2021

Public Health Assessment Initial and Public Comment Release

Bullseye Glass Co. (manufacturing site)
3722 SE 21st Ave
Portland, OR 97202

Prepared by:
Environmental Health Assessment Program
Oregon Health Authority, Public Health Division

Prepared under a cooperative agreement with:
U.S Department Health and Human Services,
Agency for Toxic Substances and Disease Registry

Oregon Health Authority
PUBLIC HEALTH DIVISION

Foreword

This report was supported by funding through a cooperative agreement with the U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR). It was completed following the approved methodologies and procedures existing at the time the Public Health Assessment was initiated. The editorial review was completed by the cooperative agreement partner.

The Oregon Health Authority (OHA), in cooperation with state and federal partners, prepared this Public Health Assessment (PHA). Through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), OHA's Environmental Health Assessment Program (EHAP) conducts PHAs to evaluate environmental data and community concerns. A PHA reviews available information about hazardous substances at a site. A PHA evaluates whether exposure to the substances may cause harm to people. A PHA is not the same as a medical exam or a community health study.

ATSDR's mission is to serve the public by:

- Using the best science
- Taking responsive public health actions, and
- Providing trusted health information to prevent:
  - » Harmful exposures, and
  - » Disease related to exposures to toxic substances.

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List of abbreviations and acronyms

Abbreviations

ADHD	attention deficit hyperactivity disorder
AT*	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
CA-EPA	California Environmental Protection Agency
CAC	community advisory committee
CDC	Centers for Disease Control and Prevention
COC	contaminant of concern
CREG*	cancer risk evaluation guide
CSF*	cancer slope factor
CV*	comparison value
DEQ	(Oregon) Department of Environmental Quality
ED*	exposure duration
EHAP	(Oregon) Environmental Health Assessment Program
EJ*	environmental justice
EMEG*	environmental media evaluation guide
EPA	(U.S.) Environmental Protection Agency
HI*	hazard index
HQ*	hazard quotient
IARC	International Agency for Research on Cancer
IQ	intelligence quotient
IR*	ingestion rate
IRIS	Integrated Risk Information System

* Abbreviations with an asterisk are defined in the glossary (Appendix J).

IUR	inhalation unit risk
µg*	microgram
mg/kg*	milligrams per kilogram
MRL*	minimal risk level
N	north
NAAQS	National Ambient Air Quality Standards
NCEH	National Center for Environmental Health
NESHAP	National Emission Standards for Hazardous Air Pollutant
ng/m^3	nanograms per cubic meter
NHANES	National Health and Nutrition Examination Survey
NOAEL*	no observed adverse effect level
OEHHA	California Office of Environmental Health Hazard Assessment
OHA	Oregon Health Authority
OSCaR	Oregon State Cancer Registry
PATS	Portland Air Toxics Solutions
PHA	public health assessment
PHD	Public Health Division
PPS	Portland Public Schools
REL	Reference Exposure Level
RfD*	reference dose
RSL	regional screening level
SIR*	standardized incidence ratio
SoilSHOP	soil screening, health, outreach, and partnership
St.	street
UCL*	upper confidence limit
U.S.	United States of America
USFS	United States Forest Service

* Abbreviations with an asterisk are defined in the glossary (Appendix J).

Summary

Introduction

Through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), the Oregon Health Authority (OHA) Public Health Division (PHD) Environmental Health Assessment Program (EHAP) works to ensure a community around the site of a possible environmental hazard exposure has the best information possible to protect its health.

In 2015, the U.S. Forest Service (USFS) analyzed moss samples collected around the city of Portland, Oregon for heavy metals. USFS moss sampling intended to identify potential sources of air contaminants. The USFS's analysis showed cadmium among other metals. USFS found the highest concentrations in the moss near two glass manufacturing facilities, Uroboros Glass and Bullseye Glass.

Bullseye Glass is in the Brooklyn neighborhood of southeast Portland. Bullseye glass is near residential areas, child care facilities, schools, public parks, and areas where people grow fruits and vegetables.

The Oregon Department of Environmental Quality (DEQ) placed one air monitoring station in a large parking lot across the street from Bullseye Glass for October 2015 to:

- Better understand the moss data, and
- Determine if the metals were from Bullseye Glass emissions.

Results became available to DEQ at the end of January 2016. They showed metals in the air and prompted DEQ to place four air monitor stations around Bullseye Glass in February 2016. DEQ also collected soil samples from the areas surrounding Bullseye Glass.

When people living near the site learned about metals in the air, they asked OHA about their long-term health risks. OHA responded by conducting a Public Health Assessment (PHA) with the support of ATSDR. In this PHA, OHA evaluated air quality data around Bullseye Glass before and after Bullseye Glass reduced emissions (February 2016). OHA also evaluated:

- Soil data
- Community urinary cadmium data, and
- Health outcome data.

In April 2016, Governor Kate Brown directed DEQ and OHA to develop a state program, Cleaner Air Oregon (CAO), to regulate emissions of toxic air contaminants from industrial facilities to reduce risks to people nearby. The Oregon Environmental Quality Commission that oversees DEQ adopted rules for the CAO program in 2018.

Conclusions

OHA reached nine conclusions *(See executive summary table below)*:

Conclusion 1

OHA cannot conclude whether inhaling air around Bullseye Glass for long periods before February 2016 could harm people's health.

Basis for decision

During October 2015, before changes in manufacturing practices and emissions controls at Bullseye Glass, there were elevated levels of arsenic, cadmium, and lead measured in the air. These metals can increase the risk of health problems if inhaled in large enough amounts over a long enough period. However, one month of air monitoring data is not enough to accurately represent long-term air quality conditions related to Bullseye's 42 years in the community. October 2015 conditions may over- or underestimate the average metals in the air over those 42 years. Bullseye's operations have been variable over that period.

Next steps

OHA will continue working with DEQ on the statewide CAO effort to regulate industrial facility air emissions based on health risk.

Conclusion 2

OHA concludes that breathing the air around Bullseye Glass during October 2015 was ***unlikely to harm people's health.***

Basis for decision

Levels of metals measured in the air near Bullseye Glass in October 2015 were too low to harm the health of people who breathed that air during that month. It is not possible to determine what levels of metals were in the air:

- Before October 2015, or
- Between October 2015 and the start of more extensive monitoring in February 2016.

Health risks from exposures during those other times could have been higher or lower than predicted based on the October 2015 monitoring data.

Next steps

OHA will continue working with DEQ on the statewide CAO effort to regulate industrial facility air emissions based on health risk.

Conclusion 3

Had there been no interventions to reduce metal emissions from Bullseye Glass, long-term exposure to conditions measured in October 2015 ***could have harmed people's health.***

Basis for decision

Lifetime exposure to the level of arsenic and cadmium measured in the air near Bullseye Glass in October 2015 could have posed an elevated risk of lung and bladder cancer to people living in the area. Exposures lasting a year or more to levels of arsenic measured in October 2015 could have elevated the risk of:

- Decreased IQ in children living in the area, and
- Decreased lung function in adults or children living in the area.

Exposures lasting a year or more to levels of cadmium measured in October 2015 could have increased the risk of kidney damage.

Next steps

OHA will continue working with DEQ on the statewide CAO effort to regulate industrial facility air emissions based on health risk.

Conclusion 4

Exposure to concentrations of metals measured in the air around Bullseye Glass since February 2016 is ***unlikely to harm people's health.***

Basis for decision

Levels of metals measured in the air since March 1, 2016 are too low to cause health effects following short- (acute) or long-term (chronic) exposure. OHA expects regulatory and policy actions since March 1, 2016 to ensure reductions in emissions from Bullseye Glass remain permanent.

Next steps

OHA will continue working with DEQ on the statewide CAO effort to regulate industrial facility air emissions based on health risk.

Conclusion 5

Interventions since February 2016 dramatically reduced potential health risks from inhaling air affected by emissions from Bullseye Glass.

Basis for decision

Compared to risk from long-term exposure without intervention, reduced emissions of metals from Bullseye Glass since 2016:

- Reduced cancer risk in the area by 57-fold, and
- Reduced non-cancer risk by 87- to 108-fold.

Next steps

OHA will continue working with DEQ on the statewide CAO effort to regulate industrial facility air emissions based on health risk.

Conclusion 6

Exposure to concentrations of metals measured in the soil around Bullseye Glass was ***unlikely to harm people's health*** *in the area.*

Basis for decision

Levels of metals measured in the soil in 2016 were too low to cause health effects. Metal concentrations in the soil generally change more slowly than concentrations in air. Therefore, soil levels measured in 2016 are likely to be representative of soil conditions from the past several years or decades.

Next steps

No additional actions are necessary.

Conclusion 7

Consumption of homegrown produce harvested around Bullseye Glass was unlikely to harm people's health.

Basis for decision

Most garden produce does not absorb metals well such as arsenic, cadmium, chromium and lead. Common gardening practices such as adding compost, mulch, and other nutrients to the soil reduces the uptake of heavy metals into plants. Generally, any risk to gardeners from metal contamination in soil is from consuming soil particles stuck to the outside of garden produce. Metals concentrations measured in the soil around Bullseye were similar to those measured in urban areas around Portland and around the country. Metals concentrations are too low to harm the health of people who consume soil particles on homegrown produce.

Next steps

OHA recommends standard urban gardening guidance. Urban gardeners should:

- Wash hands after gardening
- Take off shoes before entering the home to avoid tracking soil inside, and
- Wash homegrown produce before consuming it.

Conclusion 8

Results of urine cadmium tests have too many uncertainties and too many scientific limits to draw a health conclusion.

Basis for decision

Exposure to cadmium can come from multiple sources, this includes:

- Food
- Air
- Soil
- Cigarette smoke, and
- Some batteries, pigments and plastics.

Exposure to these sources and the effect on urine cadmium levels can vary by person. Therefore, if a person has high cadmium levels, it is difficult to link their exposure to a specific source. To identify a specific source common to a group of people, it would be necessary to:

- Recruit a randomized sample of the population
- Collect and analyze samples using standardized methods, and
- Systematically collect information about other potential sources of cadmium exposure.

In this case, OHA collected urine cadmium data intending to inform health care providers and patients who make health care decisions. Collection was not systematic. Therefore, OHA cannot use the urine cadmium test data for public health tracking or community health assessment.

Next steps

OHA will provide summary results of the urine cadmium tests to all interested community members and stakeholders. OHA will uphold privacy protections for individual health information as the law requires.

Conclusion 9

There was no statistically significant increase in bladder cancer or lung cancer rates in the three census tracts around Bullseye glass from 1999 to 2013.

Basis for decision

Lung cancer is associated with prolonged inhalation of:

- Arsenic
- Cadmium, and
- Hexavalent chromium.

Bladder cancer is associated with prolonged exposure to arsenic. OHA evaluated lung and bladder cancer data for three census tracts around Bullseye Glass. OHA did not find any evidence that reported bladder and lung cancer rates for these census tracts were any different than predicted for the population size.

Next steps

OHA will ensure that through this PHA, the evaluation of cancer data are disseminated to all interested community members and stakeholders.

Table Executive summary

Summary of Bullseye Glass PHA health conclusions, by environmental exposure for all scenarios

Exposure	Possible harm to health		
	Cancer* risk from chronic exposure	Non-cancer† risk from chronic‡ exposure	Non-cancer risk from acute§ exposure
Past air‖	Unknown	Unknown	No
No intervention	Potential	Potential	Unknown
Current air	No	No	No
Soil	No	No	No
Produce¶	No	No	No

Cells with blue shading indicate when the health risk is unknown. Cells with yellow shading indicate when health has the potential to be harmed.

* Cancer risk refers to the probability to develop cancer over a lifetime related to contaminant exposure from Bullseye Glass. "Potential" means OHA concludes the cancer risk from exposure could be high. In this case, arsenic and cadmium are why there is a "potential" risk of cancer.

† Non-cancer risk refers to the risk to develop a health effect other than cancer under various exposures scenarios related to Bullseye Glass. Each contaminant of concern for Bullseye Glass has different health effects. See text of report for details on health effects. "Potential" in a "non-cancer" column indicates that at least one contaminant of concern is high enough for that exposure to harm health. In this case, cadmium is why there is a "potential" risk.

‡ Chronic refers to exposures that last longer than one year.

§ Acute refers to short-term exposures, less than two weeks.

‖ Past air refers to air quality around Bullseye Glass before interventions to reduce emissions in February 2016.

¶ Produce refers to items grown in the area around Bullseye Glass.

For more information

If you have questions about this report, you can contact EHAP at 971-673-0977 or toll-free at 1-877-290-6767 or via email: ehap.info@dhsoha.state.or.us.

Background and statement of issues

Site location and characteristics

Bullseye Glass is at 3722 SE 21st Avenue in Portland, Oregon. It is near the intersection of SE Powell Boulevard and SE 21st Avenue (Figure 1), in the Brooklyn neighborhood of Southeast Portland. Bullseye Glass manufacturing operations are in a warehouse. However, the facility also includes retail, office, and studio areas and occupies one city block. (1) Bullseye Glass began operating in 1974. The company manufactures colored glass used in sculptures, stained-glass art, dishware and architecture. Bullseye Glass uses various metals as coloring agents in the glass it produces. The process involves melting raw materials at high temperatures in batches and then rolling the glass into sheets. Most emissions come from the melting portion of the process.

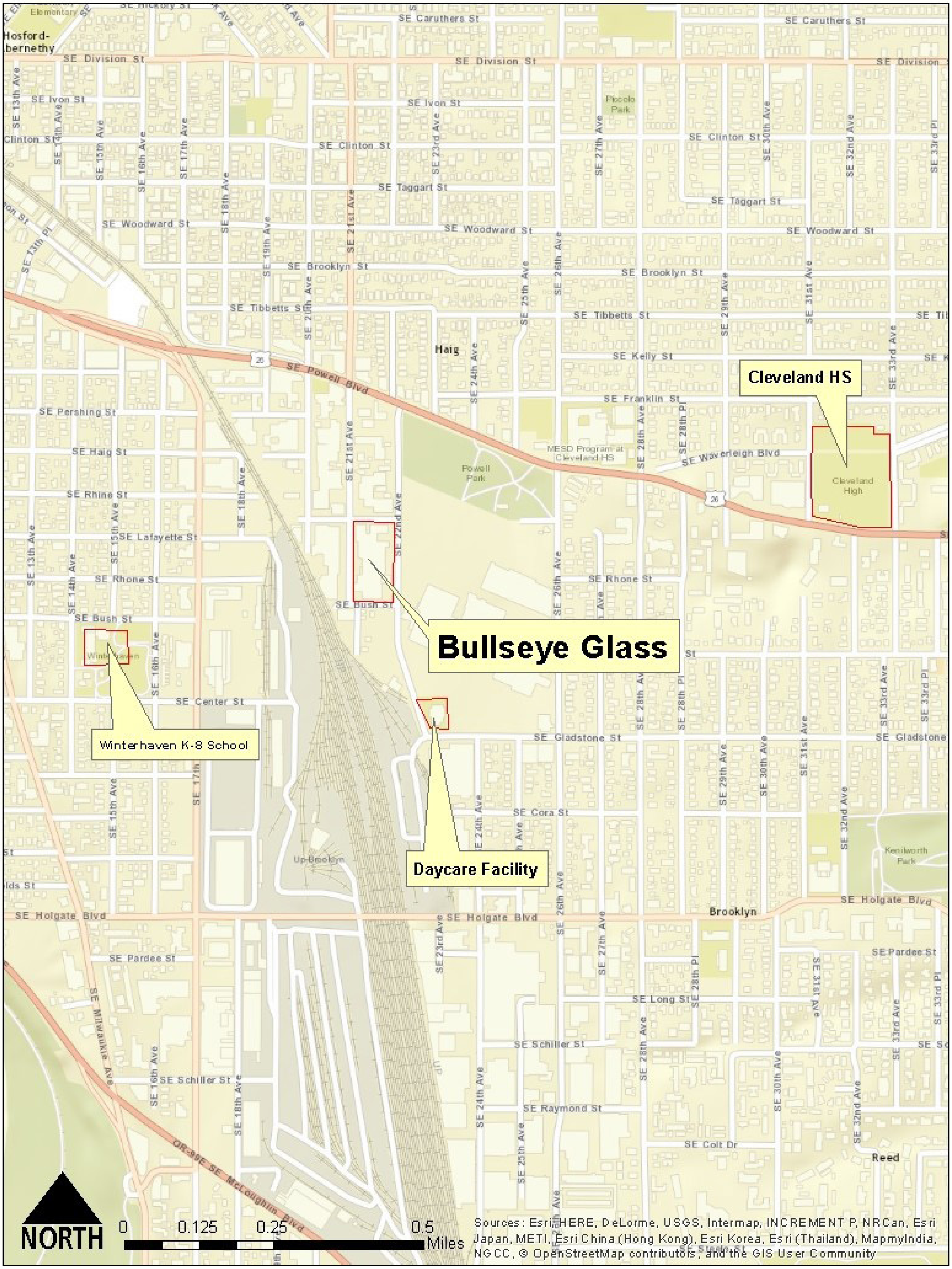
Bullseye Glass property is zoned as general industrial, as are all properties immediately north, south, and west of the facility. (1) Immediately to the east is a large parking lot for corporate offices zoned as general employment. There are other air emissions of heavy metals near Bullseye Glass:

- A major railroad line runs north and south one block west.
- A large railyard is to the south of the facility.
- A major arterial highway is one block north.
- A cement storage and loading facility is less than a block south of Bullseye Glass.

Powell Park is one block northeast of the facility and a daycare center is one block southeast. The Portland Public Schools (PPS) Winterhaven School (K-8) and Cleveland High School are within a half-mile of Bullseye Glass.

There are residences directly across the street from Bullseye Glass to the south. There are more residences less than a block to the north. There are more residences less than half a mile away in all directions. There is a more in-depth map in Appendix A that describes the Bullseye Glass site and the surrounding areas.

Figure 1. Location of Bullseye Glass site, in Portland, Oregon



Site background, investigations and OHA activities

Past investigative activities

State and federal agency activities near Bullseye Glass result from DEQ's work to understand and reduce air toxics in the Portland Metro area. From 2009-2012, DEQ conducted the Portland Air Toxics Solutions (PATS) project in the Portland Metro area. (2) DEQ worked with an advisory committee to develop recommendations for reducing air toxics emissions in the region. Members included:

- OHA representatives
- The public
- Advocacy groups
- Permitted air facilities, and
- Other stakeholders.

As part of the Portland Air Toxics (PATS) project, in 2011, DEQ produced a computer model (a simulation based on known emission sources) that projected air toxics concentrations for the year 2017. The model included several types of metals associated with estimated emissions from:

- Known industrial facilities
- Vehicle traffic, and
- Other urban activities.

DEQ used this model to better understand sources of pollutants and their concentrations.

DEQ compared the results of the model to actual measurements taken with air monitoring equipment at specific locations from 2005. DEQ made the comparison to make sure the PATS model-predicted concentrations matched actual measurements. DEQ found the model under-predicted some metal concentrations. Actual measurements in the air were higher than the values predicted by the computer simulation. This indicated there were sources of emissions of airborne metals, especially arsenic and cadmium, not accounted for in the PATS model.

The PATS project included a final report published in 2012. The advisory committee recommended that DEQ identify the missing sources of cadmium and arsenic in Portland's air. They recommended that industrial facilities that emit metals should collect better data about:

- The materials they use, and
- The emissions they create around their facilities.

At that time, DEQ was aware of glass bottle manufacturers as metal sources because they were subject to federal law; however:

- Small colored art glass manufacturing facilities were not subject to hazardous air pollutant standards, and
- Their permits did not require controls on metals emissions.

Therefore, DEQ did not identify them as significant emissions sources.

In 2013, DEQ analyzed an entire year of meteorology (weather) and air data from long-standing monitoring locations to identify cadmium sources in Portland. This study was inconclusive. It indicated there were likely several sources of the cadmium. Also, DEQ needed more information to locate those sources.

U.S. Forest Service and DEQ 2013 moss study

One way DEQ sought to gain more localized information was through a collaboration with researchers from the USFS to address any data gap in metals concentrations in the air in Portland. USFS researchers developed a research project to:

- Analyze chemical concentrations in urban moss samples, and
- Evaluate whether it would be possible to correlate chemicals in moss to concentrations of the chemicals in air measured through air sampling (monitoring).

Moss that grows on trees absorbs:

- Air pollutants from the air
- Chemicals from settling particles, and
- Pollutants in rainwater hitting the moss.

Moss in trees does not touch the soil. This means that all pollutants come from the air. At DEQ's request, USFS agreed to sample the moss for metals. This is a long-term research project which on the date of this report has not established a method to determine concentrations of air contaminants by analyzing tree moss. DEQ also sought more information on potential sources of cadmium by conducting a street-level survey of businesses near one of the long-term air monitors that measured higher-than-predicted levels of cadmium. DEQ identified another art glass manufacturer as a possible source. However, DEQ could not confirm it.

Throughout 2013, USFS researchers collected moss samples around Portland and analyzed them for an array of metals including:

- Arsenic
- Cadmium
- Chromium, and
- Lead.

In May 2015, DEQ:

- Received initial moss metal concentration data from USFS
- Examined air permit data and business listings, and
- Identified art glass facilities as potential sources of cadmium and arsenic.

Most businesses or industrial facilities that release air emissions must have a permit that is:

- Required by the federal Clean Air Act, and
- Approved by DEQ and lists materials emitted.

The areas of highest cadmium and arsenic concentrations in moss did not match DEQ's data from permitted facilities. DEQ did not have enough information from its permitted facility data to locate sources of these metals.

Moss samples collected from areas around Bullseye Glass had among the highest samples in arsenic and cadmium concentrations. Before the moss study, DEQ did not have information about the level of cadmium emissions at this facility. DEQ knew about Bullseye Glass use of metals to color glass. However, DEQ did not know how the amount of metals in the glass related to the amount released as emissions.

The United States Environmental Protection Agency (EPA) delegated authority to DEQ to fulfill federal Clean Air Act requirements regulating certain air toxics and types of facilities. This is known as National Emission Standards for Hazardous Air Pollutants (NESHAP). Under these existing rules, certain glass manufacturers must meet certain emissions limitations related to the operations of glass furnaces. At the time, NESHAP standards for glass manufacturing facilities (known as NESHAP 6S) applied only to operations whose furnaces met a definition of "continuously operated." At that time, EPA had not specifically considered whether furnaces at Bullseye Glass were in continuous operation. (Bullseye Glass makes different types of colored glass in a variable batch process.) Consistent with past EPA interpretations at similar facilities, DEQ determined that Bullseye Glass did not have to meet the requirements of NESHAP 6S.

State agency response

DEQ did not known how concentrations of metals in moss samples corresponded with actual concentrations of pollutants in the air. Therefore, DEQ developed an air sampling plan. In October 2015, DEQ placed air sampling monitors next to Bullseye Glass for approximately one month. DEQ sent the samples to an out-of-state laboratory with the equipment and expertise to process the samples. In January 2016, DEQ received the analysis and evaluated the air monitoring data with assistance from OHA. DEQ and OHA determined that cadmium and arsenic air concentrations were up to 150 times above DEQ's annual ambient benchmark concentrations at Bullseye Glass. The benchmarks are non-regulatory, health-based clean air goals set by DEQ to protect against long-term or chronic health risks.

Local media obtained and published the preliminary data, which raised public concern. DEQ and OHA responded to concerns about the public exposure to these levels of arsenic and cadmium. On Feb. 19, 2016, Oregon came to agreements with Bullseye Glass to immediately stop using cadmium, arsenic, and hexavalent chromium. The state suspected trivalent chromium converted to hexavalent chromium (a much more toxic form of chromium) during the glass-making process. Bullseye Glass also agreed to stop using trivalent chromium. Testing conducted at Bullseye Glass in 2016 later determined that nearly 100% of total chromium exiting the stack was in the hexavalent form. This was regardless of the form that went into the furnace.

DEQ received results from the October 2015 monitoring at the end of January 2016. In February 2016, DEQ placed four air monitoring stations around Bullseye Glass. The monitors helped better assess concentrations of metals emitted from the facility (Figure 2). One of the monitors was in the same location to the east as the original monitor from the October 2015 air sampling (parking lot of Fred Meyer corporate offices on SE 22nd Avenue). Two of these monitoring stations ran in 24-hour cycles from March 1, 2016 through March 30, 2017 (air monitors at the nearby daycare center and the parking lot of Fred Meyer corporate offices). The monitoring station to the west at Winterhaven School operated through Sept. 30, 2016. The monitor near the residential area to the north at SE Haig and SE 20th Avenue operated through Oct. 20, 2016.

DEQ also collected soil samples from this area in two rounds (Figure 2). The first round of soil sampling, conducted from February 12-17, 2016, included:

- Powell Park
- The nearby daycare center, and
- The parking strip along the edge of the Fred Meyer corporate office parking lot.

The second round of soil sampling conducted July 28, 2016, included parking strips in residential areas to the southeast and northwest of the facility.

OHA did not recommend urine testing for cadmium. However, because of community concerns, OHA offered reimbursement for urine testing for those within a half-mile radius of Bullseye Glass through:

- Home
- Work, or
- School.

OHA also made detectable urinary cadmium levels a reportable condition in Oregon. This meant healthcare providers who received test results had to report them to OHA. An analysis of these results from around Bullseye Glass is in the biological and health outcome data section of this PHA.

In September 2016, DEQ issued new rules for art glass manufacturers statewide. These new rules required facilities to have appropriate emissions control devices when they make batches of colored glass (five or more tons per year) and use heavy metals such as:

- Arsenic
- Cadmium
- Chromium, or
- Lead.

EPA, in response to a request for interpretation from DEQ:

- Determined in April 2016 the NESHAP 6S standards mentioned above apply to batch art glass manufacturers such as Bullseye Glass, and
- Adopted a schedule for facilities to come into compliance with that standard.

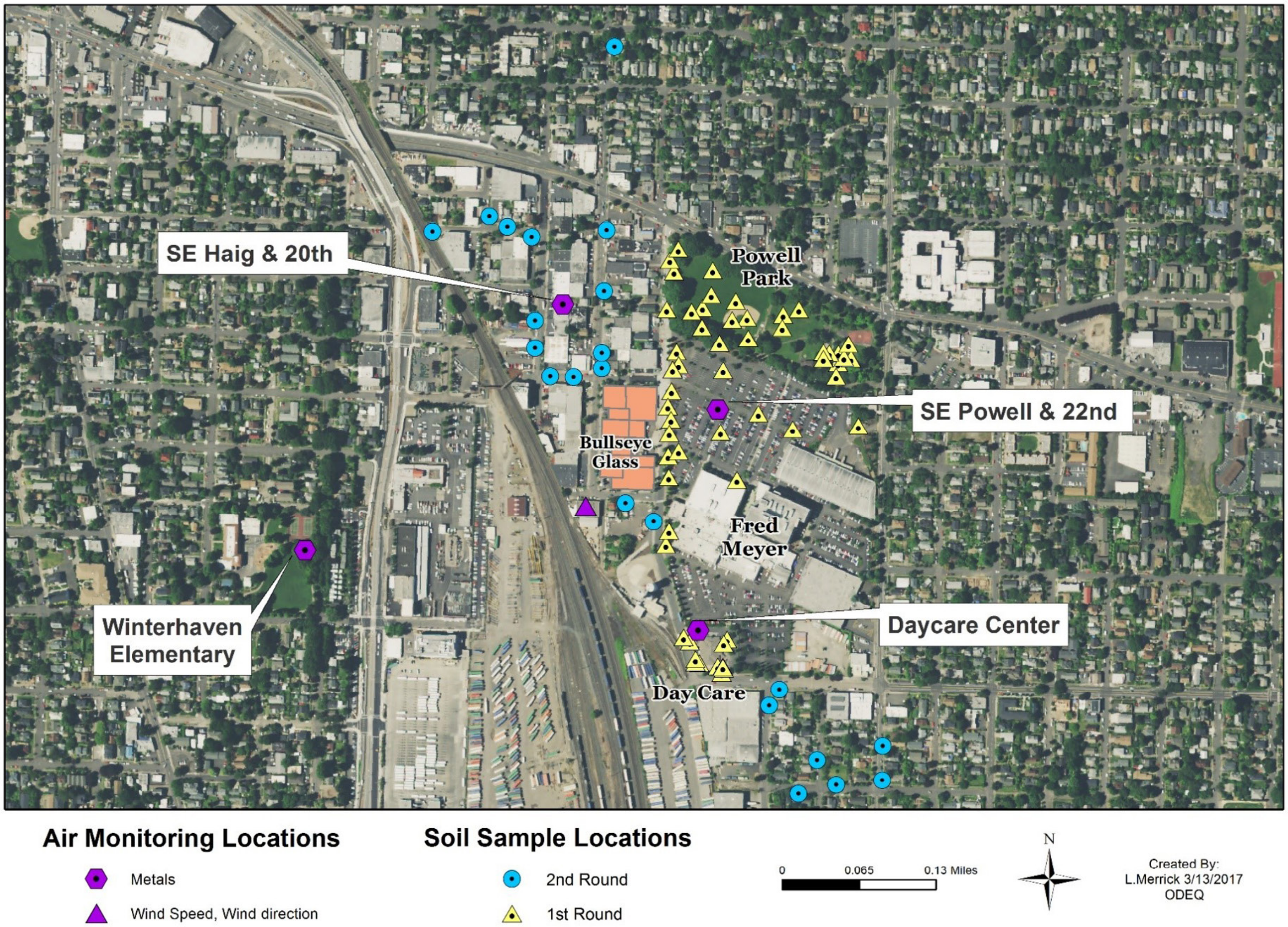
In November 2018, Oregon adopted new state rules to regulate industrial facilities statewide using a different approach based on the health risks they pose to neighbors. This regulatory program was developed by DEQ and OHA. DEQ administers the program, called Cleaner Air Oregon. It applies to all new and existing facilities in Oregon that require air discharge permits from DEQ. The program requires that facilities:

- Report on a wide range of toxic air contaminants, and
- Assess health risks to neighbors.

