
Total PM emissions	17	10.5	14.7
Distance from railyard to experience cancer risk at 10 in million[10]	4 miles	2 miles	4 miles

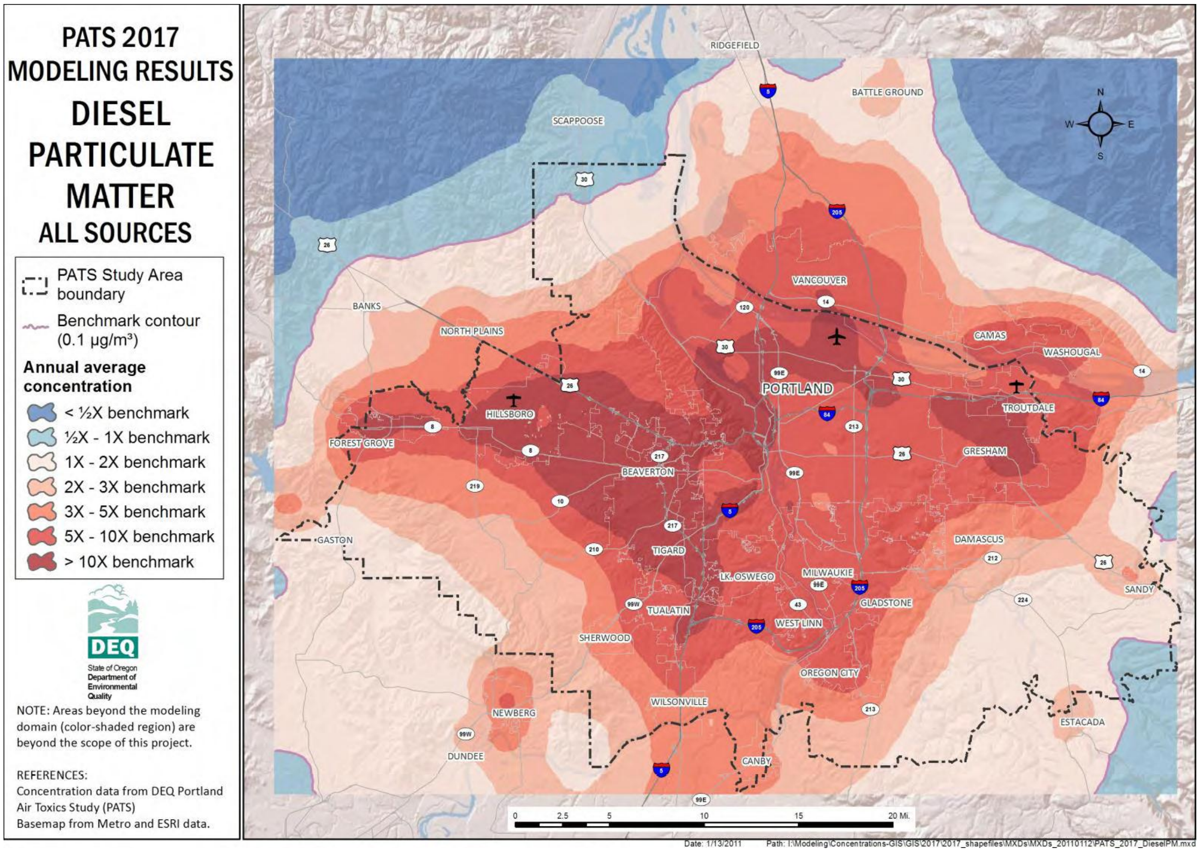
[10] Based on the state of California risk factor for diesel PM, 0.003 μ/m^3, which is also used for planning purposes in Washington state and the Greater Vancouver Regional District, for instance. The Oregon benchmark at 0.1 μ/m^3 is necessarily less protective.

Diesel Toxic Risk Assessment in the Portland Area

Diesel particulate is identified as an air toxic issue in Oregon based on ambient concentrations and exposures increasing risk for incidence of cancer in particular, even though other serious health effects are also likely. Based on the EPA assessment of direct and indirect environmental and public health costs associated with diesel particulate this annual impact in Oregon is estimated at almost $2 billion. Over 95 percent of Oregonians live in areas where lifetime exposure results in excess risk for cancer above 1 in a million based on the Oregon benchmark concentration of 0.1 μ/m^3. To complement risk reduction in the federal program, Oregon initiated a state based air toxics reduction program. In one of the first steps the Air Toxics Science Advisory Committee recommends air toxic benchmark concentrations for adoption by the Environmental Quality Commission. Benchmarks are not standards but rather planning goals and triggers for subsequent air quality programs.

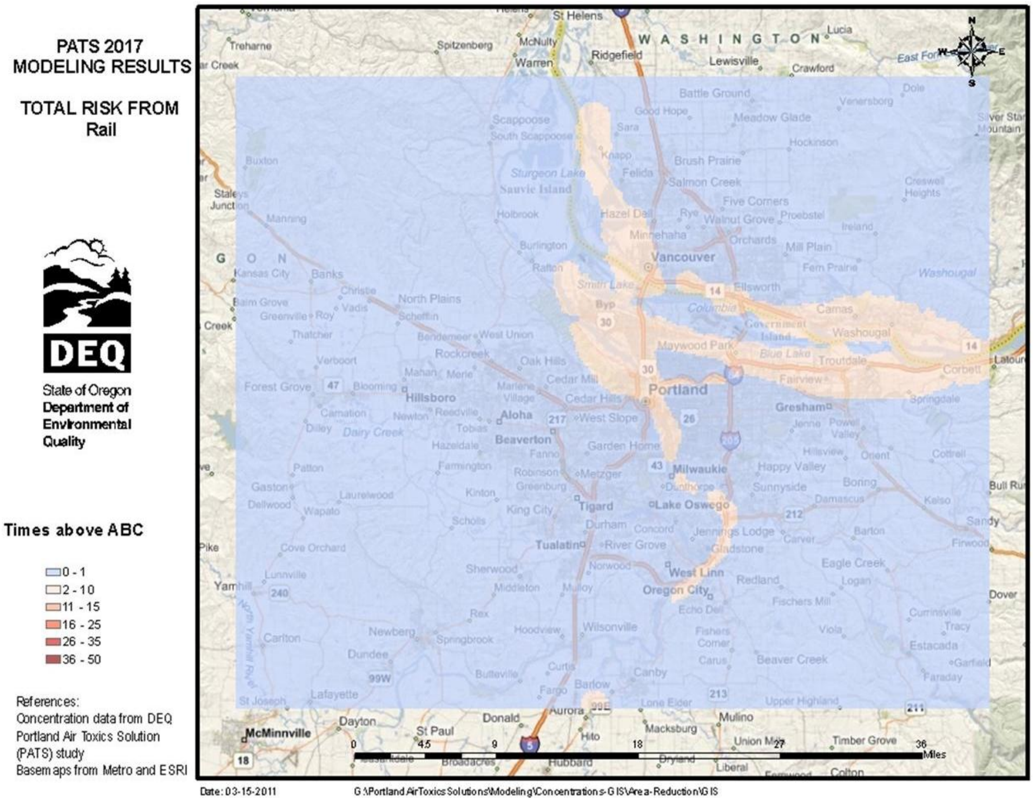
DEQ convened the Portland Air Toxics Solutions Advisory Committee in 2009 to consider air toxic risk in the Portland metropolitan area. The committee is currently underway in a process to recommend strategies for an air toxics reduction plan. In support of that effort DEQ completed the Portland Air Toxics Assessment (PATS), to model air toxic concentrations and risk for a planning target year of 2017. The study modeled air toxics concentrations using local meteorology, topography and emission information about population, neighborhood, car, truck, industrial and smaller sources based on projections for growth including the implementation of regulations in place as of 2011. The study identified 15 pollutants above benchmarks with eight showing the most risk: 1,3 butadiene, benzene, diesel particulate, 15 polycyclic aromatic hydrocarbons, naphthalene, cadmium, acrolein and formaldehyde. While each of these pollutants are emitted from a variety of sources at varying concentrations, all of them are emitted from diesel engines. Of course, diesel particulates are singularly peculiar to diesel engines. The projected ambient concentrations from all sources of diesel particulate are portrayed in Figure 1 showing that the entire region exceeds the benchmark for exposure to diesel from all sources including trucks and buses, nonroad equipment, ships and tugboats and locomotives.

Figure 1 Portland Air Toxics Study 2017 Diesel PM Cancer Risk - Overall



While emissions from construction equipment and highway trucks and buses are major sources of the impact in the region, localized impacts from railroad activity are also evident from the analysis. Figure 2 shows total risk from locomotive operation in the Portland metro area. Diesel particulate matter and 15 PAH are the major drivers for this increased risk, both of which are products of incomplete combustion.

Figure 2 Portland Air Toxics Study 2017 Total Cancer Risk - Railroad



Other toxics, acrolein, 1,3 butadiene, formaldehyde, naphthalene and benzene were also identified as contributing to above benchmark concentrations beyond background levels. The study concluded that reduction targets of between 84 and 96 percent from projected levels are necessary to meet benchmarks in 2017. This is a worst case analysis but is intended to protect sensitive populations including medically vulnerable populations, the elderly and children. Residential areas adjoin the Brooklyn Yard on all sides. Within 1 mile of the Brooklyn Yard, including the train assembly area south of SE Reedway, are five elementary schools and two retirement facilities. Further emission reductions to meet benchmarks will result in health improvements for these sensitive populations and others.

Pollution Reduction Strategies for Railyards

Moving freight by rail is an efficient mode, consuming as little as 10 percent of the fuel per ton mile carried as compared to trucks[11]. This results in fewer emissions of carbon dioxide, a greenhouse gas, but railyards can nonetheless represent a significant source of respirable pollution with known myriad adverse impacts on human health.

Strategies have been identified and evaluated to address all aspects of emissions from railyards, including repowering and remanufacturing engines, installing exhaust controls, eliminating unnecessary idling and replacing older equipment altogether.