DEQ regulates facilities based on the results of those risk assessments.

For a more complete list of public health actions, see the Public Health Action Plan included in the recommendations section of this report.

Figure 2. Location of 2016 air monitoring stations and soil sampling locations near and around the Bullseye Glass facility. The October 2015 monitoring station was at SE Powell and 22nd Avenue



Demographics

Bullseye Glass operates within the Brooklyn Neighborhood in southeast Portland, Oregon. Approximately 5,042 people live within a one-half-mile of the site. (3) Residents in the area are:

- 81% white
- 6% Hispanic
- 6% Black
- 5% Asian
- 1% American Indian
- 2% other races, and
- 5% of two or more races. (3)

Approximately 42% of residents are low income (twice the United States poverty rate) (3). Of the population:

- 7% have less than a high school education, and
- 49% have a bachelor's degree or higher. (3)

Non-English speakers at home make up 14% of the surrounding community. In linguistically isolated households (2%) Asian-Pacific Island languages are the most spoken (75%). (3)

Winterhaven School and Cleveland High School

The Portland Public Schools Winterhaven School (K-8) and Cleveland High School are within a half-mile of Bullseye Glass.

Winterhaven School is located at 3830 SE 14th Ave., in Portland. Winterhaven School is a kindergarten to 8th-grade school with 350 students for the 2015-2016 school year from September to June. (4) In 2015, enrollment of underserved groups was 21%, compared to the district's 51% average. (5) Of the student body, 13% are eligible for free or reduced lunch. (6) School hours are from 8:30 a.m. to 3:00 p.m.

Cleveland High School is at 3400 SE 26th Ave., in Portland. In the 2015-2016 school year, Cleveland High School served 1,600 students in grades 9-12, of which 171 (4%) were from other neighborhoods. (7) Of the student body, 22% are eligible for free or reduced lunch. (6) Classroom hours were 8:15 a.m. to 3:15 p.m. with many after-school activities commonly held on school grounds.

Nearby daycare center

A daycare center, operated year-round since 1994, is less than a quarter-mile away from Bullseye Glass. The daycare serves children ages 6 weeks to 5 years old, between the hours of 6:30 a.m. and 6:00 p.m. No other demographic data are publicly accessible.

Recreation and outdoor workers

Anyone who works nearby (such as Fred Meyer corporate offices or other businesses) or recreates outdoors near the site (e.g., Powell Park) may have their health affected by contamination. This demographic is difficult to define, as commercial operations and the neighborhood amenities may draw people from across the city of Portland and the metropolitan area.

Environmental justice

Low-income communities and communities of color often live and work in areas where the burdens of environmental exposure are the greatest. These same communities tend to be more susceptible to the health effects of environmental exposure. (8; 9; 10; 11) These communities may also face barriers in getting what they need to become meaningfully involved* in environmental decisions in:

- Information
- Resources, and
- Time.

OHA works to ensure environmental justice by recognizing demographic indicators that may highlight:

- Disproportionate exposures
- Increased susceptibility to disease, and
- Barriers to take part.

* Meaningful involvement means that:

(a) Potentially affected community residents have an appropriate opportunity to take part in decisions about a proposed activity that affects their environment, health, or both

(b) Public contributions can influence agency decisions

(c) Concerns of all who take part are considered in the decision-making process, and

(d) Decision-makers seek out and facilitate the involvement of those potentially affected.

There are groups and people in the community that surround Bullseye Glass who may be sensitive to the effects of environmental contaminants due to:

- Economic and psychosocial factors
- Sensitive life stages, and
- Preexisting health conditions.

Data from the American Community Survey indicate populations who live nearby Bullseye Glass are:

- 21% minority race and ethnicity, and
- 42% low-income. (12)

Other environmental justice demographic indicator values are below state averages. (12)

Data extracted from EPA's Environmental Justice Screening and Mapping Tool (EJSCREEN) indicate communities within half a mile of Bullseye Glass have higher exposure values associated with various environmental hazards when compared to state averages, including:

- Particulate matter
- Traffic proximity, and
- Lead paint. (12)

Community concerns

Addressing community concerns related to environmental health is an essential part of the public health assessment process. To identify community concerns, questions and feedback, OHA:

1. Convened the PHA-Community Advisory Committee (CAC) (see Appendix B)
2. Provided education and listening sessions to engage community members at public information sessions, meetings, and other events organized by other agency partners, including Multnomah County Health Department, DEQ, and others, and
3. Documented phone and e-mail communications.

Below is a summary of the concerns. Appendix C contains a summary of responses to these concerns.

1. Children's health

With schools and parks located within a half-mile from Bullseye Glass, community members shared concerns of health risks to young children who:

- Breath air emissions of metals while going to school
- Play outside
- Recreate in the neighborhood
- Play at parks, and
- Eat vegetables from home and school gardens.

Other concerns were:

- "How will OHA evaluate students who are going to school from outside the area versus those who live and go to school in the area?"
- "What about the combined exposure of metal emissions and recent lead in water results at Grout Elementary (within one mile from Bullseye)?"

2. Cumulative risks

Community members expressed concerns related to the cumulative effect of exposure to environmental contaminants from other sources in the neighborhood. Community members specifically mentioned emissions from the "nearby rail yard, cement plant, diesel exhaust, and tri-met bus yard." Community members also raised questions about land use and zoning considerations.

3. Past exposures

At each community event and in many discussions, community members voiced concerns over past exposures from Bullseye Glass. Community members suggested:

- Developing air dispersion models with Bullseye Glass batch records, and
- Evaluating meteorological records to better understand the geographical extent and variability of past exposures.

4. Cancer and other health issues in the neighborhood

Community members expressed concerns about cancer rates in the neighborhood. They also expressed concerns about other health outcomes including asthma and attention deficit hyperactivity disorder (ADHD).

5. Urine analysis testing and results

In late January and February of 2016, community members became very concerned and began asking health care providers to test for cadmium and arsenic. Community members expressed confusion about urine testing and analysis for these metals. People were not sure whether they should get their urine tested through the OHA-funded process. Some community members had confusion about:

- The methods and results of their testing, and
- What it meant for their health.

Community members also asked for more testing, in the form of a biomonitoring study. They also expressed a need for better education of local healthcare providers on the issue.

6. Vulnerable populations

Alongside children's health concerns, community members expressed concerns about those who live nearby Bullseye Glass with health risks from exposures experienced by:

- Communities of color
- Low-income members of the community, and
- People with preexisting health conditions.

CAC members also shared concerns for people who cannot process metals, due to a genetic mutation.

7. Gardening

Community members expressed concerns that they could not garden safely. They had concerns about heavy metals from site activities accumulating in garden soil and garden-grown plants. This made them question if produce from these gardens could be eaten.

8. Preventing and reducing exposures

While sharing concerns and frustrations, many community members also expressed a need to know what actions they could personally take to reduce their exposures to:

- Air emissions, and
- Other environmental contaminants.

Questions included, "What about indoor air and homes with air conditioning or air filtration versus those who don't have it?" Community members stated that homes in the neighborhood use rainwater for multiple purposes.

9. Risk to employees

Community members expressed concern about the health risks to glass blowers, glass art workers, and other facility workers at Bullseye Glass.

10. The gap in state industrial air emission regulations

Community members wanted to know what the state would do about the gap in regulations that allowed harmful air emissions of metals from colored glass facilities in Portland, Oregon. They wanted to know what would happen to the glass facilities, from a regulatory and enforcement perspective.

11. History of mistrust with state agencies

Community members expressed distrust of state agencies. The concerns shared by community members included the want for:

- More responsiveness to community concerns, and
- Actions that are:
  - » Respectful of community interests, and
  - » Protective of community health.

The community also shared a concern about the PHA process and lab procedures. Questions included, "What kinds of things are in place to ensure lab results are used?"

Discussion

Data sources

The data OHA evaluated in this report are what DEQ collected during the soil and air sampling events. DEQ collected these samples in response to the discovery of air quality issues described in the site background, investigations and EHAP activities section.

Air (past data)

Past air – Air monitoring data collected by DEQ near Bullseye Glass before February 2016 (before emission reductions).

Current air – Air monitoring data collected by DEQ near Bullseye Glass from February 2016 (after emissions reductions) through September 2016.

To answer the community's questions about past risk, OHA used DEQ's October 2015 air monitoring data. This very small set of data may or may not represent long-term conditions in the past. Bullseye Glass creates small batches of specialty glass at a time. Therefore, emissions likely varied month-to-month and even day-to-day over their 42 years of operations. Thus, possibly, metal concentrations from Bullseye Glass emissions were higher or lower than measured during October 2015, in both other seasons of 2015 and other years. Besides variability in emissions over time, prevailing winds change direction seasonally. Also, winds rarely blow from Bullseye Glass towards the October 2015 monitor location. On the two days with the highest measured concentrations of cadmium (Saturday, October 10 and Monday, Oct. 26, 2015), there was a small part of each day winds were blowing from the direction of Bullseye Glass to the monitor. The same is true of other metals. This means that October 2015 monitoring data could have underrepresented concentrations in locations more often downwind of Bullseye Glass.

There are significant limitations with the October 2015 monitoring data. These prevent OHA from using the data to evaluate health risks from breathing affected air over long periods before Bullseye Glass reduced its emissions (February 2016). However, OHA could use the October 2015 monitoring data to evaluate short-term risks to people who breathed affected air during that month of monitoring. OHA also used these October 2015 data to evaluate hypothetical future long-term risks to health had levels of metals measured then continued indefinitely into the future without emission reductions.

DEQ gathered these data October 2015 at the nearby Fred Meyer corporate offices (approximately SE Powell and 22nd Avenue) from October 6 through Nov. 2, 2015. This was before DEQ implemented new colored art glass manufacturing rules and emissions controls.

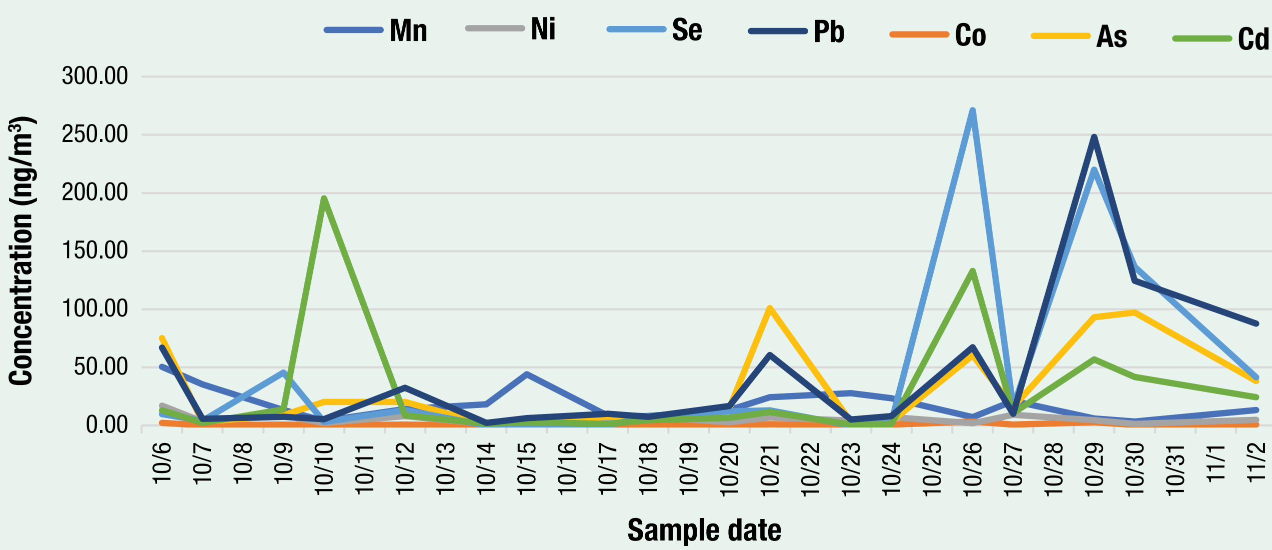
During the monitoring period, DEQ collected and analyzed 18 ambient air samples for concentrations of:

- Arsenic
- Beryllium
- Cadmium
- Cobalt
- Lead
- Manganese
- Nickel
- Selenium, and
- Total chromium (DEQ did not analyze the specific chromium, i.e., hexavalent chromium versus trivalent chromium).

It is important to note that OHA could not evaluate results for chromium because of technical issues, including the contamination of field blanks (more detail is in Appendix D).

Bullseye Glass makes batches of different colored glass at different times and at amounts based on market demand. Bullseye Glass uses different metals for different colors of glass. Figure 3 shows the wide variability in the air concentrations of different heavy metals measured at different times due to this batch process and other factors such as varying wind conditions.

Figure 3. *Air data (in nanograms per cubic meter (ng/m^3)) collected from the parking lot outside the Fred Meyer corporate offices (approximately SE Powell and SE 22nd Avenue) from Oct. 6, 2015 through Nov. 2, 2015*



This wide variability in air concentrations over time introduces uncertainty about how well this 30-day monitoring period represents Bullseye Glass's emissions over the many years of its operation. To help account for this variability and uncertainty, OHA used the 95th percent upper confidence limits (UCL) around the mean (reasonable maximum exposure) air concentrations of metals to calculate health risks in the hypothetical scenario if Bullseye had not reduced emissions. The use of 95th UCL around the mean to approximate the reasonable maximum or "worst-case" average concentration is consistent with EPA and ATSDR risk assessment guidance.

Note, there are other sources of these metals to air in the area besides Bullseye Glass.

Air (current data, after emissions reductions)

DEQ received the results of October 2015 initial air quality monitoring at Bullseye Glass at the end of January 2016. In February 2016, they placed an air monitor in the same location. DEQ added three monitors at additional locations near the site. Altogether, these four locations included:

1. The daycare center
2. The Winterhaven School
3. The parking lot of Fred Meyer corporate offices at SE Powell and 22nd Avenue, and
4. At SE Haig and SE 20th Avenue (Figure 2).

DEQ chose locations based on where the most sensitive people were likely to be exposed (e.g., children at a nearby daycare center and Winterhaven School), to:

- Be consistent with the previous monitoring location from October 2015, and
- Capture emissions from Bullseye Glass in all four directions around it.

DEQ conducted air sampling at all four of these locations beginning in mid-February 2016. The Winterhaven School monitor ran through September 2016. The SE Haig St. monitor continued running through mid-October 2016. Both the SE Powell and 22nd Avenue monitor and the daycare monitor continued running through March 30, 2017. In February 2016, sampling took place daily over 12-hour collection periods to determine whether there was an immediate risk to people in the area during work or daycare hours. OHA analyzed these data to determine whether daytime-only exposures would cause harm to health. OHA found no immediate risk based on 12-hour sampling results. Therefore, on March 1, 2016 all monitors began collecting 24-hour samples. OHA evaluated the 24-hour air monitoring data from March 1, 2016 through the end of sample collection for all four monitors. Air monitors recorded concentrations of arsenic, beryllium, cadmium, total chromium, hexavalent chromium, cobalt, lead, manganese, nickel, and selenium.

Soil

DEQ conducted two rounds of soil sampling to identify potential contamination near the Bullseye Glass site. Also, in areas used by community members. DEQ collected:

- The first round of samples during February 2016, and
- The second round during July 2016.

In the first round, DEQ collected 67 soil samples from three separate areas near the site (Powell Park, Fred Meyer corporate offices, and the daycare center) (Figure 2). In the second round, DEQ collected 26 more soil samples from parking strips to the northwest and southeast of Bullseye Glass. DEQ collected:

- Surface (1 to <6 inches below ground surface)
- Subsurface (6 to <12 inches below ground surface), and
- Duplicate soil samples from each location.

The purpose of subsurface samples was to:

- Determine the nature and extent of contamination, and
- Rule out historical or native sources for metals measured at the surface.

DEQ analyzed both rounds of soil samples for concentrations of aluminum, arsenic, cadmium, total chromium, hexavalent chromium, cobalt, iron, lead, manganese, mercury, nickel, and selenium. Also, DEQ analyzed round 1 (February 2016) samples for uranium and round 2 (July 2016) samples for beryllium, trivalent chromium, and zinc. OHA only evaluated the surface soil samples, since they represent what people are most likely to come into contact with.

It is important to note there are other sources of these metals in the soil in the area besides Bullseye Glass. Also, some of them are naturally occurring, or common in urban soil, or both.

Table 1. Number of soil samples (from DEQ's Bullseye Glass Area-Wide Soil Sample Reports) (13) (14)

Round 1 (February 12, 16, and 17, 2016)				
Sample area	Number of surface samples*	Number of subsurface samples†	Number of duplicate samples	Total samples
Powell Park	18	11	1	30
Fred Meyer	18	3	1	22
Daycare center	12	2	1	15
Total	48	16	3	67
Round 2 (July 28, 2016)				
Sample area	Number of surface samples*	Number of subsurface samples†	Number of duplicate samples	Total samples
Northwest of Bullseye	13	1	1	15
Southeast of Bullseye	9	1	1	11
Total	22	2	2	26

* Surface soil samples were collected at 1 to <6 inches below ground surface.

† Subsurface soil samples were collected at 6 to <12 inches below ground surface.

Data quality assurance and quality control for October 2015 air monitoring data

In 2017, DEQ performed extensive data quality review of the October 2015 air monitoring data. DEQ found problems with the chromium data. However, DEQ validated the data for other metals. This review is summarized by DEQ in Appendix D. In late 2019, ATSDR completed its independent review of DEQ data quality analysis. ATSDR gave OHA a technical memo confirming:

- Findings of DEQ's evaluation, and
- October 2015 monitoring data are of adequate quality to use in the PHA with certain limitations:
    - » OHA should not use chromium data for any purpose due to contamination of a filter and laboratory equipment and process issues, specifically:
        - » Field blank contamination
        - » Unresolved interferences
        - » An incomplete range of calibration standards, and
        - » Check standard recoveries outside the acceptance limits.
    - » Due to the limited number of samples, OHA should not use October 2015 data to evaluate long-term health risks from exposures before February 2016.

ATSDR's technical memo is included in Appendix D of this PHA.

Data quality assurance and quality control for 2016-2017 air monitoring data and soil data

Air monitoring and soil data from 2016-2017 were evaluated and approved by DEQ following the approved sampling plans. The air sampling and analyses were performed by DEQ (in some cases, contracted laboratories) and had three levels of review. Soil samples were collected by DEQ staff and sent to a nationally accredited laboratory for analysis. The lab reports were reviewed by DEQ staff. The quality control for both air and soil data met the project requirements in the soil and air sampling and analysis plans.

These air and soil sampling events collected enough data to identify contaminants that could pose threats to public health. Two air monitoring locations did not capture an entire year, adding uncertainty to the conclusions. However, OHA considers data collected from these soil and air samples of adequate quality to use in this Public Health Assessment.

Exposure pathways

For a contaminant to harm human health, there must be a way for people to come into contact with it. To determine if, and how, people could be exposed to air- and soil-related contamination around Bullseye Glass, OHA conducted an exposure pathway analysis. An exposure pathway analysis describes how a chemical moves from its source and comes into physical contact with people. An exposure pathway has the following five elements:

1. A source where the chemicals originate
2. A medium (for example, air, soil, or water) for a chemical to move through the environment to a place where people could come into contact with it
3. A location (point or area) where people come into contact with the chemical
4. A way (route) which people have contact with the chemicals (for example, breathing it, swallowing it, or absorbing it through the skin), and
5. A population that comes into contact with the chemical.

Depending on how much information there is about the five elements, an exposure pathway is completed, potential, or eliminated:

- **Completed exposure pathway,** means all five of these elements are present. There is a strong likelihood that people have been, are currently being or will be exposed to a contaminant. However, it does not necessarily mean the contaminant is harming people's health.
- **Potential exposure pathway,** means it is unknown whether one or more of these five elements are present.
- **Eliminated exposure pathway,** means one or more of the five elements is known to be absent. This means that exposure to a contaminant is unlikely.

OHA identified two completed, three potentials, and three eliminated exposure pathways during the evaluation of the air and soil data.

Completed exposure pathways

Table 2 describes the completed exposure pathways for the Bullseye Glass Public Health Assessment.

Table 2. *Completed exposure pathways at the Bullseye Glass site*

Pathway	Source of exposure	Location and point of exposure	Exposure route	Potential exposure population	Notes
Inhalation of air (in areas near Bullseye Glass)	Emissions from Bullseye Glass	Outdoor air near Bullseye Glass	Inhalation of air	All adults: residents; non-resident outdoor workers All children: residents; non-resident students at daycare and nearby schools	Completed exposure pathway: past, present
Ingestion of soil	Emissions from Bullseye Glass	Soil near Bullseye Glass	Ingestion of soil	All adults: residents; non-resident, and outdoor workers All children: residents; non-resident students at daycare nearby schools	Completed exposure pathway: past, present

Potential exposure pathways

Table 3 describes the potential exposure pathways identified for the Bullseye Glass site. The "consumption of produce" pathway is designated as unknown because of the lack of sampling data of produce itself. It is known that many people in the area consume vegetables grown in soil potentially affected by Bullseye Glass emissions. OHA did not address this exposure pathway quantitatively in this health assessment. However, OHA did address it qualitatively in the health evaluation section of this report.

"Inhalation of indoor air," is also listed as a potential pathway because of the lack of environmental sampling data for indoor air. In the absence of data for indoor air, OHA assumed indoor air was the same as outdoor air. This is a worst-case assumption that most likely overestimates risk. The reason being that there is some reduction in outdoor metals-laden particle levels as air moves from the outside in. However, there may be other, unidentified sources of contaminants inside buildings unrelated to Bullseye Glass emissions.

OHA also listed ingestion of indoor dust as a potential pathway because of the lack of environmental sampling data for indoor dust. The daycare near Bullseye glass did deep cleaning to remove indoor dust. That would have eliminated this exposure pathway for this group once cleaning was complete. The largest contributor to contamination of indoor dust is outdoor soil that becomes part of the indoor dust when it is tracked indoors on shoes. Therefore, OHA's assessment of risks from contact with outdoor soil partially addresses this pathway and assumes that children swallow 200 milligrams of soil per day (adults swallow 100 milligrams of soil per day). It is unlikely that indoor dust metals concentrations are much higher than outdoor soil. Therefore, the risk from exposure to indoor dust is less than the estimated risk from exposure to outdoor soil.

Table 3. *Potential exposure pathways at the Bullseye Glass site*

Pathway	Source of exposure	Location and point of exposure	Exposure route	Potential exposure population	Notes
Consumption of produce	Metals in soil	Soil near Bullseye Glass	Ingestion of locally-grown produce No data to evaluate	Adults: Ingestion of locally-grown produce Children: Ingestion of locally-grown produce	Potential exposure pathway
Inhalation of indoor air	Emissions from Bullseye Glass	Indoor spaces near Bullseye Glass	Inhalation of air No data to evaluate	All adults: residents; non-resident indoor workers All children: residents; non-resident students at daycare and nearby schools	Potential exposure pathway
Ingestion of indoor dust	Emissions from Bullseye Glass	Indoor spaces near Bullseye Glass	Ingestion of dust that sticks to hands No data to evaluate	Adults: Ingestion of dust that sticks to hands Children: Ingestion of dust that sticks to hands	Potential exposure pathway: Past, present

Eliminated exposure pathways

Table 4 shows the eliminated exposure pathways identified for the Bullseye Glass site.

Table 4. *Eliminated exposure pathways at the Bullseye site*

Pathway	Source of exposure	Location and point of exposure	Exposure route	Potential exposure population	Notes
Ground water	Soil contamination from Bullseye Glass leaching from soil into groundwater	Well water at nearby residences or other buildings (no use of groundwater)	Ingestion of water	Portland is served by a municipal water supply. There are no known drinking wells in the area around Bullseye	Eliminated exposure pathway
Surface water	Soil contamination from Bullseye Glass leaching from soil into surface water	Surface water from runoff or outfall	Ingestion of water	There are no water bodies near Bullseye Glass	Eliminated exposure pathway
Dermal contact with soil*	Emissions from Bullseye Glass	Soil near Bullseye Glass	Dermal contact with soil*	All adults: residents; non-resident, and outdoor workers All children: residents; non-resident, students at daycare nearby schools	Eliminated exposure pathway

* Metals in soil exist as inorganic compounds (there is no carbon atom in the molecule). When a person comes into contact with a metal contaminant in soil, an inorganic metal does not easily penetrate the skin barrier and enter the body. This is because it does not pass through the skin's outer layer (known as the epidermis). (15) The epidermis acts as a barrier between the environment and tissues and organs within the body. The skin prevents an inorganic metal found in soil from entering the bloodstream. When soil sticks to the skin, exposure occurs mainly through swallowing soil particles from hand-to-mouth contact. For these reasons, dermal exposure was eliminated as an exposure pathway. It was not further evaluated in this public health assessment.

Identifying contaminants of concern

OHA compared the maximum concentration of each contaminant that was found in air and soil to the most protective ATSDR comparison values (CVs; see box at right). When there was no ATSDR CV for a contaminant, OHA used environmental screening levels from other sources, such as EPA and DEQ. See Appendices E and F for more about the specific CVs or screening levels used to evaluate air and soil data.

When the maximum concentration is below or equal to the CV, the chemical does not require further evaluation since it is not expected to cause health effects. If the maximum concentration is above the CV, it requires further evaluation. It becomes known as a contaminant of concern (COC). A chemical concentration above a CV does not mean harmful health effects will occur. However, it does indicate the need to further evaluate the contaminant.

In identifying COCs, OHA evaluated each soil and air sampling location separately to assess risks for people in each area as accurately as possible. Figure 2 shows the locations where air and soil were sampled.

What is an ATSDR CV?

Comparison values (CVs) are screening tools to identify contaminants of concern at a site. CVs represent the contaminant levels in air, soil, or water that people could be exposed to on a daily basis and not experience harmful health effects. CVs are developed to evaluate exposures that are:

- Acute (short term)
- Intermediate, and
- Chronic (long term).

CVs are not environmental clean-up levels. Because CVs are created using very health protective assumptions, contaminants that exceed their CVs will not necessarily pose health risks.

Contaminants of concern

Air

For the October 2015 air data, OHA identified arsenic, cadmium, lead, and nickel as COCs. Those maximum concentrations measured exceeded CVs.

For the 2016-2017 air data, OHA identified arsenic, cadmium, hexavalent chromium, lead, and nickel as COCs. Those maximum measured concentrations (among the four air monitors) for that monitoring period exceeded CVs. For more information about the October 2015 and 2016-2017 air COCs, see Table 5 and Appendix E.

Soil

For surface soil, OHA identified arsenic, cadmium, cobalt, and lead as COCs. Those maximum concentrations DEQ measured (at certain locations) in February and July of 2016 exceeded their CVs. See Table 5 and Appendix F for information about the soil COCs. The COCs for soil and air and their general health effects are described in detail in Appendix G.

Table 5. *Contaminants of concern* for air and soil by area sampled*

Medium	Data source (location and date)	Contaminants of concern
Air	SE Powell and 22nd Avenue (Oct. 6, 2015 - Nov. 2, 2015)	arsenic, cadmium, lead, nickel
	Daycare center (March 1, 2016 - March 30, 2017)	arsenic, cadmium, hexavalent chromium, lead, nickel
	Winterhaven School (March 1, 2016- Sept. 30, 2016)	arsenic, cadmium, hexavalent chromium, nickel
	SE Powell and 22nd Avenue (March 1, 2016 – March 30, 2017)	arsenic, cadmium, hexavalent chromium, nickel
	SE Haig and 20th Avenue (March 1, 2016 – Oct. 20, 2016)	arsenic, cadmium, hexavalent chromium, nickel
Soil	Powell Park (Feb. 16, 2016)	cadmium, lead
	Fred Meyer corporate offices (February 2016)	none
	Daycare center (Feb. 12, 2016)	arsenic, cadmium, lead
	Northwest of Bullseye (July 28, 2016)	cadmium, cobalt, lead
	Southeast of Bullseye (July 28, 2016)	arsenic, lead

* Contaminants of concern (COC) are chemicals found by air or soil sampling to be present at levels indicating a need for further evaluation.

Health effects evaluation

To determine if environmental contaminants could harm the health of people exposed to them, OHA, in consultation with community residents, identified relevant "exposure scenarios." This means the places, circumstances and specific groups of people who might have been exposed to air or soil contaminants from Bullseye Glass emissions. OHA estimated how much of each contaminant could get into people's bodies. The amount that gets into people's bodies is referred to as a "dose" in toxicology. OHA then used the dose to calculate the risk of developing:

- Cancer, and
- Non-cancer health effects (health problems other than cancer).

In this section:

- **Exposure scenarios tables 6 and 7 (pages 40 and 41)**
- **Dose and risk calculations (page 41)**
  - » Cancer Risk, general information
  - » Non-Cancer Risk, general information
- **Health conclusions Table 8 (page 45)**
- **Cancer and non-Cancer analysis for each exposure scenarios (start page 45)**

For this PHA, OHA calculated doses and risk estimates for the COCs for the relevant exposure scenarios. OHA identified the COCs through the environmental screening process described in the previous section. Next, OHA developed conservative (reasonable worst-case) exposure scenarios that represent the greatest potential risk to exposed adults and children. This strategy ensures that where there is scientific uncertainty about the risk, the risk is overestimated rather than underestimated. OHA based scenarios on the two completed exposure pathways identified in the "Exposure Pathways" section (i.e., inhalation of air and ingestion of soil) and developed them with community input. See Tables 6 and 7 for a complete list of the exposure scenarios evaluated in this report.

As described previously, OHA was unable to evaluate long-term health risks from breathing the air around Bullseye Glass before February 2016. The October 2015 air monitoring data were the only information available to make quantitative estimates of past exposure. The eighteen samples collected over 30 days were insufficient to represent the 40+ years of Bullseye Glass operations. However, OHA did use the October 2015 air monitoring data for two purposes (See Table 6):

1. To evaluate health risks from short-term exposures that may have occurred during the period of monitoring.
2. To estimate what long-term health risks might have been, had Bullseye Glass continued to emit the amounts and types of contaminants reflective of that monitoring.

Next, OHA used the 2016-2017 air data from all four monitors to determine the risk for the "current conditions chronic risk" exposure scenario. These data helped determine the risk to residents who live near Bullseye Glass for a full lifetime (birth to 78 years), starting from when Bullseye's emissions were reduced in February 2016. See Table 6 for more information on the datasets used.

For surface soil, OHA selected a sampling location for four exposure scenarios (described in Table 7) based on:

- Sample location, and
- The types of land use in each location.

DEQ did not collect any soil samples from Winterhaven School or Cleveland schools. The soil at the five sampled areas may not be representative of the soil at the two schools. However, soil samples were collected from Powell Park, between Bullseye Glass and Cleveland High School (see Figure 2).

Concentrations of contaminants in soil collected closer to Bullseye Glass are too low to harm the health of anyone in the area around Bullseye Glass (see analysis in the following section). Therefore, soil samples from Winterhaven School and Cleveland schools were not needed to evaluate Bullseye-related risks from the soil.

Table 6. *Exposure scenarios related to breathing the air around Bullseye Glass in the Public Health Assessment*

Exposure scenario	Age range	Data source (location and date)
Acute past exposure	All ages	SE Powell and 22nd Avenue (10/6/2015-11/2/2015)
No intervention chronic exposure	Birth to 78 years	SE Powell and 22nd Avenue (10/6/2015-11/2/2015)
Current conditions chronic exposure	Birth to 78 years	The daycare center, the Winterhaven School, SE Powell and 22nd Avenue, and SE Haig and SE 20th Avenue (3/1/2016-3/30/2017)

Table 7. *List of exposure scenarios related to ingestion of soil around Bullseye Glass in the Public Health Assessment*

Exposure Scenario	Age range	Sampling site for past and current exposure	Rationale
Resident near the Bullseye Glass site	Birth to <78 years old*	Northwest and southeast of Bullseye July 2016	This scenario focuses on residents who were born, grew up as children, and lived as adults near the Bullseye Glass site.
Non-resident, child at the daycare center	6 weeks to <6 years old	Daycare center February 2016	This scenario focuses on children who attend the daycare center located near Bullseye Glass and do not live near the site.
Non-resident, park user at Powell Park	Birth to <78 years old*	Powell Park February 2016	This scenario focuses on park users who visit Powell Park and do not live near the site.
Non-resident, outdoor workers at the Fred Meyer corporate offices or other locations near Bullseye	21 to <46 years old†	Fred Meyer corporate offices February 2016	This scenario focuses on employees at the Fred Meyer corporate offices or other locations near Bullseye Glass who work outdoors and do not live near the site.

Note: More than one exposure scenario may apply to a person.

* The age range birth to <78 years spans 78 years, which is the average life expectancy for men and women combined. (16) (17) (18)

† The age range 21 to <46 years spans 25 years, which represents the 95th percentile estimate of tenure with a current employer from the U.S. Bureau of Labor Statistics. (16) (19)

This next section describes how OHA calculated doses for each scenario and compared them with health guidelines to determine risk. It is followed by a summary of the health effects for people in each exposure scenario.

Dose and risk calculations for cancer and non-cancer health effects

To calculate a dose, OHA made some assumptions about the frequency and duration which people come into contact with the COCs. OHA used site-specific information obtained mostly through community input. For example, community members gave feedback on school hours and park uses. When information was unavailable, OHA used default values from ATSDR or EPA. Where default values were unavailable, OHA used best professional judgment. For a complete list of the exposure assumptions and methods used to calculate doses for the COCs, see Appendices H and I.

For all chronic scenarios, OHA applied health-protective statistical methods that put more weight on sample results with the higher measured contaminant levels. Specifically, OHA used the 95% UCL of the arithmetic mean to estimate cancer risk and calculate hazard quotients (HQ), which is explained in the next section. This is because the measured concentrations were highly variable, especially for October 2015 air data. This high variability and small sample size mean that the relatively few high values have a great influence on the mean. Therefore, it is most health-protective to base conclusions on the reasonable maximum end of that variability approximated by the 95% UCL.

For past acute exposure (i.e., people breathing the emissions during October 2015), OHA used the maximum 24-hour concentrations to calculate acute risk. In other words, OHA estimated risk assuming exposure that month was at the highest level measured for a given contaminant.

Cancer risk assessment

OHA estimated people's risk of developing cancer from breathing air at the measured levels of the following metals in air samples:

- Arsenic
- Cadmium
- Total chromium
- Hexavalent chromium, and
- Nickel.

OHA also estimated cancer risk from ingesting soil with arsenic at the levels found in soil samples from the area. These contaminants were selected for a cancer risk evaluation since exposure to certain levels of these metals has been associated with cancer.

Cancer risk can be thought of as additional cancer cases in a population. Cancer risk from environmental exposure is considered in addition to the "background" risk of developing cancer over a lifetime. The American Cancer Society estimates that one in three women and one in two men will develop some type of cancer in their life. (20) These background cancers are attributed to a combination of genetic mutations (a change in a cell that alter how it works), inherited conditions (traits passed on to children), tobacco use and other lifestyle factors, common environmental exposures, and occupational exposures. The contributions of each factor to the incidence of cancer in people and communities are difficult to predict or quantify.

What is an ATSDR MRL?

A minimal risk level (MRL) is an estimate of daily human exposure to a hazardous substance. It represents the amount of a substance not expected to cause non-cancer health effects. **Exposure doses greater than MRLs do not necessarily mean that people will experience the associated adverse effects.**

Health risks depend on the amount of chemical exposure and the amount of time a person is exposed. ATSDR publishes MRLs for different exposure lengths (i.e., one chemical may have different MRLs depending on the length of exposure time):

Chronic MRL – For exposures of one year or longer.

Acute MRL – For exposures of two weeks or less.

When assessing cancer risk from a site-specific exposure, a cancer risk (or probability) is expressed in terms of chances in a million ($1x10^{-6}$ or 0.000001). For example, a one-in-a-million cancer risk means that for every one million people with that same site-specific exposure for the same period, one *additional* person could develop cancer (due to that exposure) at some point in their life. This one-in-a-million increase of cancer is *in addition* to the roughly 400,000 people out of one million (approximate background rate for men and women) that would be expected to get cancer from all causes combined. It is not possible to determine which one of the 400,001 cancer cases is the additional case due to a site-specific exposure.

OHA considers cancer risk that falls between one additional case of cancer per million people ($1x10^{-6}$) and one additional case per ten thousand people ($1x10^{-4}$) as being low.

Non-cancer assessment

OHA evaluated the non-cancer hazard associated with chronic soil ingestion and air inhalation near Bullseye Glass. Chronic exposure is contact with a chemical that occurs over a long time (more than one year). (24) Specifically, OHA assessed the possibility of non-cancer health effects of:

- Ingesting arsenic, cadmium, and cobalt in soil, and
- Inhaling arsenic, cadmium, chromium, hexavalent chromium, and nickel in air.

See the end of this section and the lead section for an explanation of how and why OHA evaluated lead differently from other COCs.

To determine the non-cancer hazard from these chronic exposures, we calculated a hazard quotient (HQ). An HQ is a way to quantify non-cancer health effects where an exposure dose is compared to a health guideline. A health guideline is the level of a chemical that is not expected to harm health. An example of a health guideline is an ATSDR Minimal Risk Level (MRL). When an HQ is less than or equal to 1.0 (the exposure is lower than or equal to the health guideline), it is unlikely that non-cancer health effects will occur. If it is greater than 1.0 (the exposure is higher than the health guideline), there is a need for more in-depth analysis to determine whether an exposed person could experience adverse health effects that are not cancer. The in-depth analysis includes factors such as:

- The severity and permanence or reversibility of the health effect underlying the health guideline
- The degree of certainty in the science underlying the health guideline (health guidelines for different chemicals have variable levels of uncertainty built in based on the underlying toxicological studies)
- Characteristics of the exposed population that might make them more or less sensitive to the health effects of the contaminant (such as age), and
- The degree of certainty about the measured or modeled concentrations of the contaminant and how representative they are of the conditions to which people are exposed.

OHA's ultimate conclusions for each scenario result from an in-depth analysis of the above factors that vary by exposed population and contaminant. Therefore, not all HQs greater than 1.0 result in a conclusion of harm. An HQ of 5 in one situation for one contaminant may result in a conclusion of harm. However, it might not for another contaminant in another situation. The conclusions are not a direct outcome of calculated HQs. However, HQs are useful tools to determine when there is a need for in-depth analysis.

When a person is exposed to more than one contaminant in the same medium (air or soil), we can calculate the total non-cancer hazard posed by all the contaminants. We do so by adding the HQ for all the COCs together, which yields a hazard index (HI). As with HQs, an HI less than or equal to 1 means that non-cancer health effects for the whole mixture of COCs are unlikely, while an HI greater than 1 would trigger an in-depth analysis of the mixture. However, it is only scientifically valid to add non-cancer hazards from different contaminants if the contaminants target the same organ or organ system. To add the non-cancer hazards of multiple contaminants, the common health effects must also operate within the same period of exposure. For example, non-cancer hazards from acute duration exposures cannot be added with non-cancer hazards from chronic exposures. For Bullseye Glass, the hazards from each chemical affected a different organ system or systems from all other chemicals evaluated. OHA, therefore, concluded it is not appropriate to add non-cancer hazards to calculate HIs for this Bullseye Glass public health assessment.

Lead assessment

OHA follows EPA and ATSDR guidance to evaluate the health risks from the heavy metal lead in a process that is separate and different from what has been explained so far. Lead has been studied for so long that we know a lot more about how lead gets into our bodies and influences health than most other hazardous chemicals. EPA developed a special model for child exposure called the integrated exposure uptake and biokinetic (IEUBK) model. This model estimates blood lead concentrations in exposed children based on concentrations of lead in different environmental media (soil, air, drinking water, food, etc.). When environmental lead data are not available for a medium, the model provides default values to assume based on national studies. What we know about the health risks from lead exposure is all based on the concentration of lead in the blood of the exposed person rather than the dose that is inhaled, swallowed, or absorbed through the skin. Lead is different from almost all other environmental contaminants in this way. That is why lead is evaluated differently than what has been described so far. It is also why OHA did not calculate HQs for lead as it did for other contaminants related to Bullseye Glass. See the exposures to lead section for details about why OHA could not apply the IEUBK model for this PHA.

Summary of health conclusions

Table 8 provides a summary of the exposures that OHA evaluated in this PHA and indicates if they could harm health. Subsequent sections give detailed information about air and soil exposure scenarios.

Table 8. Summary of the Bullseye Glass Public Health Assessment health conclusions, by type for all exposure scenarios

Exposure	Could people's health be harmed?		
	Cancer* risk from chronic exposure	Non-cancer† risk from chronic‡ exposure	Non-cancer risk from acute§ exposure
Past Air‖	Unknown	Unknown	No
No intervention	Potentially	Potentially	Unknown
Current air	No	No	No
Soil	No	No	No
Produce¶	No	No	No

Cells with blue shading indicate when the health risk is unknown. Cells with yellow shading indicate when health has the potential to be harmed.

* Cancer risk refers to the probability of developing cancer over a lifetime specifically related to exposure to contaminants from Bullseye Glass. A "potentially" in this column means that OHA concludes the cancer risk from this medium is unacceptably high. In this case, arsenic and cadmium are driving the "potentially" determinations.

† Non-cancer risk refers to the risk of developing a health effect other than cancer under these various scenarios following exposures related to Bullseye Glass. Each of the contaminants of concern for Bullseye Glass has different health effects. See text of report for details on health effects. A "potentially" in a "non-cancer" column indicates that at least one of the contaminants of concern is high enough in that medium to harm health. In this case, cadmium is driving the "potentially" determination.

‡ Chronic refers to exposures that last longer than one year.

§ Acute refers to short-term exposures, less than two weeks.

‖ Past air refers to air quality around Bullseye Glass before interventions to reduce emissions in February 2016.

¶ Produce refers to items grown in the area surrounding Bullseye glass.

Exposure scenarios related to air

Discussion of the following three exposure scenarios is all related to inhalation of air around Bullseye Glass. For each of the three scenarios, OHA assumed the most exposure possible within the scenario. For example, the two chronic scenarios assumed a full lifetime of exposure (from birth to 78 years old) breathing the air 24 hours a day, seven days a week. Therefore, findings related to health risk represent the probable worst-case. Also, people spending less time in the area would have less health risk than what OHA estimated here.

Past *acute* risk based on October 2015 air monitoring data

The maximum 24-hour air concentration of arsenic measured at the SE Powell and 22nd Avenue location (101 ng/m^3) did not exceed the acute health guideline (called a reference exposure level or REL). California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA) developed the guideline. The acute REL is 200 ng/m^3 for arsenic. (22) The air concentration of nickel also did not exceed the REL. (23) Therefore, OHA did not further evaluate the acute health risk from inhaling arsenic or nickel near Bullseye Glass as concentrations were too low to cause acute health risks.

Measured cadmium levels at the SE Powell and 22nd Avenue location indicated that multiple (four out of 18 days monitored in October 2015) 24-hour concentrations of cadmium were higher than ATSDR's acute Minimal Risk Level (MRL, 30 ng/m^3). The acute MRL for cadmium is based on studies in rats exposed for 6.2 hours per day five days per week for two weeks. The most sensitive health effect observed was inflammation in the lungs. (24) The maximum concentration measured in October 2015 (195 ng/m^3) was 6.5 times higher than the acute MRL (which would result in a hazard quotient of 6.5) (See Table 9). This acute MRL has a total uncertainty factor of 300, meaning that the air concentration where lung inflammation was observed in the rat study was 9,000 ng/m^3. The maximum concentration measured (195 ng/m^3) at the SE Powell and 22nd Avenue location was 46 times less than this. Therefore, OHA concludes that exposure to concentrations of cadmium measured near Bullseye Glass before 2016 was ***unlikely to cause lung inflammation or other non-cancer health effects following short-term exposures.***

"No intervention" chronic risk to residents

This is a hypothetical exposure scenario that includes hypothetical people:

- Born in the area at the beginning of October 2015, and
- Who live their whole lives close to Bullseye Glass.

This hypothetical scenario assumes that levels of contaminants measured by DEQ in October 2015 had continued long-term (from one year to up to a full 78-year lifetime) into the future from that point, without the February 2016 emission reductions. This exposure period spans 78 years, which is the average lifespan in the United States. (16) OHA assumed residents would spend 24 hours per day for 365 days per year in the area. The cancer risk and non-cancer HQs for air are presented in Table 9. More information is provided in Appendix H about:

- The assumptions OHA made, and
- The values and equations OHA used to calculate these estimates.

OHA used air data collected from the SE Powell and 22nd Avenue monitor from Oct. 6, 2015 through Nov. 2, 2015 to assess the hypothetical risk to a person from birth to age 78 with no interventions to reduce emissions (Table 9). Based on these air data, arsenic, cadmium, and nickel were identified as contaminants of concern needing further evaluation. The results of OHA's evaluation are described in the sections below.

Cancer

OHA calculated a cancer risk value from the combined concentrations of arsenic, cadmium, and nickel of 600 in 1,000,000 for a hypothetical person who resided near Bullseye Glass for 78 years (from birth to age 78; Table 9) had there been no emissions reductions from Bullseye Glass in February 2016. Arsenic would have been the greatest contributor to the cancer risk. Nickel would have contributed the least. OHA considers these risk levels to be elevated. **Breathing the air represented by the October 2015 data set from birth to age 78 *would have* posed an elevated cancer risk due to airborne arsenic, cadmium, and nickel had emissions from Bullseye Glass not been reduced.**

Non-cancer

Arsenic – OHA used a non-cancer chronic reference exposure level (REL) for arsenic (derived by OEHHA) as a health guideline to evaluate the non-cancer risks to hypothetical residents associated with arsenic. (22) For non-cancer risk, OHA assumed residents would have lived in the area long-term, defined as one year up to a 78-year lifetime. Based on 95% UCL for arsenic measured as part of the October 2015 air monitoring data, the chronic HQ for arsenic without emissions reductions from Bullseye would have been 6.6. HQs greater than 1 trigger the need for a more in-depth analysis.

The 95% UCL for arsenic (99.7 ng/m^3) measured at the SE Powell and 22nd Avenue monitor in October 2015 was about 7 times higher than the REL for arsenic (15 ng/m^3) (See Appendix H for details). This REL is set based on studies of communities exposed to arsenic in their drinking water. (25) OEHHA converted the water concentrations from the studies into air concentrations that would likely result in the same internal dose as the water concentrations in the study. The health effect of concern is decreased intellectual function in children. The REL has an uncertainty factor of 30. This means that the air concentration equivalent to the water concentration causing a 1-point drop in IQ in 10-year old children in the published study was 460 ng/m^3. The 95% UCL for arsenic measured at the SE Powell and 22nd Avenue monitor in October 2015 (99.7 ng/m^3) was only 4.5 times less. **Had arsenic concentrations measured near Bullseye Glass in October 2015 continued for a year or more without intervention:**

- **Children living in the area *could have been* at an elevated risk for decreased IQ.**
- **Children and adults could also have been at elevated risk for decreased lung function.**

The following could have been at increased risk for the health effects of arsenic:

- Children with other exposures to arsenic
- Children with other risk factors for decreased IQ, or
- Children or adults with other risk factors for decreased lung function.

Other potential health effects caused by arsenic at higher levels of exposure and information about other sources of arsenic are described in Appendix G.

Cadmium – Based on October 2015 air monitoring, the 95% UCL concentration of cadmium would have generated an HQ of 8.4 based on chronic kidney effects (Table 9). HQs greater than 1 trigger the need for a more in-depth analysis.

The 95% UCL for cadmium (84.2 ng/m^3) measured at the SE Powell and 22nd Avenue monitor in October 2015 was 8.4 times higher than the chronic MRL for cadmium (10 ng/m^3) (See Appendix H for details). This MRL is set based on studies of communities exposed to cadmium by conditions in their local environments. (24) The health effect of concern is increased β2-microglobulin proteinuria (protein in the urine), which is an early indication of potential kidney damage. This MRL has an uncertainty factor of 10, which means observed effects in the test sample were associated with an air concentration of 100 ng/m^3. The 95% UCL for cadmium (84.2 ng/m^3) was only slightly less than this. Had cadmium concentrations measured near Bullseye Glass in October 2015 continued for a year or more without intervention, people living in the area could have been at elevated risk to have protein in their urine. People who have preexisting kidney problems, such as what sometimes results from diabetes, would be expected to be at increased risk. People with other sources of cadmium exposure such as a history of exposure to cigarette smoking would also be at increased risk for kidney effects. (24) Other potential health effects caused by cadmium would only occur at higher doses and are described in Appendix G.

Nickel – Based on October 2015 air monitoring and using the 95% UCL concentration for nickel, EHAP calculated a chronic HQ of 0.1 for the resident child scenario (Table 9). **Exposure to measured concentrations of nickel *would have* been unlikely to cause non-cancer health effects in residents around Bullseye Glass.**

Current risk based on air monitoring data from March 1, 2016 – March 30, 2017

EHAP assessed the current risk to people living, working, and going to school near Bullseye Glass using air data collected from four areas (the daycare center, the Winterhaven School, SE Powell and 22nd Avenue, and SE Haig and 20th Avenue) around the site from March 1, 2016 through March 30, 2017. Based on these air data, EHAP identified arsenic, cadmium, hexavalent chromium, lead, and nickel as contaminants of concern. Among the four areas tested, the daycare center monitor had the highest 95% UCL concentrations for all these contaminants except nickel. The highest concentration of nickel (95% UCL) was at the SE

Haig and 20th Avenue monitoring location. OHA used 95% UCL values from the daycare center monitor location to estimate cancer risk and calculate HQs for all contaminants. The nickel 95% UCL was the second-highest at this location and only slightly lower than the 95% UCL at the SE Haig and 20th Avenue monitor. Therefore, OHA did not calculate risk using 95% UCLs from different monitoring locations for different contaminants. Nickel's contribution to overall risk was very low compared to the other contaminants of concern. Lead was also identified as a contaminant of concern in the air. It is addressed for all scenarios further in this report.

Cancer

Based on one year's worth of air monitoring data (from March 1, 2016 through March 30, 2017), calculated cancer risks for lifetime residents in the area starting from March 2016 is 10 in 1 million for a person born in the area and living there for a 78 year lifetime (see Table 9). OHA considers these cancer risks to be low. ***OHA concludes that exposure to current metals concentrations measured in air from March 1, 2016 to March 30, 2017 is not likely to harm the health of people living, working, or going to school in the area in terms of cancer risk.***

Non-cancer

Calculated HQs for non-cancer health effects are less than 1 for all contaminants of concern (COCs) based on air monitoring data from 2016 (see Table 9). HQs for all COCs for long-term residents ranged from 0.011 from nickel to 0.096 from cadmium. ***Therefore, air concentrations of all metals measured in 2016 and 2017 are unlikely to cause non-cancer health effects in anyone currently living or spending time around Bullseye Glass.*** Regulatory standards and emissions controls began in early 2016. Therefore, it is unlikely that air concentrations would increase enough from Bullseye Glass in the future to harm health.

Table 9. Summary of Hazard Quotients for non-cancer effects and cancer risk estimates for residential exposure scenarios related to breathing the air around Bullseye Glass

Exposure scenario	Age ranges (Exposure duration)	Non-cancer hazard quotient*				Cancer risk§
		Arsenic†	Cadmium	Chromium‡	Nickel	
Acute past exposure‖	All ages (24 hours – 2 weeks)¶	0.5	6.5	-	0.1	---
No intervention chronic exposure††	Birth to <78 years old** (78 years)	6.6	8.4	-	0.1	600 in 1,000,000
Current conditions chronic exposure††	Birth to <78 years old† (78 years)	0.062	0.096	0.044	0.011	10 in 1,000,000

Abbreviations: < = less than

Hazard quotients and cancer risk were calculated using the 95% upper confidence limit (95% UCL) around the arithmetic mean for chronic exposures and the maximum result for acute exposure.

See Appendix H for detailed calculations. All values are rounded. However, complete numbers were used in all calculations.

Cells with yellow shading indicate when a hazard quotient exceeds 1.

* A hazard quotient greater than 1 does not necessarily mean that health effects are expected but indicates the need for a more in-depth analysis.

† OHA used a health guideline (reference exposure level or REL) developed by the California EPA's Office of Environmental Health Hazard Assessment to evaluate the non-cancer risk of breathing air containing arsenic.

‡ The chromium measured was hexavalent chromium so OHA used the ATSDR minimal risk level for inhalation of hexavalent chromium aerosol mists.

§ OHA estimated the cancer risk from exposure to arsenic, cadmium, chromium, and nickel in the air at SE Powell and 22nd Avenue from Oct. 6, 2015 through Nov. 2, 2015. Note, there is no inhalation unit risk for total chromium or trivalent chromium, and so we used the value for hexavalent chromium.

‖ Acute risk calculations are based on air monitoring data collected at the Fred Meyer corporate offices, SE Powell and 22nd Avenue from Oct. 6, 2015 through Nov. 2, 2015.

¶ An acute exposure, according to Agency for Toxic Substances and Disease Registry, is contact with a substance for 14 days or less.

"-" Data not available

"---" It is not appropriate to calculate cancer risk from exposures lasting less than 1 year because there are too many uncertainties.

†† Chronic risk calculations are based on air monitoring data collected from multiple locations around Bullseye Glass from March 1, 2016 through Sept. 30, 2016.

** The age range birth to <78 years spans 78 years, which is the average life expectancy for men and women combined. (16) (17) (18)

Health risk reduction due to interventions to reduce emissions from Bullseye Glass

Starting in February 2016, a combination of voluntary actions and new regulations caused a significant reduction in metal emissions from the Bullseye Glass facility. This section summarizes the reduction in health risks related to those reduced emissions. OHA compared cancer (Figure 4) and non-cancer risk (Figure 5) between:

- The hypothetical "no intervention" scenario based on October 2015 monitoring data, and
- The "current conditions" scenarios based on monitoring data from March 1, 2016-March 30, 2017.

Emissions reductions decreased total cancer risk by 57-fold and non-cancer risk for cadmium by 87-fold (See Figure 4 and Figure 5). Interventions similarly decreased non-cancer risk from arsenic by 108-fold.

Figure 4. Potential reductions in cancer risk due to interventions that reduced metals emissions from Bullseye Glass

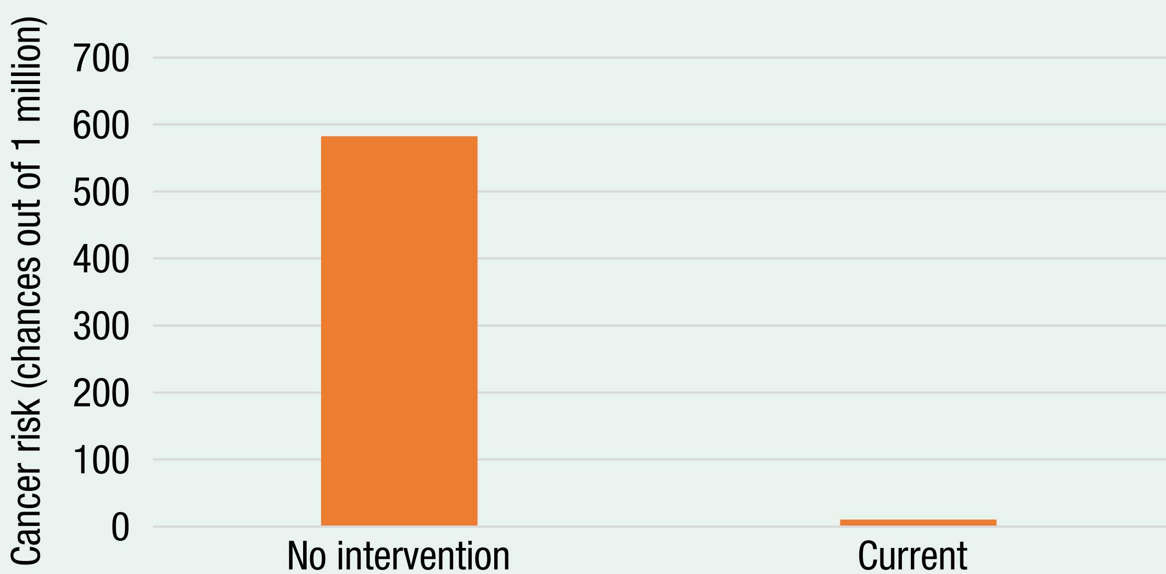
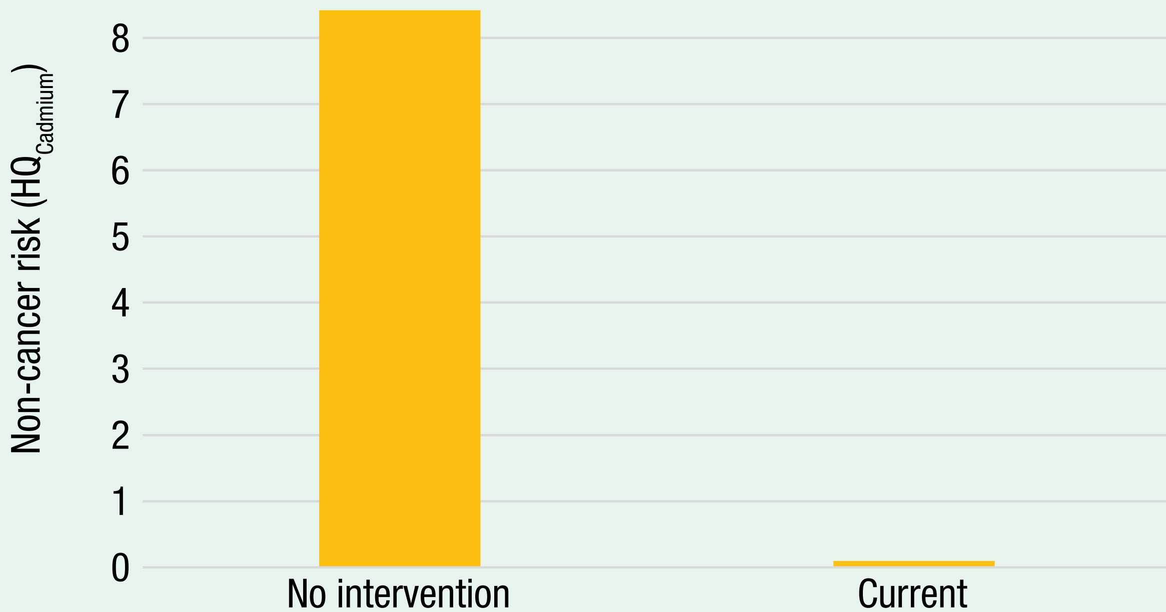


Figure 5. Potentially reduced non-cancer risk from cadmium due to interventions that reduced emissions of cadmium from Bullseye Glass



These monitoring data and analysis indicate that interventions to decrease emissions from Bullseye Glass were highly effective in reducing health risks to neighbors and visitors in the vicinity of Bullseye Glass. New state regulations since March 2016 and November 2018 are intended to ensure that reductions in emissions at Bullseye Glass and similar facilities around the state are permanent.