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[11] Davis, Stacy C.; Susan W. Diegel, Robert G. Boundy (2009). *Transportation Energy Data Book: Edition 28*. US Department of Energy. pp. Table 2.12. ORNL-6984

Repowering means replacing an existing engine with an altogether new engine. This strategy is most effective for use in diesel-powered equipment, like locomotives and nonroad equipment, with a useful life longer than that of the engine. Repowering in this context results in a new, lower emitting engine (or a new engine equipped with exhaust emission controls) than the original engine. This upgrade often results in fuel economy benefits and lower maintenance costs. Repowering can also include converting diesel-powered equipment to electrical power or other alternate fuels like natural gas and propane.

Remanufacturing retains the original engine but overhauls and upgrades worn parts along with the installation of new parts, typically offered as a package specifically intended to reduce emissions from the original certified engine.

Retrofit involves the addition of an aftermarket emission control device on the tailpipe to remove emissions from the engine exhaust. Retrofits can be very effective at reducing emissions, eliminating up to 90 percent of pollutants in some cases. Exhaust control technology is being developed for locomotives and is not common. Otherwise exhaust retrofits have been installed on truck and other nonroad engines.

Replacement is also an effective strategy, although it can be more costly as an air quality strategy because the costs incurred go beyond systems intended solely for air quality improvement purposes.

Each strategy requires evaluation within the specific constraints of the intended application whether locomotive, drayage truck or cargo handling equipment, requiring a more detailed description than can be conveyed here of the advantages and disadvantages of each strategy in each application. However there are several notable examples of successful applications in other locations across the country. For instance, idle controls on switch engines have been shown to reduce fuel consumption by as much as 15,000 gallons per year with concomitant emission reductions. A smaller auxiliary motor retrofitted on existing locomotives can perform these functions more efficiently.

Switch engines can be repowered in a "genset"[12] configuration in which the main locomotive engine is replaced with two or three smaller engines monitored by advanced computer controls that allows for precise control, starting and stopping only as power is needed. Fuel savings as much as forty percent and emission reductions up to 70 percent have been reported.

Replacement can be an expensive strategy for locomotives considering the large initial capital costs involved but could be a very cost effective strategy to upgrade trucks in drayage service. Typically these trucks are very old but are used by businesses in short distance hauling because the business model does not warrant or support acquisition of brand new trucks. The port of Seattle presents a model for drayage truck replacement by offering financial incentives for scrapping. This is also complemented by

[12] 2010 EPA Clean Air Excellence Award for Union Pacific development of genset switcher, http://yosemite.epa.gov/opa/admpress.nsf/6424ac1caa800aab85257359003f5337/524fadbc7fd3d4b3852578a80058a88e!OpenDocument

requirements established by the Port to limit access over time to port facilities to progressively newer trucks.

Many of these strategies have been evaluated by the California Air Resources Board as part of their program to further reduce emissions from locomotives and railyards[13]. While some of these strategies may face operational and other challenges, they are almost universally cost effective at reducing diesel particulate at costs ranging from $44,000 to $194,000 per ton reduced. This compares very favorably to the estimated impact costs associated with particulates emitted from diesel locomotives at up to $862,000 per ton.

Major railroads, including Union Pacific (http://www.uprr.com/she/emg/index.shtml) have identified and implemented a variety of strategies to reduce emissions in current operations. Notably most of these projects have been implemented in other parts of the country, e.g., Houston and Los Angeles, due to persistent air quality problems and aided by the availability of state funding for project development. The focus has been on these areas due to a perception that ambient air quality issues associated with criteria pollutants warrants action by the railroads. Houston and Los Angeles are communities that are remarkable for persistently high levels of smog pollution. However this is a regionally generated pollutant with many contributing sources. Railroad activity is a relatively smaller contributor to these high profile problems in Texas and southern California. Railroad yard activity is nonetheless a source of toxic air contaminants with elevated risk to nearby residents as demonstrated in a number of the California Health Risk Assessments as well in the Portland air toxics study. Portland may appear to be lower priority because criteria pollutant issues are not as pronounced. However, as noted above, emissions from railroad activity directly contribute to significant health risks for Portland neighborhoods adjacent to rail facilities.

While a dedicated source of state grant funding is not as readily available currently in Oregon as compared to Texas and California, other resources such as federal assistance in the form of federal loans (the Railroad Rehabilitation and Infrastructure Fund), federal grants (Congestion Mitigation and Air Quality and the Diesel Emission Reduction Act), state loans (State Transportation Infrastructure Bank), state lottery funds (Connect Oregon), state tax credits (Diesel Repower and Business Energy Tax Credits) and carbon offset funding (The Climate Trust) are all potential opportunities for financial support of upgrades to reduce air toxic impacts from sources associated with railyard activity.

While other sources of air toxics contribute to health risks for residents living nearby the Brooklyn Yard, the risk from railyard activities is pronounced, significant and resolvable as part of overall efforts to support and enhance quality of life in these neighborhoods.

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[13] Holmes, Harold; M. Jaczola. (2009) *Technical Options to Achieve Additional Emissions and Risk Reductions from California Locomotives and Railyards.* California Air Resources Board.
Holmes, Harold; S. Cutts. (2009) *Recommendations to Implement Further Locomotive and Railyard Emission Reductions.* California Air Resources Board