Exposure scenarios related to soil

Past and current risk- OHA used soil data collected from northwest and southeast of Bullseye to assess the risk for residents, soil data from the daycare center to assess the risk to children at the daycare, and soil data from Powell Park to assess the risk to non-residential park users. See Table 5 for the list of COCs for each exposure area. Cancer risk and non-cancer HQs for each scenario for soil are listed in Table 10. Among the COCs in soil, arsenic is the only one with the potential to increase cancer risk via ingestion of soil. It is important to note that, due to the volcanic history of soil in the Portland area, there are naturally occurring higher levels of arsenic in soil than in other parts of the country. The levels of arsenic measured here were not greater than what is typical for Portland.

Cancer

The lifetime cancer risks calculated from coming into contact with arsenic in the soil around Bullseye is 20 in 1 million for two exposure scenarios:

1. A person living their whole life in a house in the neighborhood southeast of Bullseye, and
2. A non-resident child who spends six years attending the daycare center south of Bullseye (see Table 10).

OHA considers these cancer risks to be low. Therefore, OHA concludes it is unlikely that anyone's health has been or would be harmed by levels of arsenic in the soil around Bullseye Glass due to cancer.

Non-cancer

OHA evaluated the non-cancer health risks from:

- Ingesting cadmium and cobalt in soil from northwest of Bullseye
- Arsenic from soil southeast of Bullseye, and
- Cadmium from the soil in Powell Park.

Based on the 2016 soil concentration data, HQs ranged from 0.00069 (adult resident living in the area from age 21 to age 78 due to cobalt) to 0.73 (resident child, ages 1 to <2 due to cadmium) (see Table 10). Because all HQs are less than 1.0, ***exposure to the COCs in the soil around Bullseye Glass is unlikely to cause harm to health for anyone, including young children.***

Table 10. Summary of hazard quotients for non-cancer effects and total lifetime cancer risk estimates for people exposed to contaminated soil northwest or southeast of Bullseye Glass, at the daycare center, or Powell Park

Data source	Exposure scenario	Age ranges	Non-cancer hazard quotient*			Total lifetime cancer risk (arsenic)†
			Arsenic	Cadmium	Cobalt	
Northwest of Bullseye Glass	Resident	Birth to <1 year	-	0.089	0.0012	-
		1 to <2 years	-	0.73	0.010	-
		2 to <6 years	-	0.48	0.0066	-
		6 to <11 years	-	0.26	0.0036	-
		11 to <16 years	-	0.15	0.0020	-
		16 to <21 years	-	0.12	0.0016	-
		21 to <78 years	-	0.050	0.00069	-
Southeast of Bullseye Glass	Resident	Birth to <1 year	0.010	-	-	-
		1 to <2 years	0.082	-	-	-
		2 to <6 years	0.054	-	-	-
		6 to <11 years	0.029	-	-	-
		11 to <16 years	0.017	-	-	-
		16 to <21 years	0.013	-	-	-
		21 to <78 years	0.0056	-	-	-
		Birth to <78 years‡	-	-	-	20 in 1,000,000
Daycare center	Non-resident, child at the daycare center	6 weeks to <1 year	0.13	0.4	-	20 in 1,000,000
		1 to <2 years	0.19	0.57	-	
		2 to <6 years	0.12	0.37	-	
Powell Park	Non-resident, park user at Powell Park	Birth to <1 year	-	0.063	-	-
		1 to <2 years	-	0.086	-	-
		2 to <6 years	-	0.056	-	-
		6 to <11 years	-	0.031	-	-
		11 to <16 years	-	0.017	-	-
		16 to <21 years	-	0.014	-	-
		21 to <78 years	-	0.0061	-	-

Abbreviations: < = less than

See Appendix I for detailed calculations. All values are rounded; however, complete numbers were used in all calculations.

* A hazard quotient greater than 1 does not necessarily mean that health effects are expected. It does mean that an in-depth analysis is needed.

† OHA estimated total lifetime cancer risk from exposure to arsenic-contaminated soil southeast of Bullseye Glass and at the daycare center. This is because arsenic was the only carcinogen that had maximum concentrations above the ATSDR comparison value. These exceedances were present in the soil southeast of Bullseye Glass and at the daycare center.

‡ The age range birth to <78 years spans 78 years, which is the average life expectancy for men and women combined. (16) (17) (18) This age range only applies to current and past exposures because soil levels change very slowly over time.

Exposure scenarios related to locally grown produce

Many community members had significant concerns about fruits and vegetables grown near Bullseye. People expressed doubts that produce was safe to eat. They worried that eating these fruits and vegetables was exposing them to high levels of metals from the facility. Neither DEQ nor OHA tested garden produce in the area. There are no environmental data (aside from soil samples) to directly evaluate the levels of metals in locally-grown fruits and vegetables.

The presence of metals in soils does not mean plants grown in them will contain high levels of those metals. Metals are often found in urban soils from past or present land use activities and proximity to pollution sources. (26) Some metal compounds (for example, arsenic and lead) in the soil naturally occur and exist in various concentrations in all soils. Although plants and their roots can come into contact with heavy metals, studies have shown that plants from urban gardens near industrial emissions or traffic do not have high levels of metals in their plant tissue. (27) Studies that examined metals in edible plants found the rate of metals uptake was not significant (28; 29). This is because metals like arsenic, cadmium, chromium, and lead are not readily taken up by or accumulated in most garden plants. (30; 31; 32; 33; 34)

Sources of soil and soil quality in urban gardens are different from general urban soil found in parks, sidewalks, and streets. The presence of urban infrastructure (for example, buildings, roads, and sidewalks) changes soil characteristics. This often results in compaction, poor drainage, and overall lower soil quality in urban areas. (35) Most urban gardeners do not use these soils and typically amend their gardens with compost, mulch, imported topsoil, other soil amendments, and nutrients or minerals. The amendments help garden soil reduce any uptake of metals into plants. Urban gardening studies have found that heavy metal concentrations are reduced by several factors, such as:

- The addition of organic matter (for example, adding compost or mulch)
- The presence of other less-toxic metals (for example, zinc reduces a plant's uptake of cadmium), or
- The addition of phosphorus fertilizer. (36)

These amendments result in metal concentrations lower than the "native" urban soil around it.

The most significant exposure pathway for gardeners is ingesting the soil itself, as it sticks to a gardener's hands or the outside of the produce. (37) Since all metal concentrations in the soil around Bullseye Glass were very near background levels (i.e. the levels typically found in the Portland Metro area), it is highly unlikely for produce to contain higher levels of metals. OHA concludes that it is unlikely that consumption of the produce from nearby gardens would pose a threat to the health of residents, especially if the produce is peeled or washed before consumption. There are health benefits from growing and consuming fresh vegetables. These health benefits outweigh any negligible risks from the levels of metals often present in the soil.

Exposures to lead

Lead was identified as a COC. There is no "safe" level of lead. Therefore, OHA does not calculate HQs for lead. OHA evaluates the health risks related to lead in two ways.

1. OHA compares measured concentrations against the National Ambient Air Quality Standard (NAAQS) for air and levels typical for urban environments and Oregon for soil. The NAAQS for lead (150 nanograms per cubic meter (ng/m^3)) is based on a three-month average. No three-month period exceeded the NAAQS for the lead. However, there is no "safe level" of lead in children's blood.

2. OHA tries to apply the integrated exposure biokinetic (IEUBK) model developed by the EPA. The IEUBK model estimates blood concentrations in children based on measured concentrations of lead in environmental media. Unfortunately, the IEUBK model requires longer periods of measured air concentrations than available from around Bullseye Glass to calculate a reliable estimate of blood concentrations. Therefore, OHA could not apply the IEUBK model in this PHA. The discussion and conclusions below apply to all exposure scenarios for both air and soil exposures.

Lead in Air (past and hypothetical "no intervention" scenarios)

Measured concentrations of lead were higher than the NAAQS for lead on one out of 18 days sampled in October 2015. Other days likely could have been above the NAAQS throughout Bullseye Glass's history of operations.

As described above, we were unable to apply the IEUBK model to data from around Bullseye Glass. This means that **there is insufficient information to determine whether or not lead levels in the air around Bullseye Glass would have been high enough to harm people's health:**

- **Before 2016, or**
- **In the future without intervention.**

Lead in air (current conditions)

From March 1, 2016 to March 30, 2017, lead was measured above the NAAQS at one out of four monitoring locations (daycare location) on two consecutive days out of 331 days sampled. A single two-day elevation in air lead concentrations like this is unlikely to harm anyone's health. However, repeated spikes over time could be of concern. Therefore, DEQ issued a temporary cease and desist order to halt Bullseye Glass' operations until DEQ could issue permanent state regulations to ensure lead could only be used in furnaces with emissions controls. Current rules require controls that should prevent similar patterns of temporary elevations in lead concentrations in the future. ***Under present conditions, exposure to lead in the air from Bullseye Glass is not likely to harm the health of people living, working, or going to school in the area.***

Lead in soil

Measured lead concentrations were similar to lead concentrations in urban soils. The concentrations are below levels that would require DEQ clean-up actions in a residential or any other setting. There is no indication that Bullseye Glass is the source of lead in samples that tested higher than background levels. ***OHA concludes that lead in soil around Bullseye Glass poses no special risk beyond typical urban soil in any of the exposure scenarios.*** Normal precautions to minimize exposure to lead in any urban soil should be taken. Precautions include:

- Removing shoes before entering homes to avoid tracking soil particles indoors, and
- Washing hands after working or playing in soils (as in gardening).

Homegrown vegetables should be thoroughly washed before consuming to remove any soil particles stuck to them.

Children's health

OHA and ATSDR recognize that infants and children are more vulnerable than adults to contaminated air, water, soil, or food. This is because:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are shorter. They are more likely to breathe airborne particles from dust and soil.
- Children are smaller. Their size results in higher doses of chemical exposure per body weight.
- Children are more likely to put soil and contaminated objects in their mouths.
- Children are still developing. Permanent damage can occur if toxic exposures happen during critical stages of growth.
- Children depend on adults to make decisions that can influence the levels of environmental contaminants they are exposed to, such as:
  - » Choices about their food and water, and
  - » Where they spend their time.

OHA and ATSDR are committed to evaluating the special interests of children at and around Bullseye Glass. It is important to note that the health-based screening values OHA used for air and soil were based on health guidelines that incorporate a high level of protectiveness for children and other sensitive people.

In this PHA, children were identified as the most vulnerable to health problems caused by metals in the soil and air. This PHA takes into account the special vulnerabilities of children. OHA used body weights and ingestion rates specific for children. OHA also considered specific age and weight ranges for each exposure scenario. OHA carefully evaluated child exposures to carcinogens. For example, OHA used a highly conservative cancer slope factor for arsenic. Also, OHA evaluated cancer risk with consideration of the enhanced influence of hexavalent chromium from early-life exposures due to its mutagenic mode of action.

Biological and health outcome data

Cadmium in urine testing results

Many people wanted medical tests to measure their exposure when they learned about the elevated cadmium and arsenic levels in the air around Bullseye glass in Portland.

OHA did not recommend testing for reasons discussed below. However, OHA recognized that many community members were independently obtaining urine cadmium tests. OHA reimbursed people who obtained urine cadmium testing who lived within one mile of Bullseye Glass or Uroboros Glass. OHA consulted with partners at ATSDR, Multnomah County Health Department, the Oregon Poison Center, and the Northwest Pediatric Environmental Health Specialty Unit (PEHSU) to develop guidance for clinicians on how to order the appropriate test and interpret the results. OHA also communicated that the medical testing (urine collection) results would have limited use informing individual health care decisions. Since the samples were collected in a non-systematic manner, the results would not:

- Give answers about the general population, or
- Determine causation.

OHA and partners made several revisions to the guidance document. The revisions addressed additional concerns about interpreting results and laboratory detection limits.

Measuring cadmium in urine

Typical clinical laboratory test methods for detecting cadmium in urine are designed to address occupational exposures. Occupational exposures are typically much greater than exposures outside of the workplace. For example, the Occupational Safety and Health Administration (OSHA) allowable exposure limit for airborne inorganic cadmium compounds in the workplace is 5,000 ng/m^3 averaged over eight hours. Whereas, the maximum cadmium air concentration near Bullseye Glass in October 2015 was 195 ng/m^3 (Appendix E). Because of this, occupational laboratory detection limits are often higher than the concentrations seen in the non-occupationally exposed population (lower detection limits require more complex laboratory methods).

It would not be accurate or appropriate to compare community members' results to the national background levels (the Centers for Disease Control and Prevention's (CDC's) National Health and Nutrition Examination Survey, or NHANES 95th percentile). Their laboratory methods have much lower detection limits for cadmium than typical clinical laboratories. This was particularly true for children. National urinary cadmium levels tend to be lower in children than adults. (38)

When a health care laboratory measures the amount of a contaminant in urine, they also measure creatinine, a natural waste product. When measuring chemicals in urine samples, concentrations of a chemical are divided by the measured amount of creatinine excreted, adjusting for the concentration and dilution.

Children normally excrete less creatinine than adults do. When no cadmium was detected in urine samples (below what equipment can accurately detect or determine), some laboratories divided the detection limit concentration by the naturally low creatinine levels in children's urine samples. Dividing the detection limit instead of the actual concentration can result in an artificially high number. Some community members may have misinterpreted the number as high levels of cadmium in their children's urine.

Some laboratories reported values below detection limits as the detection limit in boldface type or with a "less than" sign (<). Some community members may have interpreted this to mean that cadmium had been detected, when in fact the laboratory had not detected it. The amount of cadmium that may (or may not) have been present was below the level that could be determined by the laboratory methods used. Updates to the clinician guidance tried to provide clarity around these issues.

Cadmium results reporting

In February 2016, OHA issued an administrative rule. The rule requires health care providers and testing laboratories to report results of cadmium urine testing of Oregon residents. As of March 1, 2017, OHA received cadmium in urine test results for 936 Oregonians statewide. The results include tests done because of concerns about exposure to glass factory emissions. However, the results also include people exposed in an occupational setting. There were 93 people statewide with detectable cadmium levels and 35 of them lived in Multnomah County. Of the 35 people in the county with detectable cadmium levels, 11 were less than 18 years of age and 24 were adults. Of the 35 people in the county, 13 had test results that indicated the need for further testing.

The reported cadmium data from health care providers and testing laboratories are not sufficient for OHA to make a public health conclusion about individual exposures to cadmium from emissions around Bullseye. The tests were collected to make decisions about a person's health care, not as part of a health study to determine rates of exposure among a population. The test results can only tell us if a person tested had a detectable urinary concentration for cadmium above general population levels (as compared to the NHANES 95^{th} percentile). It does not tell us meaningful information about individuals or the entire population living near (or spending time near) Bullseye Glass.

To make general statements about cadmium levels in the population living near or spending time in proximity to Bullseye, OHA would need levels of cadmium in urine from a random sample of children and adults from around Bullseye Glass, rather than results taken from people who sought testing. For each person participating in the study, OHA would need detailed personal information about the type and timing of past exposure to cadmium from all sources (such as from smoking or occupational exposure). This is because cadmium accumulates and persists in the body for many years.

Oregon State Cancer Registry rate results

Many people wanted to know if cancer rates in the area were increased when they learned about the elevated cadmium and arsenic levels in the air around Bullseye Glass in Portland.

In February 2016, OHA leadership asked OHA's Oregon State Cancer Registry (OSCaR) to conduct a neighborhood cancer rate evaluation of the areas around Bullseye Glass. (39) OSCaR is a statewide, population-based registry that collects and analyzes information about all reported cancer cases that occur in Oregon. The purpose of OSCaR includes:

1. Providing opportunities for people in Oregon diagnosed with cancer to take part in scientific research projects aimed to improve the quality of cancer treatment, and
2. Monitoring overall rates and trends in cancer in the population to target and evaluate public health actions that can help all Oregonians.

All diagnoses of cancer in Oregon must be reported to OSCaR, that includes place of residence at the time of diagnosis.

For the area around Bullseye, OSCaR evaluated the rates of cancer diagnoses from three census tracts. A census tract is a small geographic area defined by the U.S. Census. These three tracts were chosen because they best fit the area where air and moss concentrations of arsenic and cadmium were elevated. The three tracts also included locations of community concern:

- Cleveland High School
- Winterhaven School, and
- A daycare center.

OSCaR evaluated observed rates of cancer incidence (the number of new cancer cases reported, rather than the number of existing cases) of:

- Lung cancer (which is associated with arsenic and cadmium exposure), and
- Bladder cancer (which is associated with arsenic exposure).

The evaluation was for the years 1999-2013. This date range was chosen for several reasons:

1. OHA decided to "look back" 15 years. These 15 years were then analyzed in five-year increments (1999-2003, 2004-2008, and 2009-2013) to provide sufficient numbers of newly diagnosed lung and bladder cancer cases to calculate a rate.

2. The most recent complete year of data available for analysis was for cases diagnosed in 2013. The first year that OSCaR began receiving cancer reports was 1996. However, the three years of 1996-1998 were not included because it would not have been directly comparable to the other five-year periods. For each period, OSCaR calculated the predicted number of new cancer cases for the population within this area. This was done by calculating the lung and bladder cancer rates for Multnomah County (excluding the three census tracts mentioned above) and applying those rates to the population in the selected census tracts.

Cancer registry data **cannot** be used to show that chemical exposures cause cancer. It does not account for:

- The time it takes for cancer to develop
- When and where chemical exposure occurred
- The movement of people in and out of the area, and
- Other unknown cancer risk factors (such as smoking status).

OSCaR compared the calculated predicted number of cancer cases to the observed number of reported cases for particular cancers. This was done through calculating standardized incidence ratios (SIRs), which compares the observed number of cases to the predicted number of cases for the same area (SIR = observed cases ÷ predicted cases), standardized by age. An SIR greater than 1.0 indicates the number of observed cases is greater than predicted. For each SIR, OSCaR also calculated a 95% confidence interval (the range of values that describes uncertainty surrounding the estimate) to determine how likely it is the SIR is high or low due to chance (random fluctuations in the data). The SIR was considered statistically significant when the 95% confidence interval did not include the number 1.0.

OSCaR included three census tracts in their evaluation: Census tracts 9.01, 9.02, and 10 (Figure 6). OSCaR also evaluated lung and bladder cancer rates for census tract 10 alone. OSCaR did not evaluate tracts 9.01 and 9.02 alone because most of the estimated cadmium in the air around Bullseye Glass (based on air sampling and moss sampling data) were in census tract 10. Only small amounts of the estimated cadmium were in tracts 9.01 and 9.02. (40) Because of this, OSCaR combined the lung and bladder cancer rates from census tract 10 with the rates from tracts 9.01 and 9.02.

The SIR calculations that included two additional census tracts (9.01 and 9.02) assured that cancer analysis performed by OSCaR included all the populated areas exposed to elevated levels of cadmium and arsenic, based on environmental testing conducted by the DEQ. The additional SIR calculations using three census tracts (10, 9.01 and 9.02) produced similar results to the SIR calculations for census tract 10 alone. Also, it helped confirm the conclusion that there was no meaningful difference between the observed and predicted number of lung and bladder cancer cases in the area surrounding Bullseye Glass.

Figure 6. Census tracts included in the Oregon State Cancer Registry rate results for areas surrounding Bullseye Glass

Tract 10

For tract 10 (Table 11), comparing the observed versus the predicted number of lung cancer and bladder cancer cases during the 1999-2003, 2004-2008, and 2009-2013 periods resulted in SIRs that were similar to 1.0 (the confidence intervals were above and below 1.0). ***This indicates there was no meaningful difference between the observed and predicted number of lung and bladder cancer cases.***

Table 11. Lung cancer and bladder cancer for Census tract 10, 1999-2013. Observed diagnosed cases, predicted cases (based on county-wide diagnosis rates), and standardized incidence ratios

Cancer type	OBS-EXP-SIR	Years		
		1999-2003	2004-2008	2009-2013
Lung cancer	Observed cases	15	12	9
	Predicted cases	11.4	11.2	10.3
	Standardized incidence ratio (95% confidence interval)	1.3 (0.7-2.2)	1.1 (0.6-1.9)	0.9 (0.4-1.7)
Bladder cancer	Observed cases	1	1	4
	Predicted cases	3.4	3.2	3.3
	Standardized incidence ratio (95% confidence interval)	0.3 (0.0-1.6)	0.3 (0.0-1.7)	1.2 (0.3-3.1)

Tracts 10, 9.01, and 9.02 combined

For tracts 10, 9.01, and 9.02 combined (Table 12), comparing the observed versus the predicted number of both lung and bladder cancer during the 1999-2003, 2004-2008, and 2009-2013 periods resulted in SIRs similar to 1.0 (the confidence intervals were above and below 1.0). ***This indicates there was no meaningful difference between the observed and predicted number of lung and bladder cancer cases. This means lung and bladder cancer rates in these three census tracts were not elevated compared to what would be expected for the size of the population.***

Table 12. Lung cancer and bladder cancer for census tracts 10, 9.01, and 9.02 combined, 1999-2013. Observed diagnosed cases, predicted cases (based on countywide diagnosis rates), and standardized incidence ratios

Cancer type	OBS-EXP-SIR	Years		
		1999-2003	2004-2008	2009-2013
Lung cancer	Observed cases	25	38	26
	Predicted cases	35.3	34.6	29.1
	Standardized incidence ratio (95% confidence interval)	0.7 (0.5-1.0)	1.1 (0.8-1.5)	0.9 (0.6-1.3)
Bladder cancer	Observed cases	7	3	11
	Predicted cases	10.7	10.1	9.5
	Standardized incidence ratio (95% confidence interval)	0.7 (0.3-1.4)	0.3 (0.1-0.9)	1.2 (0.6-2.1)

Uncertainties and gaps in data

In any PHA, there are uncertainties. PHAs require the use of assumptions, judgments, and limited data sets. These contribute to the uncertainty in the estimation of risk.

Health guideline values and people

Some of the uncertainty in this PHA is related to the health guideline values used to assess toxicity (for example, MRLs). These values have passed a rigorous multi-agency peer-review process. However, each person is unique. People vary in their sensitivity to toxic chemicals. There is increasing evidence that some are more sensitive to the effects of environmental exposures:

- Children
- Pregnant women
- The elderly, and
- People with preexisting chronic health conditions.

These types of uncertainties are addressed by applying uncertainty factors (dividing the doses where effects were observed by numbers ranging from 10 to 1,000). This has the effect of lowering the level at which a chemical is considered toxic. This practice intends to be protective of health by building in a safety boundary to these guideline values.

There is also some uncertainty in health guideline values related to how recently ATSDR, EPA, and other health agencies reviewed scientific literature. More recent research may begin to identify more health effects that can occur at doses lower than those used to establish the health guideline values. For example, some newer studies related to cadmium suggest potential links between:

- Cadmium and breast cancer, and
- Cadmium and neurological effects on a developing brain.

More information is in the health effects summary section on cadmium (Appendix G). There may be potential additional health effects of other COC metals evaluated in this PHA not yet been identified by scientific studies. The information about the health effects are of inadequate quality to inform a health guideline value.

There are three reasons studies like these have not yet informed the health guideline values:

1. There has not yet been sufficient corroborating evidence to verify the link between the chemical and the effect

2. The studies do not include enough information about the quantitative relationship between the dose and the response to set a threshold guideline value based on it, or

3. The studies demonstrating the links were published since ATSDR's or EPA's most recent review of the scientific literature.

Air monitoring

Although every attempt was made to collect comprehensive environmental data from around Bullseye Glass, there are limitations in these data sets. For air sampling data, there are several uncertainties with the October 2015 sampling taken in the Fred Meyer corporate office parking lot (near SE Powell and 22nd Avenue). The most important are:

- Temporal representativeness (how well that one 30-day period represents conditions over the 42 years of Bullseye's operation), and
- Spatial representativeness (how well that one sampling location in the parking lot of the Fred Meyer corporate offices represents conditions in various directions and distances from Bullseye).

Temporal representativeness – Air monitoring in October 2015 revealed highly variable concentrations of metals. This related, in part, to variable emissions from Bullseye Glass from day to day in terms of volume and type of emissions. Different colored glass requires the use of different metals. Therefore, the profile of metals in ambient air has likely varied from month to month and even day to day over the multi-decade history of operation based on glass orders being filled. This raises questions about how well a 30-day snapshot in time (October 2015 monitoring) captured long-term air quality conditions before the implementation of furnace emissions controls and reduced production. Therefore, OHA did not use these data to calculate risks from long-term exposures in the past.

Spatial representativeness – The four air monitors surrounding Bullseye Glass in 2016 measured tremendously variable air concentrations of metals between them during the monitoring period. The variations reflect the effect of weather patterns on the dispersion of site-related contaminants in the area. One of the 2016 air monitors was in the same location as the October 2015 monitor. In 2016, air concentrations of metals were typically higher at the daycare monitor than at the location of the Fred Meyer monitor (same location as the October 2015 monitor). OHA evaluated annual meteorological data collected at a station located at the daycare center (data were taken throughout the sampling around Bullseye). This analysis indicated that air concentrations monitored in October 2015 likely underestimated concentrations at the most affected location. This could mean that risk calculated from October 2015 data may underestimate the actual risk at the daycare center. At the same time, the monitor located at Winterhaven School rarely showed elevated levels of metals above typical urban background over the entire course of monitoring in 2016. This may suggest that air quality at Winterhaven School has rarely been affected by Bullseye Glass metals emissions.

There are other uncertainties related to air monitoring. October 2015 sampling results did not include reliable measurements of chromium. Based on information from DEQ and Bullseye Glass, chromium was used in glass production. As stated earlier, quality problems with the chromium data from October 2015 monitoring preclude its use in this PHA. Without air monitoring data for hexavalent chromium in October 2015, chromium could not be included in the "no intervention" long-term risk scenario. Depending on actual hexavalent chromium concentrations in October 2015, the risk calculated for the "no intervention" scenario is likely an underestimate, though OHA can't estimate by how much. Last, air monitors alone cannot determine the source of all the air pollutants detected. There were periods during the 2016 DEQ monitoring when Bullseye Glass was not using any of the hazardous metals being measured by the four DEQ monitors. Yet, these metals were still detectable at low levels at the monitors then. This is because there are other likely sources of some of these metals in the area in addition to Bullseye.

However, the magnitude of the drop in metals levels between October 2015 and March 2016 (78-fold in the case of cadmium) is consistent with the conclusion that Bullseye Glass had been the dominant source of these metals in the air before voluntary changes in emissions. Measured metals levels were higher when prevailing winds were moving from Bullseye Glass to the monitoring station. This strengthens the conclusion that Bullseye was the dominant source of these metals. Bullseye Glass' voluntary reductions in emissions in early 2016 were followed by additional regulatory actions by DEQ to make them permanent and mandatory.

Soil sampling data

When a person swallows soil, the amount of a substance absorbed from that soil into the blood versus the amount not absorbed that passes through the large intestine depends on characteristics of the surrounding soil (e.g., sandy, clay, loamy, etc.). This is referred to as the bioavailability of the contaminant. OHA does not have information on the bioavailability of cadmium in the soils surrounding Bullseye. This means that OHA assumed the fraction of cadmium absorbed into the blood stream from swallowed soil near Bullseye Glass would be the same as the fraction absorbed in the studies used to establish health guideline values. This is a reasonable assumption because those studies evaluated human populations exposure through soil and air in community environments as did this PHA.

OHA had site-specific bioavailability data for arsenic and lead in soil provided by Region 10 EPA. Bioavailability was around 22% for the samples collected. This is what OHA used in risk calculations.

Dose reconstruction

Another area of uncertainty has to do with the dose reconstruction (the estimation of actual chemical dose by using exposure factors). This type of uncertainty has two parts:

1. The concentration in air and soil to be used for dose reconstruction, and
2. The amount of air people breathe, and soil people swallow.

For air and soil, OHA used a modification of the average soil or air concentration. Because a certain spot of soil may have a higher concentration than those measured, OHA used the 95% UCL of the mean. This is intended to be protective of health by leaning towards overestimation of the true average soil concentration.

OHA can't know exactly how much:

- Soil each person accidentally swallows
- Each person weighs, or
- Total time each person spends in the area near Bullseye.

In the absence of that type of specific information, OHA used standard default values developed by ATSDR and EPA and are based on studies that measured:

- How much people weigh on average, and
- How much soil people ingest on average during their daily activities.

OHA gathered information on the amount of time people spend in different places by talking with officials with Portland Parks and Recreation and the daycare center near Bullseye Glass. Appendix H and Appendix I contain detailed assumptions made in calculating doses and the rationale used to support them. Where there was uncertainty about default values, OHA tried to overestimate exposure to be protective of health.

Testing for cadmium in urine

Urine samples collected voluntarily by community members and their healthcare providers had too many uncertainties to support any conclusions in this PHA. A urinary cadmium test result does not distinguish one source of cadmium exposure from another. There are other sources of cadmium in our bodies (diet, exposure to cigarette smoke, etc.). Therefore, urine data collected in a non-systematic manner cannot be used to determine whether measured cadmium levels are related to cadmium concentrations around Bullseye. (See Conclusion 8 in the summary for additional explanation).

Use of cancer data

Cancer registry data cannot be used to show cause and effect for several reasons:

1. Cancers caused by exposure to environmental contaminants usually have long latencies. This means that there is a long time (often years or decades) between exposure and onset or diagnosis of the disease.

2. Cancer registry data also do not include information about whether, when, and where exposure to hazardous substances occurred. Also, registry data cannot account for other unrelated risk factors (such as smoking status). Cancer registry data do not account for people moving in and out of the area. They only list a person's address at the time of cancer diagnosis. This limitation is important because a diagnosed cancer may be the result of exposures that occurred years before the person lived in that location (due to long latencies).

Conclusions

OHA reached *nine* conclusions in this PHA:

Conclusion 1

OHA cannot conclude whether inhaling air around Bullseye Glass for long periods before February 2016 could harm people's health.

Basis for decision

During October 2015, before changes in manufacturing practices and emissions controls at Bullseye Glass, there were elevated levels of arsenic, cadmium, and lead measured in the air. These metals can increase the risk of health problems if inhaled in large enough amounts over a long enough period. However, one month of air monitoring data is not enough to accurately represent long-term air quality conditions related to Bullseye's 42 years in the community. October 2015 conditions may over- or underestimate the average metals in the air over those 42 years. Bullseye's operations have been variable over that period.

Conclusion 2

OHA concludes that breathing the air around Bullseye Glass during October 2015 was ***unlikely to harm people's health.***

Basis for decision

Levels of metals measured in the air near Bullseye Glass in October 2015 were too low to harm the health of people who breathed that air during that month. It is not possible to determine what levels of metals were in the air:

- Before October 2015, or
- Between October 2015 and the start of more extensive monitoring in February 2016.

Health risks from exposures during those other times could have been higher or lower than predicted based on the October 2015 monitoring data.

Conclusion 3 *Had there been no interventions to reduce metal emissions from Bullseye Glass, long-term exposure to conditions measured in October 2015* ***could have harmed people's health.***

Basis for decision

Lifetime exposure to the level of arsenic and cadmium measured in the air near Bullseye Glass in October 2015 could have posed an elevated risk of lung and bladder cancer to people living in the area. Exposures lasting a year or more to levels of arsenic measured in October 2015 could have elevated the risk of:

- Decreased IQ in children living in the area, and
- Decreased lung function in adults or children living in the area.

Exposures lasting a year or more to levels of cadmium measured in October 2015 could have increased the risk of kidney damage.

Conclusion 4 *Exposure to concentrations of metals measured in the air around Bullseye Glass since February 2016 is* ***unlikely to harm people's health.***

Basis for decision

Levels of metals measured in the air since March 1, 2016 are too low to cause health effects following short- (acute) or long-term (chronic) exposure. OHA expects regulatory and policy actions since March 1, 2016 to ensure reductions in emissions from Bullseye Glass remain permanent.

Conclusion 5 *Interventions since February 2016 dramatically reduced potential health risks from inhaling air affected by emissions from Bullseye Glass.*

Basis for decision

Compared to risk from long-term exposure without intervention, reduced emissions of metals from Bullseye Glass since 2016:

- Reduced cancer risk in the area by 57-fold, and
- Reduced non-cancer risk by 87- to 108-fold.

Conclusion 6 *Exposure to concentrations of metals measured in the soil around Bullseye Glass was* ***unlikely to harm people's health*** *in the area.*

Basis for decision

Levels of metals measured in the soil in 2016 were too low to cause health effects. Metal concentrations in the soil generally change more slowly than concentrations in air. Therefore, soil levels measured in 2016 are likely to be representative of soil conditions from the past several years or decades.

Conclusion 7

Consumption of homegrown produce harvested around Bullseye Glass was unlikely to harm people's health.

Basis for decision

Most garden produce does not absorb metals well such as arsenic, cadmium, chromium and lead. Common gardening practices such as adding compost, mulch, and other nutrients to the soil reduces the uptake of heavy metals into plants. Generally, any risk to gardeners from metal contamination in soil is from consuming soil particles stuck to the outside of garden produce. Metals concentrations measured in the soil around Bullseye were similar to those measured in urban areas around Portland and around the country. Metals concentrations are too low to harm the health of people who consume soil particles on homegrown produce.

Conclusion 8

Results of urine cadmium tests have too many uncertainties and too many scientific limits to draw a health conclusion.

Basis for decision

Exposure to cadmium can come from multiple sources, this includes:

- Food
- Air
- Soil
- Cigarette smoke, and
- Some batteries, pigments and plastics.

Exposure to these sources and the effect on urine cadmium levels can vary by person. Therefore, if a person has high cadmium levels, it is difficult to link their exposure to a specific source. To identify a specific source common to a group of people, it would be necessary to:

- Recruit a randomized sample of the population
- Collect and analyze samples using standardized methods, and
- Systematically collect information about other potential sources of cadmium exposure.

In this case, OHA collected urine cadmium data intending to inform health care providers and patients who make health care decisions. Collection was not systematic. Therefore, OHA cannot use the urine cadmium test data for public health tracking or community health assessment.

Conclusion 9

There was no statistically significant increase in bladder cancer or lung cancer rates in the three census tracts around Bullseye glass from 1999 to 2013.

Basis for decision

Lung cancer is associated with prolonged inhalation of:

- Arsenic
- Cadmium, and
- Hexavalent chromium.

Bladder cancer is associated with prolonged exposure to arsenic. OHA evaluated lung and bladder cancer data for three census tracts around Bullseye Glass. OHA did not find any evidence that reported bladder and lung cancer rates for these census tracts were any different than predicted for the population size.

Recommendations

State agencies have already taken actions that resulted in reduced exposures and health risks. These actions are documented in the *Public Health Action Plan* section below. Based on OHA's analysis of the available environmental data from the Bullseye Glass site, past public health actions, and current regulatory reform, OHA has **no additional recommendations at this time.**

Public Health Action Plan

A Public Health Action Plan describes the specific actions OHA has taken and will take to implement the recommendations outlined in this report, to prevent and reduce people's exposure to hazardous substances in the environment. OHA took numerous actions between 2016 and 2020 to respond to the immediate concerns about toxic air contaminants from Bullseye Glass and to support the development of DEQ regulations to prevent similar situations in the future. Due to the long delay in finalizing this public health assessment, it largely documents actions that have already taken place.

Completed public health actions

To date, OHA has taken the following actions:

Exposure prevention:

- Worked with DEQ to draft regulations (adopted as temporary rules in April 2016 and permanent rules in November 2016) that ensure glass manufacturers have pollution controls protective of the public's health.
- Collaborated with Oregon DEQ to establish Cleaner Air Oregon (CAO). CAO is a statewide program designed to regulate industrial emissions of toxic air contaminants to protect the health of people nearby. The Environmental Quality Commission, which oversees DEQ, adopted CAO rules in November 2018. These rules are designed to prevent a situation similar to what happened at Bullseye Glass from happening again in Oregon.

Data consulting and interpretation:

- To ensure that data would be representative of the public's exposure collaborated with Oregon DEQ on:
  - » Soil sampling plans, and
  - » Placement of air monitors in 2016.
- Assisted Oregon DEQ with reviewing preliminary 2016 soil sampling and air monitoring data that were collected immediately after air quality issues at the facility were discovered.

Guidelines and recommendations:

- Developed 2016 clinician guidance on urine cadmium testing with support from:
  - » Multnomah County Health Department
  - » Oregon Poison Center, and
  - » The Northwest Pediatric Environmental Health Specialty Unit.
- Revised OHA's gardening fact sheet for the community around Bullseye Glass.
- Created the 2016 garden soil test interpretation guidelines for concerned residents conducting soil tests.
- Created a list of labs that will test garden soil for concerned residents conducting soil tests.
- Created a 2016 fact sheet describing Public Health Assessments (PHAs) and OHA's plans for preparing a PHA for Bullseye Glass.
- Developed and regularly updated from 2016-2017 online frequently asked questions for Southeast and North Portland community members about Bullseye Glass.
- Developed Heavy Metals and the Protective Benefits of a Healthy Diet fact sheet in 2016 as a part of the PHA process, in response to community advisory committee (CAC) requests; translated content into Spanish.
- Developed Garden Grown Food and Air Toxics-Metals fact sheet as a part of the PHA process, in response to CAC requests; translated content into Spanish.

Meetings, presentations, and public events:

- Convened six Bullseye Public Health Assessment CAC meetings from 2016-2020 to inventory community concerns and gather input for exposure pathways, exposure scenarios, exposure factors. Also, to consult on whether or not to pursue document certification through ATSDR. (See Appendix B for more CAC information.)
- Attended and participated in a 2016 community meeting for residents at Cleveland High School.
- Spoke on the "Grow PDX" radio show on XRAY.FM about the Portland metals emissions issues and gardening.
- Exhibited a table in 2016 at the neighborhood co-op near Bullseye Glass to hear community concerns and distribute gardening materials.
- Presented on the ongoing Portland air toxics issue to OHA's Grand Rounds seminar, to interested Public Health Division staff not typically working on environmental health topics.
- Participated in a Cleaner Air webinar in 2016 to answer questions related to air toxics and health. The webinar was broadcast live on YouTube and was made available later as a recording.

- Held a 2016 public "SoilSHOP" event to screen community members' soil from their gardens and provide guidance on best health practices when gardening in urban areas.
- Met with parents at the nearby daycare center in 2016 to discuss air monitoring and answer questions.
- Participated in a 2019 DEQ-hosted public hearing about an air quality permit update for Bullseye Glass. OHA answered health-related questions at the hearing.

Planned public health actions

OHA will take the following public health actions following completion of the PHA:

- Continue to work with DEQ on the statewide implementation of Cleaner Air Oregon.
- Make the Public Health Assessment available to all interested community members and stakeholders.

Endnotes

1. **PortlandMaps.** 3722 S/SE 21st Ave. [Online] 2017. https://www.portlandmaps.com/detail/property/3722-S-SE-21ST-AVE/R271570_did/.

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Report preparation

Authors

David G. Farrer, PhD
Public health toxicologist
Environmental Public Health

Nadège Dubuisson, MPH, CHES
Former public health educator
Environmental Health Assessment Program

Lauren Karam, MPH
Former program coordinator and health assessor
Environmental Health Assessment Program

Todd Hudson, MSPH
Toxicologist and health assessor
Environmental Health Assessment Program

Julie Early Sifuentes, MS
Principal investigator and program manager
Environmental Health Assessment Program

Gabriela Goldfarb, MPP
Section manager
Environmental Public Health

State agency reviewers

Oregon Department of Environmental Quality:

Keith Johnson, manager for Cleaner Air Oregon Section

David Kauth, permit writer for Northwest Region

Michael Orman, manager for Air Planning Section

Tom Roick, manager for Air Monitoring Section at DEQ Laboratory

Sarah Armitage, former planner in Air Quality Planning Section

Oregon Health Authority

André Ourso, administrator for the Center for Health Protection

Ali Hamade, deputy state epidemiologist

Appendix A. ATSDR general site profile map

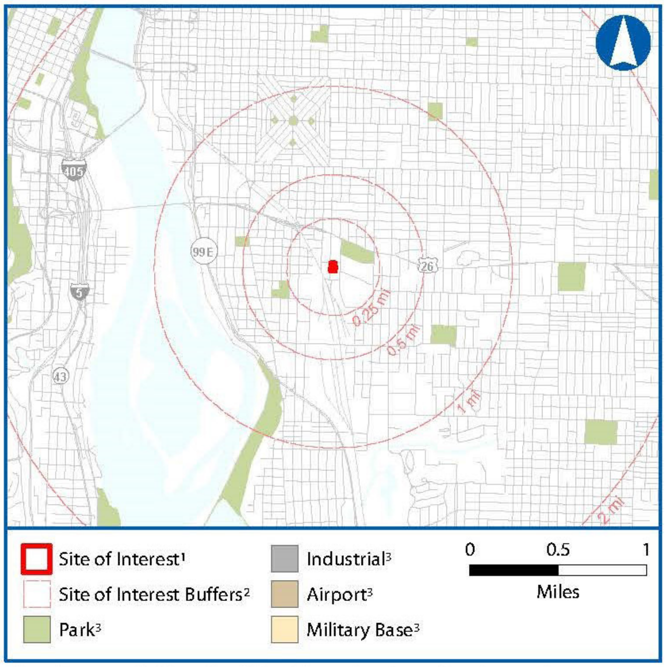
Bullseye Glass Co.

Portland, Multnomah County, OR

GENERAL SITE PROFILE

INTRODUCTORY MAP SERIES

Site Vicinity Map



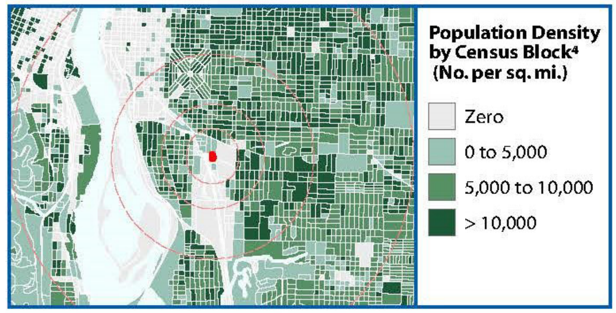
The **General Site Profile Map** depicts the hazardous waste site of interest, along with any airport, industrial, military, or park land uses. It also provides community demographic and housing statistics.

Demographic Statistics[4,5]

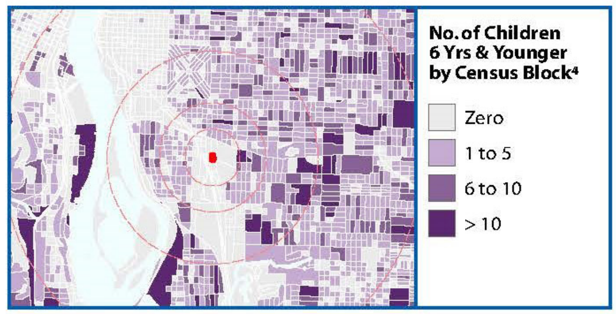
Within 1 Miles buffer of site boundary

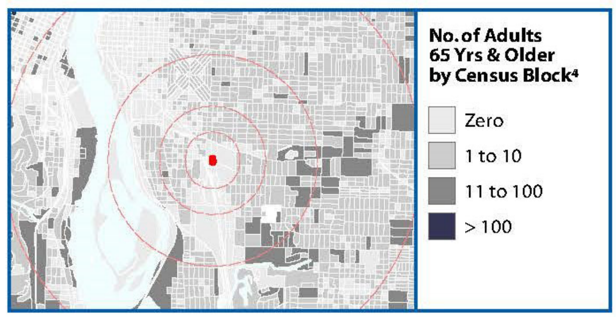
Measure	2000	2010	Change
Total Population	20,074	20,727	+3%
White Alone	16,662	17,557	+5%
Black Alone	529	569	+7%
Am. Indian & Alaska Native Alone	225	161	-28%
Asian Alone	1,383	1,168	-15%
Native Hawaiian & Other Pacific Islander Alone	58	51	-12%
Some Other Race Alone	438	337	-23%
Two or More Races	774	890	+14%
Hispanic or Latino[6]	1,020	1,153	+13%
Children Aged 6 and Younger	1,344	1,356	+0%
Adults Aged 65 and Older	1,908	1,795	-5%
Females Aged 15 to 44	5,377	5,762	+7%
Housing Units	9,675	10,159	+5%
Housing Units Pre 1950	5,759	5,668	-1%

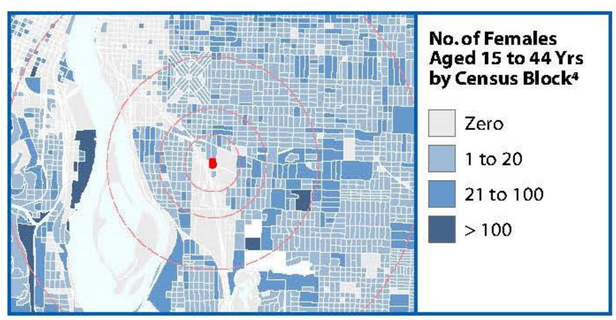
General Population Density



Sensitive Populations







Data Sources: [1]ATSDR GRASP Hazardous Waste Site Boundary Database. [2]ATSDR GRASP. [3]TomTom International BV (2012). [4]US Census 2010. **Notes:** [5]Calculated using area-proportion spatial analysis method. [6]Individuals identifying origin as Hispanic or Latino may be of any race.
Projection: Projection used for all map panels is NAD 1983 StatePlane Oregon North FIPS 3601 Feet.

PRJ 04871 LWR8 8/1/16

GRASP

Agency for Toxic Substances and Disease Registry

Division of Toxicology and Human Health Sciences

ATSDR

FINAL - FOR PUBLIC RELEASE

Appendix B. OHA actions to involve the community

OHA has taken the following steps to ensure meaningful involvement through the Bullseye Glass PHA by convening a Public Health Assessment Community Advisory Committee (PHA-CAC) that met between 2016 and 2019.

a. Developed recruitment material and facilitated outreach efforts that prioritized residents living near the site (within a 0.5-mile radius) and populations most sensitive and vulnerable to the effects of exposure to air emissions of metals.

b. Visited several community locations as part of the in-person outreach strategy, including:
- Asian Health & Service Center
- Multnomah County Southeast Health Center
- Esperanza Court apartments (low-income and refugee housing)
- Powell Park
- Healthy Family Living Community
- StumpTown Kilts and residents of the artist's collective
- Nearby daycare, and
- Several small business startups located on the street behind (west of) Bullseye.

c. Recruited eleven Community Advisory Committee (CAC) members from the area with a diversity of perspectives including:
- Parents of young children
- Long-time residents of the neighborhood
- Expecting mothers
- Immuno-compromised people, and
- Facility employees.

d. Hosted CAC meetings, which included strategies to remove barriers for participation, such as:
- Hosting meetings outside of daytime work hours
- Selecting a neighborhood location, and
- Having food available for participants.

e. Structured the advisory committee meetings in ways that provided an opportunity for meaningful participation[1]. OHA structured the meetings with evidence-based strategies (41) for effective adult education and presentations. (42) The purpose of the educational content and training was to explain the PHA process. At every CAC meeting, OHA allowed time for community advisors to:
- Make suggestions
- Ask questions, and

---

[1] "Meaningful participation" means engaging a diverse group of stakeholders who are representative of the communities that policies and programs will effect, not only in consultative roles to provide input, but also to co-plan or lead program development efforts, have access to data and resources to make informed decisions, have decision-making authority, and participate in the analysis of data and program effect efforts.

- Share concerns.

For example, CAC members:

- Provided input on exposure pathways and scenarios to assess within the PHA
- Reviewed draft educational material, and
- Provided suggestions for improvement.

A list of CAC concerns, questions and advice was also generated at PHA CAC meetings by OHA. This information is summarized within the “Community Concerns” section of this PHA.

OHA did not translate recruitment materials or directly target non-English speaking residents due to the limitations imposed by:

- A tight timeline
- Funding, and
- Staff constraints.

Appendix C. Community concerns

To identify community concerns, questions, and feedback, OHA:

1. Convened the PHA-CAC (See Appendix B)
2. Provided education and listening sessions to engage community members at public information sessions, meetings, and other events organized by agency partners, including Multnomah County Health Department, DEQ, and others; and
3. Documented phone and e-mail communications.

1. **Children's Health**

   With schools and parks located within a half-mile from Bullseye, community members shared concerns of health risks to young children breathing air emissions of metals while:

   - *Going to school*
   - *Playing outside*
   - *Recreating in the neighborhood*
   - *Playing at parks, and*
   - *Eating vegetables from home and school gardens.*

   Additional concerns include:

   - *"How will OHA evaluate students who are going to school from outside the area vs those who live and go to school in the area?" and*
   - *"What about the combined exposure of metal emissions and recent lead in water results at Grout Elementary (within one mile from Bullseye)?"*

   The PHA addresses concerns about children's health in the child health sections where resident child scenarios are evaluated. The PHA looks at the scenario for full-time resident children (24 hours a day, 7 days a week in the neighborhood) and three non-resident scenarios (a child attending daycare, school, or park). Public health actions to follow up with local school and daycare administrators for the dissemination of this PHA report are included in the Public Health Action Plan section.

   This PHA does not address lead found in school drinking water. Portland Public School (PPS) drinking water was tested in the same timeframe as this PHA. Results for 2016 are at https://www.pps.net/Page/14260. Results for 2019-2020 are at http://www.pps.net/Page/5378. For more information on sources of lead exposure, health effects, and healthy school facilities, visit www.healthoregon.org/lead.

2. **Cumulative risks**

   Community members expressed concern over the collective effect of exposure to environmental contaminants from other sources in the neighborhood. Specifically mentioned were emissions from the:

   - *Nearby rail yard*

- *Cement plant*
- *Diesel exhaust, and*
- *Tri-met bus yard*

Community members also expressed concerns about the use of land use and zoning considerations.

PHAs were designed to evaluate site-specific contaminants, health outcomes and community concerns. The focus of this PHA is to evaluate the contaminants, health outcomes and community concerns from the Bullseye Glass Facility site. While this PHA does not analyze exposure risks from other sources beyond the site, there are multiple potential sources of metals to air in the area. These include a railyard, a busy trucking route, a municipal bus barn, and a cement storage and transfer facility. All of these could contribute hexavalent chromium to the air. Emissions from trains, trucks and buses, could include:

- Diesel particulate matter
- Polycyclic aromatic hydrocarbons, and
- Other typical urban air pollutants.

This PHA acknowledges potential exposures from other sources. However, the PHA does not evaluate risks from off-site sources directly. This PHA also does not address land use and zoning issues. For this site, the land use and zoning concerns can be pursued by the community through the local land use and zoning authority within the City of Portland. More information can be found at www.portlandoregon.gov/bds/35881.

To address some of the cumulative risk concerns, OHA encourages residents to engage with elected officials and share environmental health concerns and community-identified solutions. One way to get involved in addressing health risks from industrial facilities is to get involved in the Cleaner Air Oregon regulatory reform. More information about Cleaner Air Oregon is available at CleanerAir.Oregon.gov. Community members can learn more about industrial facilities and emissions at the neighborhood level through these online sources, databases and maps:

- DEQ Facility Profiler: Enter an address and find locations, maps, information about industries permitted by DEQ to release emissions into the air, or discharge into the water or ground.
  https://hdcgcx1.deq.state.or.us/Html5viewer291/?viewer=FacilityProfilerLite
- DEQ Air Quality Monitoring and Facilities Location Map: Concerns of metal emissions and deposition around Portland area manufacturing facilities prompted DEQ to develop a statewide web map that displays the current status of air quality

monitoring, as well as completed and future projects. http://www.oregon.gov/deq/aq/Pages/Air-Quality-Map.aspx

- DEQ and Diesel Emissions: DEQ has summarized their efforts on these pages. http://www.oregon.gov/deq/aq/programs/Pages/Diesel.aspx
- EPA EJScreen Tool: This database combines environmental and demographic indicators in maps and reports for your location. https://www.epa.gov/ejscreen
- DEQ Leaky Underground Storage Tanks (LUST) Cleanup Site Database: This database allows the public to look up information by location. http://www.oregon.gov/deq/tanks/Pages/Leaking-Tanks-Database-Instructions.aspx
- DEQ Environmental Cleanup Site Information (ECSI) Database: Includes information about sites that DEQ has assisted or conducted clean-up enforcement. http://www.deq.state.or.us/lq/ecsi/ecsiquery.asp?listtype=lis&listtitle=Environmental+Cleanup+Site%20Information+Database

Community members can also contact DEQ's Air Quality program at 503-229-5359, airquality.info@deq.state.or.us and ask about facilities permitted to discharge pollutants into the air in a given neighborhood.

3. **Past exposures**

At each community event and in many individual discussions with community members, concerns were voiced over past exposures. As a result, including past exposures in the PHA analysis was very important. Community members also suggested the development of air dispersion models with Bullseye Glass batch records and meteorological records.

Past and current health risk information is included in this PHA. Unfortunately, there was too much uncertainty in the available monitoring data from October 2015 to accurately calculate risk from long-term past exposures. To better understand the process used to determine how past exposures from air and soil around Bullseye Glass were addressed, please see the *Health Effects Evaluation* section of this PHA. OHA was able to use the October 2015 monitoring data to estimate what the risk from long-term exposure might have been if conditions measured in October 2015 continued long-term into the future without any intervention.

4. **Cancer and other health issues in the neighborhood**

Community members expressed concerns about cancer rates in the neighborhood and other health outcomes including asthma and ADHD.

The cancer rate analysis is summarized in the health outcome data section. The Oregon State Cancer Registry (OSCaR) records all cancer diagnoses in the state. This includes cancer type and address at the time of diagnosis. The program did a cancer rate analysis for the area surrounding Bullseye Glass. The results and limitations of the analysis are summarized in the uncertainties and gaps in data section of this PHA.

There is no state registry to report diseases such as asthma, kidney disease and neurodevelopmental problems to OHA. As a result, there are no data to determine if rates found in this neighborhood are more or less or the same as predicted. Several metals detected in the air around Bullseye Glass are respiratory irritants that could trigger asthma attacks in people who already have asthma. However, these types of health effects would typically be expected at concentrations much higher than were measured around Bullseye. As stated in the report, some groups of people may have an increased risk of lung and bladder cancer and kidney problems. The Centers for Disease Control and Prevention (CDC) has made information on lung and bladder cancer available at https://www.cdc.gov/cancer/lung/index.htm and https://www.cdc.gov/cancer/bladder/index.htm/.

While past exposures may have increased risk of lung and bladder cancer and kidney problems, there are many other contributing factors and preventive measures that people and parents have control over. For example, a diet rich in calcium, iron and vitamin C can protect you from heavy metals. A detailed fact sheet is available at www.healthoregon.org/bullseyepha.

Each person is uniquely susceptible to the effects of certain exposures. This PHA is not able to address unique vulnerabilities. The PHA process is an estimate that reflects population-based exposures, which is very different than an individualized, medical-based analysis. To learn more about the type of studies that could answer these questions, a webinar on environmental investigations is available on OHA's webpages at www.healthoregon.org/ehap. A good resource for community health studies can be found at http://communityhealthstudies.org/.

5. **Urine analysis testing and results**

In late January and February 2016, community members became very concerned and began asking health care providers to test for cadmium and arsenic. The confusion was expressed by community members about urine testing and analysis for these metals. People were not sure whether they should have had, or should get, their urine tested through the OHA-funded process. Some community members were confused about the methods and the results of their testing and what it meant for their health. Community members also:

- *Requested additional testing, in the form of a biomonitoring study, and*
- *Expressed a need for better education on testing for local healthcare providers.*

Due to overwhelming public concern, OHA reimbursed the cost of cadmium urine testing for people living near Bullseye Glass (and Uroboros Glass). The purpose of the testing was for individual conversations with physicians. Even though this service was provided, OHA did not recommend testing for heavy metal exposure. The urine data OHA received from testing were intended to be used for the clinical treatment of people, not for assessing risks to the public. There are very different protocols for collecting samples to analyze for public health purposes.

Many community members continued to pursue alternative testing, independent of OHA recommendations. For example, Beaverton-based, ZRT Laboratory offered free urine testing using an experimental method for cadmium and other chemicals. These experimental tests were offered to long-term residents living near Bullseye Glass and Uroboros Glass. ZRT's results demonstrate that some people in the community may have elevated levels of cadmium. However, because each person's urine test results are not part of a systematic and controlled study, general exposure trends in the neighborhoods around Bullseye Glass cannot be determined. The results also cannot tell us whether exposures came from air pollution from Bullseye.

Continued concern and growing confusion led the community and OHA to request additional information. OHA formally requested that ATSDR conduct biomonitoring to help determine if a specific population was more exposed than normal. However, ATSDR cannot conduct a biomonitoring study. That is because biomonitoring cannot distinguish the source of cadmium since it stays in the body for many years (long biological half-life).

Health care providers also began having many questions, so OHA convened a group of experts and developed a clinician guidance document that could help clinicians make decisions. The document is available at https://www.oregon.gov/oha/PH/newsadvisories/Documents/se-portland-metals-emissions-physician-guidance.pdf. The guidance provides health care providers with information about cadmium reporting and how to interpret test results. It is available at CleanerAir.oregon.gov.

A summary of the urine data is available in the health outcomes section of this PHA and analysis methods in the discussion section. The potential for increased human exposure to cadmium in the community emphasizes the need to make our air pollution laws stronger. This is why OHA is actively engaged in the Cleaner Air Oregon program, in collaboration with DEQ, technical advisors, and community leaders. OHA encourages concerned citizens to get involved in the CleanerAir.Oregon.gov process.

6. **Vulnerable populations**

Alongside children's health concerns, community members expressed concerns about health risks from exposures living nearby Bullseye Glass experienced by:

- *Communities of color*
- *Low-income members of the community, and*
- *People with preexisting health conditions.*

CAC members also shared concerns for people who have increased susceptibility because they cannot process metals, due to a genetic mutation. Also, CAC members expressed the concept of "precision public health" which asks:

- *Who is vulnerable?*
- *Why they are vulnerable, and*
- *What can we do about it?*

Some of the CAC concerns and OHA's approach are captured within the environmental justice (EJ) section of this PHA. EJ considerations are a priority for OHA, as described in the EJ section. For many reasons, vulnerable populations are either:

- More likely to be exposed to environmental hazards, or
- At greater risk for poor health outcomes as a result of environmental exposures.

Those who are most sensitive to environmental exposures are:

- Children
- The elderly
- Pregnant women
- People with chronic conditions and disabilities
- People with autoimmune disease, or
- People taking medications that weaken their immune responses.

More information is available here: https://www.atsdr.cdc.gov/emes/public/docs/Sensitive%20Populations%20FS.pdf.

The genetic mutation (methylation) that prevents people from processing metals is very common. It is generally already accounted for in the studies used to develop the toxicity guideline values OHA used to estimate risk. The PHA estimates a dose (and therefore risk). However, the PHA cannot identify every vulnerability.

7. **Gardening**

Community members were concerned that they cannot garden safely. They were concerned that heavy metals associated with site activities were accumulating in garden soil and garden-grown plants. This made people question if produce from these gardens could be eaten.

The Bullseye Glass PHA discusses the gardening exposure pathway. OHA has developed several documents that describe the safety of urban gardening. OHA has reviewed current scientific data on the uptake of metals in plants and has determined that it is safe to garden, with a few precautions. Precautions include:

- Washing all produce (soaking cruciferous, root and leafy green vegetables)
- Peeling root vegetables
- Washing hands after gardening
- Removing shoes, and
- Wiping down pets' feet to avoid tracking dirt into the home.

These recommendations are based on the fact that the primary exposure risk comes from ingestion of the soil itself, not through uptake in or deposition on plants. OHA also recommends dust suppression techniques such as:

- Keeping the ground moist or covering the bare ground (with woodchips for example), and
- Using compost or other amendments to keep the soil at as close to a neutral pH level as possible.

OHA does not collect plant tissue samples. DEQ did not include plant samples in their sampling plan. Gardening resources and more information can be found at www.healthoregon.org/gardening.

To address additional concerns and questions about soil-testing and gardening in areas potentially affected by metal emissions, OHA planned a gardening and soil screening event in October 2016. With partners, OHA used the ATSDR Soil Screening, Health, Outreach and Partnership (soilSHOP) toolkit for the event. SoilSHOP provided blood lead level testing for children and offered soil testing using an X-ray fluorescence (XRF) machine (which quantifies levels of lead or other metals). Educators gave an interpretation of all blood and soil test results. Educators also provided information about how to reduce potential exposures to contaminated soil and garden plants. The event:

- Included partners from state and local government and non-profit groups
- Welcomed over 100 attendees, and
- Screened 124 bags of soil in four hours.

8. Preventing and reducing exposures

While sharing concerns and frustrations, community members also expressed a need to know what actions they can individually take to reduce their exposure to air emissions and other environmental contaminants. Questions included "What about indoor air and homes with air conditioning or air filtration vs. those who don't have it?" There were also statements that more zero net homes are appearing in the neighborhood, using rainwater for multiple purposes.

Steps for people to minimize exposures to metals in the outdoor environment are available at www.healthoregon.org/ehap, listings are by the exposure site. These steps include healthy gardening practices, protective diets, and more, and are based on common exposure pathways. Exposure pathways for Bullseye Glass are described in detail in the discussion section of this PHA. The exposure pathways explain how people may come into contact with metals related to the site. These pathways were determined with input from residents who served on the Community Advisory Committee (CAC).

Indoor air is not directly addressed in the PHA. Generally, indoor air would have fewer metal particles than outdoor air. This PHA assumes that people spend 100% of their time outside to capture the worst-case scenario. OHA does not have any indoor air data for homes with filtration, compared to those without. Similarly, OHA does not have rainwater data.

9. Risk to employees

Community members expressed concern about the health risks to indoor glass blowers, glass art workers, and other facility workers at Bullseye Glass and neighboring businesses.

Employee health is overseen by Oregon Occupational Safety and Health (OR-OSHA). OHA does not have data to evaluate the risk to:

- Glass blowers
- Glass artists, or
- People working at Bullseye Glass and neighboring businesses.

OSHA has standards and analysis specific to employees. OSHA uses different screening values and has a different exposure analysis. Generally, the risk to glass blowers would be expected to be low. That is because the temperatures used to soften glass for blowing are not nearly as high as the temperatures used to melt the raw materials to make glass in the first place. At the temperatures used for glass blowing, the metals remain fused to the glass instead of escaping into the air where they could be inhaled. (43) (44)

10. The gap in state industrial air emission regulations

Community members shared that they would like to know what is being done about the gap in regulations that allowed for harmful air emissions of metals from colored glass facilities in Portland, Oregon. They wanted to know what will happen to the glass facilities, from a regulatory and enforcement perspective.

Currently, DEQ's Air Quality Program includes:

- Industrial (pollution) source control
- Major new source review
- Coordination of air emissions permits and plans
- Data analysis

- Reporting, and
- Air regulations.

For more information on air quality regulations in general call 503-229-5359 or email airquality.info@deq.state.or.us.

As of November 2018, new rules were adopted that regulate air toxics from all industrial stationary sources in a way that protects the health of near neighbors to those facilities. Visit CleanerAir.Oregon.gov to learn about the implementation process and DEQ's progress in moving facilities through the Cleaner Air Oregon process.

11. History of mistrust with state agencies

Community members expressed trust issues with state agencies. The concerns shared by the community include:

- *A lack of responsiveness to community concerns, and*
- *A lack of actions that are respectful of community interests and protective of community health.*

The community also shared a concern for the PHA process and lab procedures. Questions include, "What kinds of things are in place to ensure lab results are used?"

OHA acknowledges the history of mistrust of government agencies. To help address this mistrust, OHA formed a Community Advisory Committee for this PHA. Committee agendas and meeting minutes are available by request.

The PHA process is nationally recognized and guided by ATSDR. OHA must adhere to using the best science available at the time of our analysis, which is based on available data. The environmental data used in the PHA follows the lab's quality assurance plan, lab methodology, the chain of custody, standardization of sampling, and analysis techniques.

Appendix D. Data quality review for Oregon Department of Environmental Quality October 2015 air monitoring and Agency for Toxic Substances and Disease Registry Memo

DEQ Memo

To: Gabriela Goldfarb with OHA, David Farrer with OHA

From: Brian Boling

Date: November 29, 2017

Subject: October 2015 Air Quality Sampling in SE Portland

State of Oregon
Department of Environmental Quality

Laboratory and Environmental Assessment Program
7202 NE Evergreen Pkwy, Suite 150
Hillsboro, OR 97124
Phone: 503-693-5700

Fax: 503-693-4999

www.oregon.gov/DEQ

This memorandum describes an air toxics sampling study performed in SE Portland in the fall of 2015.

Project Background/Description

In 2009 the EPA School Air Toxics study (SAT) was performed at Tubman School in North Portland. The results of this study showed elevated cadmium spikes coming from the south to southwest. DEQ did not know where this cadmium (Cd) was coming from and looked for methods to identify the source. Between August 2009 and October 2011, DEQ collaborated with the Portland Air Toxics Solutions Advisory Committee (PATSAC), made up of diverse stakeholders, to consider a technical study and develop a framework for an air toxics reduction plan. The information, modeling and monitoring generated from the PATSAC were a large part of what guided DEQ to focus on metals as part of the research collaboration.

In 2013 DEQ begin working with the US Forest Service to conduct a moss study in the Portland area to measure metals. The moss study, performed by USFS in December of 2013, showed elevated cadmium levels from a moss sampling site near the intersection of SE Powell and SE 22nd Avenue. After some source profiling work in July and August of 2015, DEQ determined that the likely source of the cadmium was an art glass manufacturer a few blocks to the south of the moss-sampling site.

On August 26, 2015, DEQ staff met with representatives from USFS, Portland State University, and Reed College to discuss an air quality monitoring study to collect data to establish a link between concentrations of metals in moss and in air. The meeting resulted in a plan to monitor metals in air at a location in the Fred Meyer headquarters parking lot near Powell Park.

The monitoring study consisted of the collection of 20 samples over a 30-day period beginning in October, 2015. The samples were collected by students from Reed College. The DEQ laboratory conducted the related activities for the sampling including providing the samplers, performing all field equipment calibrations, providing sample media, training of samplers in equipment operation and handling filters. Desert Research Institute (DRI), a research laboratory with specialization in air monitoring sample analysis, completed the analyses of metals concentrations in ambient air. The US EPA has previously contracted with DRI for national air quality projects. Reed College field crew collected a field blank, sample duplicate, and submitted them to DRI as additional quality control. The study used two separate air samplers to facilitate the collection of duplicate samples.

DEQ Memo

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Laboratory Quality Control Results

DEQ received the results from the sample analysis in late January 2016. The DRI data did not include a laboratory control sample (LCS) that is normally provided by most industry environmental laboratories. The LCS is used to assess the performance of the analytical method by assessing the recovery of the metals after going through all of the analytical procedures. Normally in metals analysis LCS recovery is good or tends to be low, so the data reported, in a worst case, would have a low bias.

Calibrations checks were conducted throughout the analytical sequence, indicating the instrument was showing acceptable accuracy. Instrument blanks were analyzed to show the instrument was operating with a clean baseline.

Reporting Limit

The low point in a calibration is commonly used as the laboratory limit of quantitation or reporting limit. Since a reporting limit was not provided by DRI, DEQ has subsequently used the low calibration points provided by DRI and multiplied them through all the processing steps to calculate what would be an appropriate reporting limit in ng/m^3 that can be compared to sample results. The laboratory method blank provided by DRI was processed the same way to calculate a result that can be compared to sample results. Any results below this calculated reporting limit should be considered not detected.

All sample data provided by DRI, including the field blank and field duplicates had to be adjusted for sampling volume before reporting results to OHA.

Blank Results

Method Blank: The method blank results for all analytes are below the RL except for beryllium, arsenic, selenium and cadmium.

Field Blank: The field blank results for all analytes were below the RL except for beryllium, chromium and cadmium.

Data Interpretation: The presence of an analyte in a blanks indicates some source of contamination may be present from the laboratory (reagents) or introduced in the field (equipment, filters, etc), DEQ evaluates the blanks in the following manor:

- If the sample result is less than 2x the blank concentration, the sample value is considered unusable.
- If the sample result is between 2x and 10x the blank concentration, contamination may be contributing to the concentration and data is used cautiously.
- If the sample result is greater than 10x the level in the blank, the contamination is deemed as inconsequential and the sample concentration is considered fully valid.

DEQ Memo

Operational Deviations

A draft Quality Assurance Project Plan (QAPP) was started prior to the implementation of the study but was not completed.

Training to Reed College students on instrument operation and sampling custody and handling was provided by Oregon DEQ staff but was not documented.

BGI Sampler #685 failed to complete the November 2nd, 2015 sample. Water intrusion into the sampler caused the sampler to shut down. A final field flow verification was not possible before being returned to the ODEQ laboratory for maintenance. The precision acceptance criteria was met for all analytes from the duplicate sampling event. Therefore, the determination was made to qualify successive samples from the duplicate event as estimates.

The samples did not follow the standard procedure associated with DEQ field samples being processed through DEQs Laboratory Information Management System (LIMS).

While Chain of Custody (COC) forms were used for all samples, there were instances where scientific documentation guidelines were not followed as well as some text omissions in other fields. The critical elements of the COC are discernible and do not impact the custody verification and data needed to process the samples.

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October 2015 Air Quality Sampling in SE Portland

Revised: 11/30/2017

Key	(See memo for details.)
Post deplyment check not performed due to water intrusion	
Result within 10x the field blank	
Result within 10x the instrument method blank	
Result within 2x the field blank	
Result within 2x the instrument method blank	

* 50ml aliquot used for conversion from instrument to sample units

**MRL determined from lowest calibration data reported using 50 ml aliquot and 24.04 sample volume.

Filter ID	Sample Date	Volume (m^3)	BE ug/filter	BE ug/m^3	BE ng/m^3	CR ug/filter	CR ug/m^3	CR ng/m^3	MN ug/filter	MN ug/m^3	MN ng/m^3	CO ug/filter	CO ug/m^3	CO ng/m^3	Instrument
F52226	10/6/2015	24.04	0.001490	0.000062	0.061972	9.777139	0.406703	406.702938	1.214065	0.050502	50.501881	0.054318	0.002259	2.259468	685
F52220	10/7/2015	24.04	0.000295	0.000012	0.012258	0.485409	0.020192	20.191709	0.848040	0.035276	35.276215	0.007399	0.000308	0.307772	720
F52221	10/9/2015	24.04	0.000434	0.000018	0.018066	0.587165	0.024425	24.424519	0.316061	0.013147	13.147288	0.020704	0.000861	0.861250	685
F52231	10/10/2015	24.04	0.000176	0.000007	0.007328	0.598764	0.024907	24.907008	0.097215	0.004044	4.043865	0.006547	0.000272	0.272328	720
F52211 primary	10/12/2015	24.04	0.000360	0.000015	0.014968	0.612148	0.025464	25.463723	0.341501	0.014206	14.205518	0.021369	0.000889	0.888885	720
F52212 duplicate	10/12/2015	24.04	0.000407	0.000017	0.016948	0.625653	0.026025	26.025500	0.372180	0.015482	15.481678	0.023136	0.000962	0.962408	685
F52230	10/14/2015	24.04	0.000197	0.000008	0.008197	0.456096	0.018972	18.972366	0.439205	0.018270	18.269753	0.002557	0.000106	0.106367	685
F52232	10/15/2015	24.04	0.000718	0.000030	0.029852	0.418755	0.017419	17.419101	1.062385	0.044192	44.192394	0.010155	0.000422	0.422422	720
F52216 blank	10/16/2015	24.04	0.000149	0.000006	0.006188	0.422585	0.017578	17.578419	0.000000	0.000000	0.000000	0.000028	0.000001	0.001165	685
F52224	10/17/2015	24.04	0.000290	0.000012	0.012062	0.504036	0.020967	20.966542	0.197484	0.008215	8.214818	0.005426	0.000226	0.225698	685
F52217	10/18/2015	24.04	0.000186	0.000008	0.007722	0.482091	0.020054	20.053716	0.193051	0.008030	8.030396	0.008747	0.000364	0.363849	720
F52228	10/20/2015	24.04	0.000204	0.000008	0.008466	0.513931	0.021378	21.378146	0.315963	0.013143	13.143235	0.008065	0.000335	0.335477	685
F52215	10/21/2015	24.04	0.000479	0.000020	0.019940	0.548455	0.022814	22.814248	0.582408	0.024227	24.226612	0.025995	0.001081	1.081317	720
F52229	10/23/2015	24.04	0.000310	0.000013	0.012884	0.561294	0.023348	23.348334	0.665881	0.027699	27.698881	0.006332	0.000263	0.263406	685
F52222	10/24/2015	24.04	0.000694	0.000029	0.028864	10.565750	0.439507	439.507059	0.564558	0.023484	23.484119	0.019358	0.000805	0.805229	720
F52218	10/26/2015	24.04	0.000239	0.000010	0.009936	1.153036	0.047963	47.963210	0.173329	0.007210	7.210036	0.083590	0.003477	3.477117	685
F52214	10/27/2015	24.04	0.000457	0.000019	0.019029	0.585933	0.024373	24.373251	0.508412	0.021149	21.148585	0.018330	0.000762	0.762464	720
F52219	10/29/2015	24.04	0.000215	0.000009	0.008946	0.905609	0.037671	37.670924	0.144379	0.006006	6.005787	0.067175	0.002794	2.794281	685
F52227	10/30/2015	24.0414	0.000163	0.000007	0.006789	0.926290	0.038529	38.528967	0.080552	0.003351	3.350546	0.009627	0.000400	0.400442	720
F52213	11/2/2015	24.04	0.000162	0.000007	0.006733	1.263408	0.052554	52.554411	0.319138	0.013275	13.275303	0.016366	0.000681	0.680786	720
F52225	11/2/2015	void	void	void	void	void	void	void	void	void	void	void	void	void	

QC Data Only

Method Blank*		24.04	0.000200	0.000008	0.008319	-0.015000	-0.000624	-0.623960	-0.000450	-0.000019	-0.018719	-0.000100	-0.000004	-0.004160	
F52216 blank	10/16/2015	24.04	0.000149	0.000006	0.006188	0.422585	0.017578	17.578419	0.000000	0.000000	0.000000	0.000028	0.000001	0.001165	685
F52211 primary	10/12/2015	24.04	0.000360	0.000015	0.014968	0.612148	0.025464	25.463723	0.341501	0.014206	14.205518	0.021369	0.000889	0.888885	720
F52212 duplicate	10/12/2015	24.04	0.000407	0.000017	0.016948	0.625653	0.026025	26.025500	0.372180	0.015482	15.481678	0.023136	0.000962	0.962408	685

Precision Criteria (Field Primary vs. Field Duplicate)	BE ng/m^3	CR ng/m^3	MN ng/m^3	CO ng/m^3
Relative Percent Difference (RPD)	12.4%	2.2%	8.6%	7.9%

	Arsenic, Total (ng/m³ LTP)	Beryllium, Total (ng/m³ LTP)	Cadmium, Total (ng/m³ LTP)	Chromium, Total (ng/m³ LTP)	Cobalt, Total (ng/m³ LTP)	Hexavalent Chromium Cr(VI) (ng/m³ LTP)	Lead, Total (ng/m³ LTP)	Manganese, Total (ng/m³ LTP)	Nickel, Total (ng/m³ LTP)	Selenium, Total (ng/m³ LTP)
Urban Background from NATTS sites	0.2 - 1.4	< MDL	0.04 - 0.5	1.6 - 4	0.05 - 0.3	0.01 - 0.08	2 - 10	3.2 - 19.5	0.8 - 2.8	0.1 - 1
DEQ Annual Ambient Benchmark	0.2	0.4	0.6	N/A	100	0.08	150	90	4	N/A
Oregon 24-Hour Screening Levels	36	10	30	N/A	100	36	150	400	200	710

	BE	CR	MN	CO	NI	AS	SE	CD	PB
Method Blank (ppb)	0.004000	-0.300000	-0.009000	-0.002000	-0.020000	0.016000	0.652000	0.012000	-0.112000
Calibration Data (ppb)	0.001	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001
Reporting Limit (ng/m^3) **	0.002079867	0.020798669	0.020798669	0.002079867	0.002079867	0.002079867	0.002079867	0.002079867	0.002079867

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Result within 2x the instrument method blank	

* 50ml aliquot used for conversion from instrument to sample units

**MRL determined from lowest calibration data reported using 50 ml aliquot and 24.04 sample volume.

Filter ID	Sample Date	Volume (m^3)	NI ug/filter	NI ug/m^3	NI ng/m^3	AS ug/filter	AS ug/m^3	AS ng/m^3	SE ug/filter	SE ug/m^3	SE ng/m^3	CD ug/filter	CD ug/m^3	CD ng/m^3	PB ug/filter	PB ug/m^3	PB ng/m^3	Instrument
F52226	10/6/2015	24.04	0.408443	0.016990	16.990147	1.803122	0.075005	75.005085	0.234985	0.009775	9.774743	0.312144	0.012984	12.984369	1.607603	0.066872	66.872009	685
F52220	10/7/2015	24.04	0.082391	0.003427	3.427256	0.072391	0.003011	3.011263	0.098170	0.004084	4.083630	0.053429	0.002222	2.222495	0.140977	0.005864	5.864264	720
F52221	10/9/2015	24.04	0.200401	0.008336	8.336150	0.212310	0.008832	8.831524	1.097347	0.045647	45.646706	0.332168	0.013817	13.817293	0.181630	0.007555	7.555320	685
F52231	10/10/2015	24.04	0.055534	0.002310	2.310072	0.487534	0.020280	20.280106	0.071354	0.002968	2.968149	4.698015	0.195425	195.424901	0.130060	0.005410	5.410161	720
F52211 primary	10/12/2015	24.04	0.193043	0.008030	8.030064	0.483273	0.020103	20.102858	0.317805	0.013220	13.219835	0.206074	0.008572	8.572132	0.780619	0.032472	32.471675	720
F52212 duplicate	10/12/2015	24.04	0.192664	0.008014	8.014291	0.514504	0.021402	21.401982	0.344154	0.014316	14.315873	0.220369	0.009167	9.166764	0.826969	0.034400	34.399712	685
F52230	10/14/2015	24.04	0.033508	0.001394	1.393831	0.027602	0.001148	1.148162	0.000000	0.000000	0.000000	0.038373	0.001596	1.596206	0.054054	0.002249	2.248509	685
F52232	10/15/2015	24.04	0.084535	0.003516	3.516440	0.027530	0.001145	1.145167	0.000000	0.000000	0.000000	0.064711	0.002692	2.691790	0.150379	0.006255	6.255364	720
F52216 blank	10/16/2015	24.04	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000859	0.000036	0.035739	0.000000	0.000000	0.000000	685
F52224	10/17/2015	24.04	0.070249	0.002922	2.922183	0.184350	0.007668	7.668462	0.018158	0.000755	0.755305	0.035416	0.001473	1.473210	0.243870	0.010144	10.144343	685
F52217	10/18/2015	24.04	0.177632	0.007389	7.389034	0.162261	0.006750	6.749627	0.199185	0.008286	8.285566	0.106763	0.004441	4.441042	0.181687	0.007558	7.557696	720
F52228	10/20/2015	24.04	0.069397	0.002887	2.886741	0.356410	0.014826	14.825708	0.294675	0.012258	12.257676	0.156271	0.006500	6.500474	0.401609	0.016706	16.705877	685
F52215	10/21/2015	24.04	0.163602	0.006805	6.805391	2.430858	0.101117	101.117207	0.311687	0.012965	12.965353	0.279898	0.011643	11.642994	1.458829	0.060683	60.683402	720
F52229	10/23/2015	24.04	0.103368	0.004300	4.299837	0.073123	0.003042	3.041709	0.000000	0.000000	0.000000	0.018624	0.000775	0.774718	0.123936	0.005155	5.155406	685
F52222	10/24/2015	24.04	0.170744	0.007102	7.102476	0.085017	0.003536	3.536474	0.065133	0.002709	2.709358	0.026580	0.001106	1.105668	0.195872	0.008148	8.147769	720
F52218	10/26/2015	24.04	0.046621	0.001939	1.939321	1.451589	0.060382	60.382223	6.517750	0.271121	271.121058	3.195142	0.132909	132.909396	1.617265	0.067274	67.273900	685
F52214	10/27/2015	24.04	0.220851	0.009187	9.186800	0.383167	0.015939	15.938740	0.376118	0.015646	15.645520	0.258913	0.010770	10.770088	0.245589	0.010216	10.215856	720
F52219	10/29/2015	24.04	0.110607	0.004601	4.600952	2.239859	0.093172	93.172154	5.287937	0.219964	219.964122	1.366799	0.056855	56.855204	5.969062	0.248297	248.297096	685
F52227	10/30/2015	24.0414	0.034380	0.001430	1.430018	2.337929	0.097246	97.245944	3.282050	0.136517	136.516596	1.001881	0.041673	41.673146	2.990152	0.124375	124.375113	720
F52213	11/2/2015	24.04	0.119905	0.004988	4.987747	0.920397	0.038286	38.286079	0.995504	0.041410	41.410326	0.585271	0.024346	24.345721	2.105037	0.087564	87.563922	720
F52225	11/2/2015	void	void	void	void	void	void	void	void	void	void	void	void	void	void	void	void	

QC Data Only

Method Blank*		24.04	-0.001000	-0.000042	-0.041597	0.000800	0.000033	0.033278	0.032600	0.001356	1.356073	0.000600	0.000025	0.024958	-0.005600	-0.000233	-0.232945	
F52216 blank	10/16/2015	24.04	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000859	0.000036	0.035739	0.000000	0.000000	0.000000	685
F52211 primary	10/12/2015	24.04	0.193043	0.008030	8.030064	0.483273	0.020103	20.102858	0.317805	0.013220	13.219835	0.206074	0.008572	8.572132	0.780619	0.032472	32.471675	720
F52212 duplicate	10/12/2015	24.04	0.192664	0.008014	8.014291	0.514504	0.021402	21.401982	0.344154	0.014316	14.315873	0.220369	0.009167	9.166764	0.826969	0.034400	34.399712	685

Precision Criteria (Field Primary vs. Field Duplicate)	NI ng/m^3	AS ug/m^3	SE ng/m^3	CD ng/m^3	PB ng/m^3
Relative Percent Difference (RPD)	0.2%	6.3%	8.0%	6.7%	5.8%

	Arsenic, Total (ng/m³ LTP)	Beryllium, Total (ng/m³ LTP)	Cadmium, Total (ng/m³ LTP)	Chromium, Total (ng/m³ LTP)	Cobalt, Total (ng/m³ LTP)	Hexavalent Chromium Cr(VI) (ng/m³ LTP)	Lead, Total (ng/m³ LTP)	Manganese, Total (ng/m³ LTP)	Nickel, Total (ng/m³ LTP)	Selenium, Total (ng/m³ LTP)
Urban Background from NATTS sites	0.2 - 1.4	< MDL	0.04 - 0.5	1.6 - 4	0.05 - 0.3	0.01 - 0.08	2 - 10	3.2 - 19.5	0.8 - 2.8	0.1 - 1
DEQ Annual Ambient Benchmark	0.2	0.4	0.6	N/A	100	0.08	150	90	4	N/A
Oregon 24-Hour Screening Levels	36	10	30	N/A	100	36	150	400	200	710

	BE	CR	MN	CO	NI	AS	SE	CD	PB
Method Blank (ppb)	0.004000	-0.300000	-0.009000	-0.002000	-0.020000	0.016000	0.652000	0.012000	-0.112000
Calibration Data (ppb)	0.001	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001
Reporting Limit (ng/m^3) **	0.002079867	0.020798669	0.020798669	0.002079867	0.002079867	0.002079867	0.002079867	0.002079867	0.002079867

Desert Research Institute

January 22, 2016

Steven D. Kohl
Desert Research Institute
2215 Raggio Parkway
Reno, NV 89512

Jarred Willis
ESC Lab Sciences.
12065 Lebanon Rd
Mt Juliet, TN 37122

Dear Mr. Willis

Enclosed please find Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) analysis results for the batch of Teflon filters that we received on 12/17/2015. Elemental concentrations and uncertainties in micrograms per filter are shown in Table 1. Values for calibrations standards and check standards in parts per billion are shown in Table 2. All sample preparation and analysis was done at the Desert Research Institute's Environmental Analysis Facility (EAF). Table 3 defines laboratory analysis flags.

No anomalies were noted with any of these filters during our log in process.

Sincerely,

Steven D. Kohl
Associate Research Scientist
Desert Research Institute

Table 1

TID	ELPF	BEPC	BEPU	CRPC	CRPU	MNPC	MNPU	COPC	COPU	NIPC	NIPU	ASPC	ASPU	SEPC	SEPU	CDPC	CDPU	PBPC	PBPU	COMMENT
F52211		0.000360	0.000036	0.612148	0.051732	0.341501	0.009011	0.021369	0.000800	0.193043	0.003045	0.483273	0.024248	0.317805	0.020119	0.206074	0.001100	0.780619	0.008573	
F52212		0.000407	0.000040	0.625653	0.052873	0.372180	0.009822	0.023136	0.000867	0.192664	0.003039	0.514504	0.025816	0.344154	0.021560	0.220369	0.001175	0.826969	0.009082	
F52213		0.000162	0.000016	1.263408	0.106768	0.319138	0.008420	0.016366	0.000613	0.119905	0.001892	0.920397	0.046181	0.995504	0.057188	0.585271	0.003120	2.105037	0.023117	
F52214		0.000457	0.000045	0.585933	0.049516	0.508412	0.013414	0.018330	0.000687	0.220851	0.003484	0.383167	0.019227	0.376118	0.023308	0.258913	0.001381	0.245589	0.002697	
F52215		0.000479	0.000047	0.548455	0.046349	0.582408	0.015366	0.025995	0.000974	0.163602	0.002581	2.430858	0.121969	0.311687	0.019784	0.279898	0.001494	1.458829	0.016021	
F52216		0.000149	0.000015	0.422585	0.035712	0.000000	0.000064	0.000028	0.000002	0.000000	0.000010	0.000000	0.000094	0.000000	0.002348	0.000859	0.000005	0.000000	0.000059	
F52217		0.000186	0.000018	0.482091	0.040741	0.193051	0.005093	0.008747	0.000328	0.177632	0.002802	0.162261	0.008142	0.199185	0.013630	0.106763	0.000572	0.181687	0.001995	
F52218		0.000239	0.000024	1.153036	0.097440	0.173329	0.004573	0.083590	0.003131	0.046621	0.000736	1.451589	0.072834	6.517750	0.359250	3.195142	0.017021	1.617265	0.017760	
F52219		0.000215	0.000021	0.905609	0.076531	0.144379	0.003810	0.067175	0.002516	0.110607	0.001745	2.239859	0.112385	5.287937	0.291981	1.366799	0.007283	5.969062	0.065551	
F52220		0.000295	0.000029	0.485409	0.041021	0.848040	0.022373	0.007399	0.000277	0.082391	0.001300	0.072391	0.003632	0.098170	0.008105	0.053429	0.000286	0.140977	0.001548	
F52221		0.000434	0.000043	0.587165	0.049620	0.316061	0.008341	0.020704	0.000775	0.200401	0.003162	0.212310	0.010654	1.097347	0.062759	0.332168	0.001770	0.181630	0.001995	
F52222		0.000694	0.000068	10.565750	0.892885	0.564558	0.014895	0.019358	0.000725	0.170744	0.002694	0.085017	0.004267	0.065133	0.006298	0.026580	0.000143	0.195872	0.002151	
F52224		0.000290	0.000029	0.504036	0.042595	0.197484	0.005212	0.005426	0.000203	0.070249	0.001108	0.184350	0.009250	0.018158	0.003728	0.035416	0.000189	0.243870	0.002678	
F52225		0.000247	0.000024	0.469061	0.039639	1.264638	0.033370	0.030611	0.001146	0.742832	0.011718	0.008116	0.000408	0.000000	0.001874	0.001458	0.000012	0.000000	0.000053	
F52226		0.001490	0.000147	9.777139	0.826240	1.214065	0.032031	0.054318	0.002034	0.408443	0.006443	1.803122	0.090472	0.234985	0.015588	0.312144	0.001663	1.607603	0.017655	
F52227		0.000163	0.000016	0.926290	0.078280	0.080552	0.002126	0.009627	0.000361	0.034380	0.000543	2.337929	0.117307	3.282050	0.182260	1.001881	0.005338	2.990152	0.032837	
F52228		0.000204	0.000020	0.513931	0.043431	0.315963	0.008336	0.008065	0.000302	0.069397	0.001095	0.356410	0.017884	0.294675	0.018853	0.156271	0.000835	0.401609	0.004410	
F52229		0.000310	0.000031	0.561294	0.047433	0.665881	0.017571	0.006332	0.000237	0.103368	0.001631	0.073123	0.003670	0.000000	0.002483	0.018624	0.000100	0.123936	0.001361	
F52230		0.000197	0.000019	0.456096	0.038544	0.439205	0.011589	0.002557	0.000096	0.033508	0.000529	0.027602	0.001388	0.000000	0.001901	0.038373	0.000205	0.054054	0.000594	
F52231		0.000176	0.000017	0.598764	0.050602	0.097215	0.002566	0.006547	0.000245	0.055534	0.000876	0.487534	0.024464	0.071354	0.006638	4.698015	0.025033	0.130060	0.001428	
F52232		0.000718	0.000071	0.418755	0.035388	1.062385	0.028032	0.010155	0.000380	0.084535	0.001334	0.027530	0.001384	0.000000	0.001706	0.064711	0.000346	0.150379	0.001651	
F52211R	r1	0.000352	0.000035	0.689065	0.058231	0.338695	0.008937	0.020948	0.000785	0.189102	0.002983	0.476500	0.023909	0.342953	0.021494	0.207780	0.001108	0.790245	0.008678	
F52221R	r1	0.000386	0.000038	0.649579	0.054894	0.305676	0.008066	0.021396	0.000801	0.202450	0.003194	0.201342	0.010103	1.092513	0.062495	0.331609	0.001767	0.181663	0.001995	
F52232R	r1	0.000615	0.000061	0.433398	0.036627	1.102978	0.029110	0.010779	0.000404	0.085944	0.001356	0.029925	0.001506	0.000000	0.001554	0.064320	0.000344	0.153494	0.001686	

TID	Teflon filter ID
ELPF	ICP Analysis flag
BEPC	Beryllium concentration (µg/filter)
BEPU	Beryllium concentration (µg/filter) uncertainty
CRPC	Chromium concentration (µg/filter)
CRPU	Chromium concentration (µg/filter) uncertainty
MNPC	Manganese concentration (µg/filter)
MNPU	Manganese concentration (µg/filter) uncertainty
COPC	Cobalt concentration (µg/filter)
COPU	Cobalt concentration (µg/filter) uncertainty
NIPC	Nickel concentration (µg/filter)
NIPU	Nickel concentration (µg/filter) uncertainty
ASPC	Arsenic concentration (µg/filter)
ASPU	Arsenic concentration (µg/filter) uncertainty
SEPC	Selenium concentration (µg/filter)
SEPU	Selenium concentration (µg/filter) uncertainty
CDPC	Cadmium concentration (µg/filter)
CDPU	Cadmium concentration (µg/filter) uncertainty
PBPC	Lead concentration (µg/filter)
PBPU	Lead concentration (µg/filter) uncertainty
COMMENT	

Table 2

	Be (ppb)		Cr (ppb)		Mn-4 55 (ppb)		Co-1 59 (ppb)		Ni-1 58 (ppb)		As-1 75 (ppb)		Se-1 82 (ppb)		Cd-1 114 (ppb)		Pb 208 (ppb)
0.001	0.001	**0.01**	0.010	**0.01**	0.010	**0.001**	0.001	**0.001**	0.001	**0.001**	0.001	**0.001**	0.001	**0.001**	0.001	**0.001**	0.001
0.01	0.010	**0.1**	0.085	**0.1**	0.103	**0.01**	0.009	**0.01**	0.000	**0.01**	0.011	**0.01**	0.009	**0.01**	0.009	**0.01**	0.009
0.1	0.100	**1**	1.030	**1**	0.998	**0.1**	0.100	**0.1**	0.096	**0.1**	0.103	**0.1**	0.094	**0.1**	0.099	**0.1**	0.014
1	1.000	**10**	10.012	**10**	9.993	**1**	1.000	**1**	1.001	**1**	1.000	**1**	0.972	**1**	1.001	**1**	1.011
10	9.993	**100**	100.054	**100**	99.969	**10**	9.992	**10**	9.993	**10**	9.990	**10**	9.944	**10**	9.993	**10**	10.005
100	100.110	**DDW**	-0.066	**DDW**	0.005	**100**	100.082	**100**	100.076	**100**	100.070	**100**	99.955	**100**	100.116	**100**	100.231
200	202.093	**DDW**	-0.268	**DDW**	-0.038	**200**	194.897	**200**	194.975	**200**	195.360	**200**	198.802	**200**	196.938	**200**	194.024
DDW	0.014	**std-10 Check**	11.477	**std-10 Check**	11.842	**DDW**	0.014	**DDW**	0.007	**DDW**	0.085	**DDW**	1.094	**DDW**	0.018	**DDW**	-0.108
DDW	0.007	**DDW**	-0.254	**DDW**	-0.002	**DDW**	0.002	**DDW**	-0.013	**DDW**	0.083	**DDW**	1.097	**DDW**	0.001	**DDW**	-0.105
std-10 Check	9.727	**Method Blank**	-0.300	**Method Blank**	-0.009	**std-10 Check**	9.939	**std-10 Check**	10.331	**std-10 Check**	10.734	**std-10 Check**	10.132	**std-10 Check**	9.976	**std-10 Check**	9.638
DDW	0.004	**ddw**	0.068	**ddw**	0.002	**DDW**	0.002	**DDW**	-0.010	**DDW**	0.036	**DDW**	0.899	**DDW**	0.013	**DDW**	-0.104
Method Blank	0.004	**std - 10**	10.770	**std - 1**	1.033	**Method Blank**	-0.002	**Method Blank**	-0.020	**Method Blank**	0.016	**Method Blank**	0.652	**Method Blank**	0.012	**Method Blank**	-0.112

Table 3
Chemical Analysis Data Validation Flags[a]

Validation Flag	Sub Flag	Description
b		Blank.
	b1	Field/dynamic blank.
	b2	Laboratory blank.
	b3	Distilled-deionized water blank.
	b4	Method blank.
	b5	Extract/solution blank.
	b6	Transport blank.
c		Analysis result reprocessed or recalculated.
	c1	XRF spectrum reprocessed using manually adjusted background.
	c2	XRF spectrum reprocessed using interactive deconvolution
d		Sample dropped.
f		Filter damaged or ripped.
	f1	Filter damaged, outside of analysis area.
	f2	Filter damaged, within analysis area.
	f3	Filter wrinkled.
	f4	Filter stuck to PetriSlide.
	f5	Teflon membrane separated from support ring.
	f6	Pinholes in filter.
g		Filter deposit damaged.
	g1	Deposit scratched or scraped, causing a thin line in the deposit.
	g2	Deposit smudged, causing a large area of deposit to be displaced.
	g3	Filter deposit side down in PetriSlide.
	g4	Part of deposit appears to have fallen off; particles on inside of PetriSlide.
	g5	Ungloved finger touched filter.
	g6	Gloved finger touched filter.
h		Filter holder assembly problem.
	h1	Deposit not centered.
	h2	Sampled on wrong side of filter.
	h4	Filter support grid upside down- deposit has widely spaced stripes or grid pattern.
	h5	Two filters in PetriSlide- analyzed separately.
i		Inhomogeneous sample deposit.
	i1	Evidence of impaction - deposit heavier in center of filter.
	i2	Random areas of darker or lighter deposit on filter.
	i3	Light colored deposit with dark specks.
	i4	Non-uniform deposit near edge - possible air leak.

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Table 3 (continued)
Chemical Analysis Data Validation Flags[a]

Validation Flag	Sub Flag	Description
m		Analysis results affected by matrix effect.
	m1	Organic/elemental carbon split undetermined due to an apparent color change of non-carbon particles during analysis; all measured carbon reported as organic.
	m2	Non-white carbon punch after carbon analysis, indicative of mineral particles in deposit.
	m3	A non-typical, but valid, laser response was observed during TOR analysis. This phenomena may result in increased uncertainty of the organic/elemental carbon split. Total carbon measurements are likely unaffected.
	m4	FID drift quality control failure
n		Foreign substance on sample.
	n1	Insects on deposit, removed before analysis.
	n2	Insects on deposit, not all removed.
	n3	Metallic particles observed on deposit.
	n4	Many particles on deposit much larger than cut point of inlet.
	n5	Fibers or fuzz on filter.
	n6	Oily-looking droplets on filter.
	n7	Shiny substance on filter.
	n8	Particles on back of filter.
	n9	Discoloration on deposit.
q		Standard.
	q1	Quality control standard.
	q2	Externally prepared quality control standard.
	q3	Second type of externally prepared quality control standard.
	q4	Calibration standard.
r		Replicate analysis.
	r1	First replicate analysis on the same analyzer.
	r2	Second replicate analysis on the same analyzer.
	r3	Third replicate analysis on the same analyzer.
	r4	Sample re-analysis.
	r5	Replicate on different analyzer.
	r6	Sample re-extraction and re-analysis.
	r7	Sample re-analyzed with same result, original value used.
s		Suspect analysis result.
v		Invalid (void) analysis result.
	v1	Quality control standard check exceeded ± 10% of specified concentration range.
	v2	Replicate analysis failed acceptable limit specified in SOP.
	v3	Potential contamination.

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Table 3 (continued)
Chemical Analysis Data Validation Flags[a]

Validation Flag	Sub Flag	Description
	v4	Concentration out of expected range.
w		Wet Sample.
	w1	Deposit spotted from water drops.
y		Data normalized
	y1	XRF data normalized to a sulfate/sulfur ratio of three
	y2	Each species reported as a percentage of the measured species sum

[a] Analysis results are categorized as valid, suspect, or invalid. Unflagged samples, or samples with any flag except 's' or 'v' indicate valid results. The 's' flag indicates results of suspect validity. The 'v' flag indicates invalid analysis results. Chemical analysis data validation flags are all lower case.

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OREGONDEQ State of Oregon Sample Chain of Custody OREGONDEQ

Agency, Authorized Purchaser or Agent: **ODEQ**	**Contract Laboratory Name: ESC Lab Sciences**	**Lab Selection Criteria:**	**Turn Around Time:**
Send Lab Report To: Jarred Willis Address: 12065 Lebanon Rd, Mt Juliet, TN 37122 Tel. #: 615-773-9678 E-mail: jwillis@esclabsciences.com	**Lab Batch #:** **Invoice To:** ESC Lab Sciences Address: 12065 Lebanon Rd, Mt Juliet, TN 37122 Tel. #: 615-773-9678	☐ Proximity (if TAT < 48 hrs) ☐ Prior work on same project ☐ Cost (for anticipated analyses) ☐ Other labs disqualified or unable to perform requested services ☐ Emergency work	☐ 10 days (std.) ☐ 5 days ☐ 72 hours ☐ 48 hours ☐ 24 hours ☒ Other_STD____

Project Name:
Project #:
Sampler Name:

Sample ID#	Collection Date/Time	Matrix	Number of Contain-ers	Sample Preservative: NA Requested Analyses: Metals by ICP-MS*									Comments
52225	2-Nov-2015	Filter	1	X									
52213	2-Nov-2015	Filter	1	X									
52227	30-Oct-2015	Filter	1	X									
52219	29-Oct-2015	Filter	1	X									
52218	26-Oct-2015	Filter	1	X									
52214	27-Oct-2015	Filter	1	X									
52229	23-Oct-2015	Filter	1	X									
52222	24-Oct-2015	Filter	1	X									
52228	20-Oct-2015	Filter	1	X									
52215	21-Oct-2015	Filter	1	X									
52216	NA	Filter	1	X									
52224	17-Oct-2015	Filter	1	X									

Notes: *beryllium, chromium, manganese, cobalt, nickel, arsenic, selenium, cadmium and lead
Subbed directly to Desert Research Institute (DRI) for ESC Lab Sciences
Send report, Excel EDD, and invoice to Janice Cozby with ESC jcozby@esclabsciences.com

Relinquished By:	Agency/Agent:	Received By:	Agency/Agent:
Signature:	Time & Date:	Signature:	Time & Date:
Relinquished By:	Agency/Agent:	Received By:	Agency/Agent:
Signature:	Time & Date:	Signature:	Time & Date:

THIS PURCHASE IS SUBMITTED PURSUANT TO STATE OF OREGON SOLICITATION **#102-1098-07** AND PRICE AGREEMENT # []. THE PRICE AGREEMENT INCLUDING CONTRACT TERMS AND CONDITIONS AND SPECIAL CONTRACT TERMS AND CONDITIONS (T'S &C'S) CONTAINED IN THE PRICE AGREEMENT ARE HEREBY INCORPORATED BY REFERENCE AND SHALL APPLY TO THIS PURCHASE AND SHALL TAKE PRECEDENCE OVER ALL OTHER CONFLICTING T'S AND C'S, EXPRESS OR IMPLIED.

Version: 4/4/2008

Agency, Authorized Purchaser or Agent:
ODEQ

Send Lab Report To: Jarred Willis
Address: 12065 Lebanon Rd, Mt Juliet, TN 37122
Tel. #: 615-773-9678
E-mail: jwillis@esclabsciences.com

Contract Laboratory Name: ESC Lab Sciences
Lab Batch #:
Invoice To: ESC Lab Sciences
Address: 12065 Lebanon Rd, Mt Juliet, TN 37122
Tel. #: 615-773-9678

Lab Selection Criteria:
- ☐ Proximity (if TAT < 48 hrs)
- ☐ Prior work on same project
- ☐ Cost (for anticipated analyses)
- ☐ Other labs disqualified or unable to perform requested services
- ☐ Emergency work

Turn Around Time:
- ☐ 10 days (std.)
- ☐ 5 days
- ☐ 72 hours
- ☐ 48 hours
- ☐ 24 hours
- ☒ Other _STD___

Project Name:
Project #:
Sampler Name:

Sample Preservative: NA

Requested Analyses

Sample ID#	Collection Date/Time	Matrix	Number of Contain-ers	Metals by ICP-MS*	Comments
52217	18-Oct-2015	Filter	1	X	
52230	14-Oct-2015	Filter	1	X	
52232	15-Oct-2015	Filter	1	X	
52212	12-Oct-2015	Filter	1	X	
52211	12-Oct-2015	Filter	1	X	
52221	9-Oct-2015	Filter	1	X	
52231	10-Oct-2015	Filter	1	X	
52220	7-Oct-2015	Filter	1	X	
52226	6-Oct-2015	Filter	1	X	

Notes: *beryllium, chromium, manganese, cobalt, nickel, arsenic, selenium, cadmium and lead
Subbed directly to Desert Research Institute (DRI) for ESC Lab Sciences
Send report, Excel EDD, and invoice to Janice Cozby with ESC jcozby@esclabsciences.com

Relinquished By:	Agency/Agent:	Received By:	Agency/Agent:
Signature:	Time & Date:	Signature:	Time & Date:
Relinquished By:	Agency/Agent:	Received By:	Agency/Agent:
Signature:	Time & Date:	Signature:	Time & Date:

THIS PURCHASE IS SUBMITTED PURSUANT TO STATE OF OREGON SOLICITATION **#102-1098-07** AND PRICE AGREEMENT # . THE PRICE AGREEMENT INCLUDING CONTRACT TERMS AND CONDITIONS AND SPECIAL CONTRACT TERMS AND CONDITIONS (T'S &C'S) CONTAINED IN THE PRICE AGREEMENT ARE HEREBY INCORPORATED BY REFERENCE AND SHALL APPLY TO THIS PURCHASE AND SHALL TAKE PRECEDENCE OVER ALL OTHER CONFLICTING T'S AND C'S, EXPRESS OR IMPLIED.

Version: 4/4/2008

BGI Metals Monitoring Chain of Custody

<table>
<tr><td rowspan="1"></td><td>Lab Pre-Sample</td><td>Sample Date: 10/05/2015
Site name: PPT
Sample type: Primary 1 / Primary 2 / Duplicate (both) (circle one)</td></tr>
<tr><td rowspan="5">In Field</td><td>Field Setup</td><td>Setup Date& Time: 10/05/2015 14:15PST Operator JB</td></tr>
<tr><td>Field Retrieval</td><td>Retrieval date 10/8/2015 12:31 Operator MK
Status: Valid Void (Circle one)</td></tr>
<tr><td>Sample Date</td><td>Start Time Oct 6th 2015 0001 Instrument # 685
End Time Filter # 52226
Total time 1440 min</td></tr>
<tr><td>Flow (LPM)</td><td>Average Flow 16.7 (L)</td></tr>
<tr><td>Lab Post Sampling</td><td>Received by: CRM Date: 9 Nov 2015 @1300
Status: Valid Void (Circle one)
If Void, Why:</td></tr>
</table>

Comments:

Total Vol: 24.04 m³

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: Oct 5th 2015 09:01 Site name: PPT Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 10/05/2015 14:18 Operator MK
In Field	Field Retrieval	Retrieval date 8 Oct 12:35 Operator JB Status: Valid Void (Circle one)
In Field	Sample Date	Start Time Oct 7th 2015 00:01 Instrument # 720 End Time ____ Filter # 52220 Total time 1440 min
In Field	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 @ 1300 Status: Valid Void (Circle one) If Void, Why:

Comments:

Volume: 24.04 m^3

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

<table>
<tr><td rowspan="1"></td><td>Lab Pre-Sample</td><td>Sample Date: 10/08/15
Site name: PPT
Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)</td></tr>
<tr><td rowspan="4">In Field</td><td>Field Setup</td><td>Setup Date& Time: 10/08/15 12:41 Operator JB</td></tr>
<tr><td>Field Retrieval</td><td>Retrieval date 11 Oct 18:25 Operator JB/MK
Status: Valid Void (Circle one)</td></tr>
<tr><td>Sample Date</td><td>Start Time 10/10/15 00:01 Instrument # 720
End Time ______ Filter # 52231
Total time 1440min</td></tr>
<tr><td>Flow (LPM)</td><td>Average Flow 16.7 (L)</td></tr>
<tr><td></td><td>Lab Post Sampling</td><td>Received by: CBM Date: 9 Nov 2015 @ 1300
Status: Valid Void (Circle one)
If Void, Why: ______</td></tr>
</table>

Comments:

Volume 24.04 m^3

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/08/15 Site name: PPT Sample type: Primary 1 / Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 10/08/15 12:37 Operator MK
In Field	Field Retrieval	Retrieval date 11 Oct 18:19 Operator JB/MK Status: Valid Void (Circle one)
In Field	Sample Date	Start Time 10/09/15 00:01 Instrument # 685 End Time ____ Filter # 52221 Total time 1440min
In Field	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2016 @ 1300 Status: Valid Void (Circle one) If Void, Why: ____

Comments:

Volume 24.04m^3

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/11/2015 Site name: PPT Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 11 oct 2015 18:28 PST Operator JB/MK
	Field Retrieval	Retrieval date 10/13/2015 10:22PST Operator JB/MK Status: Valid Void (Circle one)
	Sample Date	Start Time Oct 12th 2015, 00:01 Instrument # 720 End Time ______ Filter # 52211 Total time 1440min
	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CBM Date: 9Nov2015@1300 Status: Valid Void (Circle one) If Void, Why:

Comments:

Vol = 24.04M

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/11/2015 Site name: PPT Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 10/11/2015 18:22 PST Operator JB/ MK
In Field	Field Retrieval	Retrieval date 10/13/2015 10:17 PST Operator JB/MK Status: Valid Void (Circle one)
In Field	Sample Date	Start Time Oct 12th 2015, 00:01 Instrument # 685 End Time ____ Filter # 52212 Total time 1440 min
In Field	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 @ 1300 Status: Valid Void (Circle one) If Void, Why: ____

Comments:

Vol = 24.04 M

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/13/2015 Site name: PPT Sample type: Primary 1 / Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 10/13/2015 10:19 PST Operator JB/MK[redacted]
In Field	Field Retrieval	Retrieval date 10/16/2015 14:13 Operator JB/MK[redacted] Status: Valid Void (Circle one)
In Field	Sample Date	Start Time 10/14/2015, 00:01 Instrument # 685 End Time ____ Filter # 52230 Total time 1440min
In Field	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 01300 Status: Valid Void (Circle one) If Void, Why: ____

Comments:

24.04M

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/13/2015 Site name: PPT Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 10/13/2015 10:24 PST Operator JB/MK
	Field Retrieval	Retrieval date 10/16/2015 14:35 PST Operator JB/MK Status: Valid Void (Circle one)
	Sample Date	Start Time 10/15/2015, 00:01 Instrument # 720 End Time _____ Filter # 52232 Total time 1440 min
	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 @ 1300 Status: Valid Void (Circle one) If Void, Why: _____

Comments:

24.04 M

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/16/2015 Site name: PPT Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 10/16/2015 14:41PST Operator JB/MK/CM
In Field	Field Retrieval	Retrieval date 10/19/2015 16:53PST Operator JB/MK/CM Status: Valid Void (Circle one)
In Field	Sample Date	Start Time 10/18/2015 00:01 Instrument # 120 End Time ______ Filter # 52219 Total time 1440
In Field	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 @ 1300 Status: Valid Void (Circle one) If Void, Why: ______

Comments:

24:04M

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

<table>
<tr><td rowspan="1"></td><td>Lab Pre-Sample</td><td>Sample Date: 10/16/2015
Site name: PPT
Sample type: Primary 1 / Primary 2 / Duplicate (both) (circle one)</td></tr>
<tr><td rowspan="5">In Field</td><td>Field Setup</td><td>Setup Date& Time: 10/16/2015 Operator JB/MK/CM</td></tr>
<tr><td>Field Retrieval</td><td>Retrieval date 10/16/2015 Operator JB/MK/CM
Status: Valid Void (Circle one)</td></tr>
<tr><td>Sample Date</td><td>Start Time ____ Instrument # 685
End Time ____ Filter # 52216
Total time 3 minutes</td></tr>
<tr><td>Flow (LPM)</td><td>Average Flow 16.7 (L)</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td>Lab Post Sampling</td><td>Received by: CBM Date: 9 Nov 2015 @1300
Status: Valid Void (Circle one)
If Void, Why: ____</td></tr>
</table>

Comments: Blank

Vol: 24.04M

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/16/2015 Site name: PPT Sample type: Primary 1 / Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 10/16/2015 14:39PST Operator JB/MK/CM
In Field	Field Retrieval	Retrieval date 10/19/2015 16:49PST Operator JB/MK/CM Status: Valid Void (Circle one)
In Field	Sample Date	Start Time 10/19/2015 00:01 Instrument # 685 End Time Filter # 52224 Total time 1440 min
In Field	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CM Date: 9Nov2015@1300 Status: Valid Void (Circle one) If Void, Why:

Comments:

24.04m

Battery 64%

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/19/2015 Site name: PPT Sample type: Primary 1 / Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 10/19/2015 16:51PST Operator JB/MK
In Field	Field Retrieval	Retrieval date 10/22/2015 11:21PST Operator JB/MK Status: Valid Void (Circle one)
In Field	Sample Date	Start Time 10/20/2015 00:01PST Instrument # 685 End Time ______ Filter # 52228 Total time 1440 min
In Field	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CBM Date: 9Nov2015 @ 1300 Status: Valid Void (Circle one) If Void, Why: ______

Comments:

2 F:04 M

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/19/2015 Site name: PPT Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 10/19/2015 16:55PST Operator JB/MK
In Field	Field Retrieval	Retrieval date 10/22/2015 11:23 PST Operator JB/MK Status: Valid Void (Circle one)
In Field	Sample Date	Start Time 10/21/2015 00:01 Instrument # 720 End Time ____ Filter # 52215 Total time 1440min
In Field	Flow (LPM)	Average Flow 16.7 (L)
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 @1300 Status: Valid Void (Circle one) If Void, Why:

Comments:

24.04M

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

~~Sample~~

BGI Metals Monitoring Chain of Custody

<table>
<tr><td rowspan="1"></td><td>Lab Pre-Sample</td><td>Sample Date: ~~21~~ 22 Oct 2015
Site name: PPT
Sample type: Primary 1 / Primary 2 / Duplicate (both) (circle one)</td></tr>
<tr><td rowspan="4">In Field</td><td>Field Setup</td><td>Setup Date& Time: 22 Oct 2015 @ ~~15:00~~ 11:24 PST Operator ~~[illegible]~~ JB/MK</td></tr>
<tr><td>Field Retrieval</td><td>Retrieval date 25th Oct 2015 11:28 PST Operator JB/MK
Status: Valid Void (Circle one)</td></tr>
<tr><td>Sample Date</td><td>Start Time ~~22~~ 23 Oct 2015 @ 00:01 Instrument # 685
End Time ______ Filter # 52229
Total time 1440 min</td></tr>
<tr><td>Flow (LPM)</td><td>Average Flow 16.7 (L) Volume: 24.04 M</td></tr>
<tr><td></td><td>Lab Post Sampling</td><td>Received by: CM Date: 9 Nov 2015 @ 1300
Status: Valid Void (Circle one)
If Void, Why: ______</td></tr>
</table>

Comments: ______

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 22 Oct 2015 Site name: PPT Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date& Time: 22 Oct 2015 11:28PST Operator JB/MK
In Field	Field Retrieval	Retrieval date 25th Oct 2015 11:25PST Operator JB / MK Status: Valid Void (Circle one)
In Field	Sample Date	Start Time 24 Oct 2015 00:01 Instrument # 720 End Time ______ Filter # 52222 Total time 1440min
In Field	Flow (LPM)	Average Flow 16.7 (L) Volume: 24.04M
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 @ 1300 Status: Valid Void (Circle one) If Void, Why: ______

Comments:

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

<table>
<tr><td></td><td>Lab Pre-Sample</td><td>Sample Date: 25th Oct 2015
Site name: PPT
Sample type: Primary 1 / Primary 2 / Duplicate (both) (circle one)</td></tr>
<tr><td rowspan="4">In Field</td><td>Field Setup</td><td>Setup Date & Time: 25th Oct 11:23PST Operator JB/MK</td></tr>
<tr><td>Field Retrieval</td><td>Retrieval date: 10/28/15 17:58PST Operator: JB/MK
Status: Valid Void (Circle one)</td></tr>
<tr><td>Sample Date</td><td>Start Time: 10/26/15 00:01 Instrument # 685
End Time: Filter # 52218
Total time: 1440min</td></tr>
<tr><td>Flow (LPM)</td><td>Average Flow: 16.7 (L) Volume: 24.04M</td></tr>
<tr><td></td><td>Lab Post Sampling</td><td>Received by: CPM Date: 9 Nov 2015 @ 1300
Status: Valid Void (Circle one)
If Void, Why:</td></tr>
</table>

Comments:

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: 10/25/2015 Site name: PPT Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date & Time: 25th Oct 11:26 PST Operator JB/MK
In Field	Field Retrieval	Retrieval date: 10/28/15 18:03 PST Operator: JB/MK Status: Valid Void (Circle one)
In Field	Sample Date	Start Time: 10/27/15 00:01 Instrument # 720 End Time: Filter # 52214 Total time: 1440 min
In Field	Flow (LPM)	Average Flow: 16.7 (L) Volume: 24.04M
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015e 1300 Status: Valid Void (Circle one) If Void, Why:

Comments:

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: Oct 28th 2015 Site name: PPT Sample type: Primary 1 / Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date & Time: Oct 28th 2015 18:01 PST Operator JB/MK
	Field Retrieval	Retrieval date: Oct 31st / 6:35 PST Operator: JB/MK Status: Valid Void (Circle one)
	Sample Date	Start Time: Oct 29th 00:01 Instrument # 685 End Time: ______ Filter # 522/9 Total time: 1440min
	Flow (LPM)	Average Flow: 16.7 (L) Volume: 24.04M
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 @1300 Status: Valid Void (Circle one) If Void, Why: ______

Comments: ______

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: Oct 28th 2015 Site name: PPT Sample type: Primary 1/ Primary 2 / Duplicate (both) (circle one)
In Field	Field Setup	Setup Date & Time: Oct 28th 2015 18:05PST Operator JB/MK
In Field	Field Retrieval	Retrieval date: Oct 31st 2015 16:41PST Operator: JB/MK Status: Valid Void (Circle one)
In Field	Sample Date	Start Time: Oct 30th 2015 00:01 Instrument # 720 End Time: Filter # 52227 Total time: 1440min
In Field	Flow (LPM)	Average Flow: 16.7 (L) Volume: 24.04M
	Lab Post Sampling	Received by: CBM Date: 9Nov 2015 @1300 Status: Valid Void (Circle one) If Void, Why:

Comments:

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: Oct 31st 2015 Site name: PPT Sample type: Primary 1/ Primary 2 / ~~Duplicate~~ (both) (circle one)
In Field	Field Setup	Setup Date & Time: Oct 31st 2015 16:43 PST Operator JB/MK
In Field	Field Retrieval	Retrieval date: Nov 3rd 2015 13:23 PST Operator: JB/MK Status: Valid Void (Circle one)
In Field	Sample Date	Start Time: Nov 2nd 2015 00:01 Instrument # 720 End Time: ______ Filter # 52213 Total time: 1440 min
In Field	Flow (LPM)	Average Flow: 16.7 (L) Volume: 24.04
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 @ 1300 Status: Valid Void (Circle one) If Void, Why: ______

Comments: ______

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

BGI Metals Monitoring Chain of Custody

	Lab Pre-Sample	Sample Date: Oct 31st 2015 Site name: PPT Sample type: Primary 1/ Primary 2 / ~~Duplicate~~ (both) (circle one)
In Field	Field Setup	Setup Date & Time: Oct 31st 2015 16:38PST Operator JB/MK
	Field Retrieval	Retrieval date: Nov 2nd 2015 13:20PST Operator: JB/MK Status: Valid Void (Circle one) this is void AB 11/23/15
	Sample Date	Start Time: Nov 2nd 00:01 Instrument # 685 End Time: Filter # 52225 Total time:
	Flow (LPM)	Average Flow: (L) Volume:
	Lab Post Sampling	Received by: CBM Date: 9 Nov 2015 @ 13:00 Status: Valid Void (Circle one) If Void, Why: Equipment error

Comments: Maximum Load

DEQ ~~Pic~~ Retrieval Date/time From Reed:

initials:

9 Nov 2015 @ 1300 CBM

PPT = Portland, SE Powell Blvd and SE 22nd Avenue

PQ 100 SN 685

Particulate Sampler

Book II

2

4 feb 15 | 14:30 @PNS s/u # 1381
T= 12.4 BP=757
Timer programed ~~start @~~ 6feb15 @ 00:01 Run for 24:00
~~stop @ 6 f~~

6feb15 | 0814 @PNS p/u # 1381
T= 11.1 BP= 747 TE= 9:59 min "Max out"
CBM | 841min TS= 12.61 flow 15.0Lpm

10feb15 | BGF Removed from PNS After timer issues
CBM

2Oct 2015 | flow Calibration in lab.

Correction factor 0.9886 ~~Raw flow. 1.0~~ Monometer 1.08
Raw flow = 16.57
Indicated flow 16.7 16.38

~~16.38~~ 16.7 - 16.38 / 16.38 = 1.95%

8 feb 2016 @ 12:05 in Lab.
Delta Cal calibration

	Ind	Act	
Flow	16.7	16.68	0.118%
Time	12:105	12:05	
BP	~~7~~	765	

BGI PQ100
SN 720

2 Oct 2015 Calibrated in Lab.

Indicated flow 16.7 ~~Actual~~ Raw flow 16.65
Smart Manometer 1.09 Correction factor 0.9886
Actual flow 16.46
(16.7 − 16.46/16.46 x100 → 1.45% − CBM

Transcribed from Notes.

18 Nov 2015 unit Pulled from PTT site - Calibration checked
at 16.7 ok.

Unit was then Recalibrated to 15.0 Lpm for use as chrome 6
sampler to replace malfunctioning equipment at PNR

Calibration 1 pt.
orifice 033 manometer zero = 0.0/.60 => Raw flow 14.94
Temp 23.6 Bp 30.02 Correction factor . .9959
Actual flow - 14.87 Indicated 15.0
% diff = 0.87% ✓

19 Nov 2015 14:13 @ PNS s/u# 1514 T = 8.0 Bp = 760
Start timer 20 Nov 2015 @ 00:01 for 24 hrs. - CBM

23 Nov 2015 0730 @ PNS p/u # 1514 T = 3.5 Bp 756 TT = 1440
Stop time 21 Nov 2015 @ 00:01 Ave flow/temp/Bp - 15.0/5.0/765 Vol = 21.6 - CBM

25 Nov 2015 14:15 @ PNS s/u # 1517 T = 9.7 Bp = 762
Start timer 26 Nov 2015 @ 00:01 for 24 hrs - CBM

27 Nov 2015 0722 @ PNS p/u # 1517 T = 0.5 Bp = 765 TT 1440 Vol. 21.6
Stop time 27 Nov 2015 @ 00:01 Ave flow/temp/Bp - 15.0/1.2/765 - CBM

Agency for Toxic Substances and Disease Registry Memo

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

Agency for Toxic Substances
and Disease Registry
Atlanta GA 30333

Ms. Julie Sifuentes
Oregon Health Authority
Public Health Division
Environmental Public Health Section
Environmental Public Health Assessment Program

December 19, 2019

Dear Ms. Sifuentes,

This letter responds to Oregon Health Authority's (OHA) requests for technical support regarding a dataset of air sampling results from Oregon Department of Environmental Quality (ODEQ) that was collected in October of 2015 near the Bullseye Glass facility. We appreciate OHA's forbearance with ATSDR during the review of these data, but to perform a complete review required us to consult with several experts outside of our agency. In addition, we had to collaborate with ODEQ to gather additional information and receive additional analyses of the data.

OHA initially requested that we review the data package submitted by the Oregon Department of Environmental Quality (ODEQ) in November 2017 (Boling 2017a, 2017b, 2017c). OHA was evaluating the October 2015 data in a draft of OHA's Public Health Assessment (PHA) to address community and lawmaker's concerns regarding air emissions from Bullseye Glass under a cooperative agreement program with ATSDR. The air data collected next to the Bullseye facility in 2015 and the follow-up air monitoring effort led to changes in the institutional controls at the facility and in rulemaking in Oregon about air quality. For the PHA regarding Bullseye Glass, the October 2015 data represented the only sampling data collected prior to many of these controls being instituted. However, the lab detected contaminants, particularly chromium in blank samples (GRM 2017).

The scope of ATSDR's review is outlined in Chapter 5 of ATSDR's Public Health Assessment Guidance manual (PHAGM), which addresses evaluation of data usability for Public Health Assessment Purposes (c.f. PHAGM page 5-7, ATSDR 2005). However, during our review of the details of the October 2015 data, we identified additional potential issues involving quality assurance and quality control (QAQC). For instance, multiple analyses of the same contaminants in some samples had apparently produced inconsistent results, a calibration curve did not cover the range of contaminants, lack of method documentation, and some check standards did not produce consistent results. The PHAGM does not advise health assessors to make detailed assessments of data quality unless there is reason to suspect data quality has been compromised. When conducting such a review, the PHAGM advises that, "you should consult with other team members (e.g., analytical chemists), site investigators, or the laboratory that generated the data to clarify questions you may have related to methods used or data validation documentation." The PHAGM recommends three general aspects of environmental data that should be checked in a usability review:

1. check the analytical method,
2. review data validation documentation, and
3. consult with site investigators, regulators, and technical experts.

The PHAGM also states that the decision of the usability of the data in a PHA should be justified and transparently discussed in the document and considered when making public health conclusions. For instance, the presence of blank contamination might not invalidate the use of the data in a PHA if the level with the additional potential blank contamination is below corresponding health comparison value (see PHAGM page 5-7). ATSDR consulted with analytical chemists from the Environmental Protection Agency's (EPA's) technical support contractor (ERG), EPA's Manchester Lab in Region 10, and the Division of Laboratory Science at the National Center of Environmental Health (NCEH/DLS) at the Centers for Disease Control and Prevention. Based on this feedback, and in consultation with EPA Region 10's Manchester Lab, ODEQ worked with their contracted lab (Desert Research Institute) to gather additional information, evaluate laboratory performance in analyzing check standards, calculate detection limits, and validate laboratory calculations. ODEQ then submitted a revised data package to OHA in February 2019 (Boling 2019). This reanalysis invalidated all chromium results due to blank contamination, poor check standard performance, and inconsistent results between analytic runs indicating uncontrolled interferences. Manganese showed some variability between runs but not at a magnitude that prompted ODEQ to invalidate the samples.

In March 2019, OHA revised the request to ATSDR for technical assistance, asking four specific questions about the revised data set and its usability for the Bullseye PHA (Our responses are below the questions):

1. **Does ATSDR agree that the revised October 2015 dataset submitted by Oregon DEQ on February 22, 2019 is consistent with how the data should have been presented to OHA originally?**

   ATSDR has worked with OHA, EPA and ODEQ to provide the appropriate review when data quality is suspect per PHAGM guidance. Analytic chemists at ODEQ checked the methods, verified analytic procedures and worked with experts at EPA Region 10 to ensure the data are of a known and verifiable quality. Currently, we see no reason that the ODEQ revised data set cannot be evaluated as part of the PHA authored by OHA.

2. **Does Oregon DEQ's February 22, 2019 memo and the accompanying revised October 2015 data adequately describe the quality of the October 2015 data?**

   ATSDR guidance recommends resolving such questions by consulting with the laboratory/organization that generated the data, with appropriate technical consultation to assist in resolving QAQC issues. Based on input from EPA Region 10, ODEQ chemists worked with the contracted laboratory (DRI) to perform a QAQC review of the data. These issues revolved around concerns regarding method capabilities, method check standards, reporting limits, and significant digits. As documented in Boiling 2019, ODEQ assessed the quality of the data by recalculating the measurements based on updated calibration curves, assessing relative standard deviation between the multiple analytic runs, and assessing the relative percent deviation from the original analysis and the recalculated analysis. The results of this analysis are summarized in Table 1. ATSDR verified the relative percent deviation and calculated the relative standard deviation (RSD) of the results based on the revised calibration curves. Our calculation of RSD is slightly different from Boiling 2019 as we did not include the original sample analysis in the calculation of RSD, which would bias the RSD downward due to counting the original run twice. To compare the accuracy, we calculated the percent difference from the check standards for the data presented by Boiling 2019 and presented the highest percent difference at each check standard. We converted the check standard solution results to equivalent air concentrations (micrograms per cubic meter) assuming an air volume of 24.04 cubic meters so their overall impact on the health assessment can be assessed. As noted in Boiling 2019, there are some issues with high RSD's with manganese and chromium, as well as issues apparent with the accuracy of the chromium results.

3. **Does ATSDR agree that total chromium data from the October 2015 data set should be, and should have been, considered "void"?**

   Unless additional information is available, ATSDR agrees with not using the total chromium data from the October 2015 data set in a public health assessment. There was exceptionally high relative standard deviation of the sample results between analytic runs indicating unresolved interferences, detection of chromium in the field blank, an incomplete range of calibration standards, and check standard recoveries outside the acceptance limits.

4. **How should OHA use the remaining October 2015 data for metals other than chromium in terms of evaluating health risks from long-term exposure?**

   You can use the data in a PHA following ATSDR screening and further evaluation procedures as are discussed in Chapters 7 and 8 of the ATSDR PHAGM (ATSDR 2005). ATSDR has an Exposure Point Concentration Guidance, which may be of assistance for developing a statistical estimate of upper confidence of the average exposure for an in-depth evaluation (ATSDR 2019). OHA should factor judgements about the local meteorology during sampling, patterns of potential emissions from Bullseye Glass over time, other potential sources of air contaminants in the area, the location of the sampler during the monitoring relative to exposed populations, as well as the small overall number of samples collected. As noted by ODEQ, you should give attention to manganese during screening; some of the samples had high relative standard deviation across the runs and this variation could create uncertainty if the screening values are within the variation of the manganese results (Table 1).

A key limitation of the October 2015 data is that ODEQ did not collect these samples to assess Bullseye Glass air emissions, and the only represent a single month of facility operations, which is reported to be a batch process. Therefore, you should be cautious in extrapolating to past conditions and any calculation of past risk would be hypothetical. However, such hypothetical risk may still be useful. For instance, for the valid sample results, OHA may want to highlight good public health practice through permitting, by evaluating hypothetical risks using the October 2015 data. The exposure assessment for the October 2015 data may also be compared to follow-up monitoring after institutional controls were put in place (along with any other data that support a change in emissions).

Finally, ATSDR has assisted OHA with air dispersion modeling utilizing the October 2015 data and produced several draft maps for the PHA that show the estimated concentrations before and after controls. ATSDR is withdrawing the maps that use these October 2015 data; however, modeled maps using long-term data from multiple points around the facility may still be considered. Use of modeled maps requires that the PHA go through CDC/ATSDR clearance.

Thank you for your patience as we worked through the technical nature of this dataset. If you have further questions, do not hesitate to reach out to your Technical Project Officer, LCDR Jona Johnson, at 770-488-7374 or IJG0@cdc.gov.

Sincerely,

James Durant, MSPH, CIH
Environmental Health Scientist, Division of Community Health Investigations

Rhonda S. Kaetzel, Ph.D., DABT
Regional Director (Region 10), Western Branch, Division of Community Health Investigations

LCDR Jona Johnson, PhD, MPH, CPH
Technical Project Officer, Division of Community Health Investigations

Table 1: Accuracy Relative to Check Standards and Precision across all Runs of October 2015 Metal Measurements

[ppb, parts per billion; µg/m3, micrograms per cubic meter; RPD, relative percent deviation; RSD, relative standard deviation; NA, Not Available.]

Metal	1 ppb Check Standard* [0.0021 µg/m^3]†	10 ppb Check Standard* [0.021 µg/m^3]†	100 ppb Check Standard* [0.21 µg/m^3]†	Sample RPD Range	Sample RSD Range
Arsenic	30.0%	10.0%	20.0%	0.0% – 7.4%	0.0% – 9.8%
Beryllium	10.0%	-91.9%	10.0%	NA‡	NA‡
Cadmium	10.0%	2,100.0%	20.0%	0.0% – 2.8%	0.0% – 12.5%
Cobalt	-12.0%	-55.0%	20.0%	1.9% – 13.6%	2.4% – 19.3%
Chromium	20.0%	2,000.0%	-61.0%	0.0% – 2.4%	3.1% – 122.3%
Manganese	60.0%	30.0%	20.0%	0.0% – 5.1%	3.4% – 67.8%
Nickel	20.0%	20.0%	20.0%	0.0% – 5.7%	5.4% – 40.4%
Lead	-12.0%	-13.0%	10.0%	0.0% – 8.8%	0.0% – 7.5%
Selenium	120.0%	30.0%	20.0%	0.0% – 25.5%	18.1% – 39.6%

* Maximum Percent Difference from Check Standard Across ALL analytic runs

† Equivalent air concentration to check standard at 24.04 meters of air collected.

‡ Samples below detection so precision could not be measured between runs.

References

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Boling B. 2019. Memo to Gabriela Goldfarb, Follow-up to DEQ Memo dated 11/29/2017 regarding the October 2015 Air Quality Sampling in SE Portland. Oregon Department of Environmental Quality. February 22, 2019.

[GRN] GRM Law Group. 2017. Letter to Patrick Allen and Lillian Shirley, Oregon Health Authority, RE: Bullseye Glass Manufacturing Site Public Health Assessment PHD Internal Review DRAFT-June 2017.

Appendix E. Summary of air data for areas sampled near the Bullseye Glass site

Table E-1. Summary of the air data collected from the Fred Meyer corporate offices [SE Powell and 22nd Avenue] from Oct. 6, 2015 through Nov. 2, 2015

Contaminant	Number of detections and samples	Minimum concentration (ng/m^3)	Maximum concentration (ng/m^3)	Mean concentration‡ (ng/m^3)	Screening level (ng/m^3)	Contaminant of concern?	Urban background£ (ng/m^3)
Arsenic	18/18	**1.15**	**101**	**31.8**	0.23[a]	Yes	0.78
Beryllium	0/18	ND	ND	ND	0.42[a]	No	0.0069
Cadmium	18/18	**0.77**	**195**	**29.4**	0.56[a]	Yes	0.1
Chromium€	0/18	Void	Void	Void	0.052[a]	No	5.5
Cobalt	17/18	ND	3.48	0.95	100[b]	No	NA
Lead	18/18	2.25	**248**	**42.9**	150[c]	Yes	3
Manganese	18/18	3.35	**50.5**	**18.6**	300[b]	No	9.7
Nickel¥	18/18	**1.39**	**17.0**	**5.42**	4[d]	Yes	1.1
Selenium	14/18	ND	**271**	**56.9**	21,000[e]	No	0.37

Abbreviations: ng/m^3 = nanogram per cubic meter; > = greater than; ATSDR = Agency for Toxic Substances and Disease Registry; ND = Not detected; NA = Not available

Screening level sources:

- **a.** ATSDR Cancer Risk Evaluation Guide from February 2020
- **b.** ATSDR Chronic Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
- **c.** U.S. Environmental Protection Agency National Ambient Air Quality Standards rolling three-month average
- **d.** Oregon Department of Environmental Quality Ambient Benchmark Concentration, and
- **e.** U.S. Environmental Protection Agency Regional Screening Level for resident ambient air, non-cancer, November 2019

‡ To calculate the mean concentration for each contaminant, non-detect observations were omitted. Non-detects were included when calculating exposure point concentrations as described in Appendix H. This is why some exposure point concentrations are lower than the means listed here.

€ All chromium was void due to quality issues in data. There is no screening level for chromium. So, we used the value for hexavalent chromium as a surrogate. Blank contamination and problems with calibration and analytical interference made chromium results unusable.

¥ We used the value for nickel refinery dust, the most toxic form of this contaminant, as a surrogate since we did not know the actual form of nickel emitted from Bullseye.

£Typical urban background concentrations were calculated by averaging the annual mean concentrations of each metal from five to 18 cities across the country using their National Ambient Air Toxics Trend Site monitoring data.

Rows with yellow shading indicate when the maximum concentration is above the screening level.

Bolded values indicate a concentration higher than the typical urban background.

Table E-2. Summary of the air data collected from all four areas (the daycare center, the Winterhaven School, SE Powell and 22nd Avenue, and SE Haig and SE 20th Avenue) around the Bullseye Glass site from March 1, 2016 through March 30, 2017

Contaminant	Number of detections and samples	Minimum concentration (ng/m^3)	Maximum concentration (ng/m^3)	Mean concentration‡ (ng/m^3)	Screening level (ng/m^3)	Contaminant of concern?	Urban background£ (ng/m^3)
Arsenic	1013/1013	0.046	**4.93**	0.694	0.23[a]	Yes	0.78
Beryllium	372/1014	ND	**0.035**	**0.007**	0.42[a]	No	0.0069
Cadmium	832/1013	ND	**20.9**	**0.419**	0.56[a]	Yes	0.1
Chromium€	91/1012	ND	**7.93**	2.35	100[b]	No	5.5
Chromium, hexavalent	860/1004	ND	**3.63**	**0.141**	0.052[a]	Yes	0.0036
Cobalt	947/1014	ND	8.44	0.216	100[c]	No	NA
Lead	1003/1013	ND	**669**	**6.32**	150[d]	Yes	3
Manganese	1002/1014	ND	**130**	9.32	300[c]	No	9.7
Nickel¥	635/1013	ND	**15.3**	0.831	4[e]	Yes	1.1
Selenium	1001/1014	ND	**887**	**7.57**	21,000[f]	No	0.37

Abbreviations: ng/m^3 = nanogram per cubic meter; > = greater than; ATSDR = Agency for Toxic Substances and Disease Registry; NA = Not available

Screening level sources:

a. ATSDR Cancer Risk Evaluation Guide from February 2020
b. ATSDR Intermediate Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
c. ATSDR Chronic Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
d. U.S. Environmental Protection Agency National Ambient Air Quality Standards rolling three-month average
e. Oregon Department of Environmental Quality Ambient Benchmark Concentration, and
f. U.S. Environmental Protection Agency Regional Screening Level for resident ambient air, non-cancer, November 2019

‡ To calculate the mean concentration for contaminants of concern (cadmium, hexavalent chromium, and nickel) OHA incorporated non-detects using software provided by the EPA called "ProUCL." For all other contaminants, OHA omitted non-detects from the mean. ProUCL is described in more detail in Appendix H.
€ There is no screening level for chromium. So, we used the value for trivalent chromium as a surrogate.
¥ We used the value for nickel refinery dust, the most toxic form of this contaminant, as a surrogate since we did not know the actual form of nickel emitted from Bullseye.
£Typical urban background concentrations were calculated by averaging the annual mean concentrations of each metal from five to 18 cities across the country using their National Ambient Air Toxics Trend Site monitoring data.
Rows with yellow shading indicate when the maximum concentration is above the screening level.
Bolded values indicate a concentration higher than the typical urban background.

Table E-3. Summary of the air data collected from *only* the daycare center from March 1, 2016 through March 30, 2017

Contaminant	Number of detections and samples	Minimum concentration (ng/m^3)	Maximum concentration (ng/m^3)	Mean concentration‡ (ng/m^3)	Screening level (ng/m^3)	Contaminant of concern?	Urban background£ (ng/m^3)
Arsenic	331/331	0.046	**4.93**	**0.863**	0.23[a]	Yes	0.78
Beryllium	190/332	ND	**0.035**	**0.008**	0.42[a]	No	0.0069
Cadmium	305/331	ND	**20.9**	**0.773**	0.56[a]	Yes	0.1
Chromium€	44/331	ND	**7.69**	2.14	100[b]	No	5.5
Chromium, hexavalent	299/326	ND	**3.63**	**0.19**	0.052[a]	Yes	0.0036
Cobalt	313/332	ND	8.44	0.294	100[c]	No	NA
Lead	327/331	ND	**669**	**10.1**	150[d]	Yes	3
Manganese	328/332	ND	**130**	**10.4**	300[c]	No	9.7
Nickel¥	226/331	ND	**15.3**	0.886	4[e]	Yes	1.1
Selenium	328/332	ND	**887**	**16.3**	21,000[f]	No	0.37

Abbreviations: ng/m^3 = nanogram per cubic meter; > = greater than; ATSDR = Agency for Toxic Substances and Disease Registry; NA = Not available
Screening level sources:

a. ATSDR Cancer Risk Evaluation Guide from February 2020
b. ATSDR Intermediate Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
c. ATSDR Chronic Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
d. U.S. Environmental Protection Agency National Ambient Air Quality Standards rolling 3-month average
e. Oregon Department of Environmental Quality Ambient Benchmark Concentration, and
f. U.S. Environmental Protection Agency Regional Screening Level for resident ambient air, non-cancer, November 2019

‡ To calculate the mean concentration for contaminants of concern (cadmium, hexavalent chromium, and nickel) OHA incorporated non-detects using software provided by the EPA called "ProUCL." For all other contaminants, OHA omitted non-detects from the mean. ProUCL is described in more detail in Appendix H.
€ There is no screening level for chromium. So, we used the value for trivalent chromium as a surrogate.
¥ We used the value for nickel refinery dust, the most toxic form of this contaminant, as a surrogate since we did not know the actual form of nickel emitted from Bullseye.
£Typical urban background concentrations were calculated by averaging the annual mean concentrations of each metal from five to 18 cities across the country using their National Ambient Air Toxics Trend Site monitoring data.
Rows with yellow shading indicate when the maximum concentration is above the screening level.
Bolded values indicate a concentration higher than the typical urban background.

Table E-4. Summary of the air data collected from *only* the Winterhaven School from March 1, 2016 through Sept. 30, 2016

Contaminant	Number of detections and samples	Minimum concentration (ng/m^3)	Maximum concentration (ng/m^3)	Mean concentration‡ (ng/m^3)	Screening level (ng/m^3)	Contaminant of concern?	Urban background£ (ng/m^3)
Arsenic	202/202	0.075	**4.03**	0.460	0.23[a]	Yes	0.78
Beryllium	55/202	ND	**0.016**	0.006	0.42[a]	No	0.0069
Cadmium	124/202	ND	**1.34**	0.095	0.56[a]	Yes	0.1
Chromium€	11/202	ND	**7.54**	2.19	100[b]	No	5.5
Chromium, hexavalent	165/203	ND	**0.695**	**0.075**	0.052[a]	Yes	0.0036
Cobalt	179/202	ND	4.53	0.177	100[c]	No	NA
Lead	198/202	ND	**51.5**	2.93	150[d]	No	3
Manganese	200/202	ND	**46.4**	9.17	300[c]	No	9.7
Nickel¥	127/202	ND	**8.24**	0.821	4[e]	Yes	1.1
Selenium	201/202	ND	**22.3**	**0.50**	21,000[f]	No	0.37

Abbreviations: ng/m^3 = nanogram per cubic meter; > = greater than; ATSDR = Agency for Toxic Substances and Disease Registry; NA = Not available
Screening level sources:

a. ATSDR Cancer Risk Evaluation Guide from February 2020
b. ATSDR Intermediate Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
c. ATSDR Chronic Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
d. U.S. Environmental Protection Agency National Ambient Air Quality Standards rolling 3-month average
e. Oregon Department of Environmental Quality Ambient Benchmark Concentration, and
f. U.S. Environmental Protection Agency Regional Screening Level for resident ambient air, non-cancer, November 2019

‡ To calculate the mean concentration for contaminants of concern (cadmium, hexavalent chromium, and nickel) OHA incorporated non-detects using software provided by the EPA called "ProUCL." For all other contaminants, OHA omitted non-detects from the mean. ProUCL is described in more detail in Appendix H.
€ There is no screening level for chromium. So, we used the value for trivalent chromium as a surrogate.
¥ We used the value for nickel refinery dust, the most toxic form of this contaminant, as a surrogate since we did not know the actual form of nickel emitted from Bullseye.
£Typical urban background concentrations were calculated by averaging the annual mean concentrations of each metal from five to 18 cities across the country using their National Ambient Air Toxics Trend Site monitoring data.
Rows with yellow shading indicate when the maximum concentration is above the screening level.
Bolded values indicate a concentration higher than the typical urban background.

Table E-5. Summary of the air data collected from *only* SE Powell and 22nd Avenue from March 1, 2016 through March 30, 2017

Contaminant	Number of detections and samples	Minimum concentration (ng/m^3)	Maximum concentration (ng/m^3)	Mean concentration‡ (ng/m^3)	Screening level (ng/m^3)	Contaminant of concern?	Urban background£ (ng/m^3)
Arsenic	331/331	0.083	**3.61**	0.681	0.23[a]	Yes	0.78
Beryllium	77/331	ND	**0.015**	0.006	0.42[a]	No	0.0069
Cadmium	278/331	ND	**7.22**	**0.329**	0.56[a]	Yes	0.1
Chromium€	25/330	ND	**7.14**	2.51	100[b]	No	5.5
Chromium, hexavalent	301/328	ND	**3.10**	**0.14**	0.052[a]	Yes	0.0036
Cobalt	307/331	ND	7.04	0.156	100[c]	No	NA
Lead	329/331	ND	**116**	**4.63**	150[d]	No	3
Manganese	325/331	ND	**123**	7.80	300[c]	No	9.7
Nickel¥	177/331	ND	**13.2**	0.74	4[e]	Yes	1.1
Selenium	324/331	ND	**119**	**2.32**	21,000[f]	No	0.37

Abbreviations: ng/m^3 = nanogram per cubic meter; > = greater than; ATSDR = Agency for Toxic Substances and Disease Registry; NA = Not available
Screening level sources:

a. ATSDR Cancer Risk Evaluation Guide from February 2020
b. ATSDR Intermediate Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
c. ATSDR Chronic Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
d. U.S. Environmental Protection Agency National Ambient Air Quality Standards rolling 3-month average
e. Oregon Department of Environmental Quality Ambient Benchmark Concentration, and
f. U.S. Environmental Protection Agency Regional Screening Level for resident ambient air, non-cancer, November 2019

‡ To calculate the mean concentration for contaminants of concern (cadmium, hexavalent chromium, and nickel) OHA incorporated non-detects using software provided by the EPA called "ProUCL." For all other contaminants, OHA omitted non-detects from the mean. ProUCL is described in more detail in Appendix H.
€ There is no screening level for chromium. So, we used the value for trivalent chromium as a surrogate.
¥ We used the value for nickel refinery dust, the most toxic form of this contaminant, as a surrogate since we did not know the actual form of nickel emitted from Bullseye.
£Typical urban background concentrations were calculated by averaging the annual mean concentrations of each metal from five to 18 cities across the country using their National Ambient Air Toxics Trend Site monitoring data.
Rows with yellow shading indicate when the maximum concentration is above the screening level.
Bolded values indicate a concentration higher than the typical urban background.

Table E-6. Summary of the air data collected from *only* SE Haig and SE 20th Avenue from March 1, 2016 through Oct. 20, 2016

Contaminant	Number of detections and samples	Minimum concentration (ng/m^3)	Maximum concentration (ng/m^3)	Mean concentration‡ (ng/m^3)	Screening level (ng/m^3)	Contaminant of concern?	Urban background£ (ng/m^3)
Arsenic	149/149	0.101	**4.39**	0.664	0.23[a]	Yes	0.78
Beryllium	50/149	ND	**0.015**	0.006	0.42[a]	No	0.0069
Cadmium	125/149	ND	**4.84**	**0.273**	0.56[a]	Yes	0.1
Chromium€	11/149	ND	**7.93**	3.02	100[b]	No	5.5
Chromium, hexavalent	95/147	ND	**2.88**	**0.121**	0.052[a]	Yes	0.0036
Cobalt	148/149	ND	6.41	0.219	100[c]	No	NA
Lead	149/149	0.406	**61.7**	**6.34**	150[d]	No	3
Manganese	149/149	1.51	**43.7**	**10.49**	300[c]	No	9.7
Nickel¥	105/149	ND	**12.5**	0.928	4[e]	Yes	1.1
Selenium	148/149	ND	**285**	**9.22**	21,000[f]	No	0.37

Abbreviations: ng/m^3 = nanogram per cubic meter; > = greater than; ATSDR = Agency for Toxic Substances and Disease Registry; NA = Not available
Screening level sources:

a. ATSDR Cancer Risk Evaluation Guide from February 2020
b. ATSDR Intermediate Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
c. ATSDR Chronic Environmental Media Evaluation Guide/Minimal Risk Level from February 2020
d. U.S. Environmental Protection Agency National Ambient Air Quality Standards rolling 3-month average
e. Oregon Department of Environmental Quality Ambient Benchmark Concentration, and
f. U.S. Environmental Protection Agency Regional Screening Level for resident ambient air, non-cancer, November 2019

‡ To calculate the mean concentration for contaminants of concern (cadmium, hexavalent chromium, and nickel) OHA incorporated non-detects using software provided by the EPA called "ProUCL." For all other contaminants, OHA omitted non-detects from the mean. ProUCL is described in more detail in Appendix H.
€ There is no screening level for chromium. So, we used the value for trivalent chromium as a surrogate.
¥ We used the value for nickel refinery dust, the most toxic form of this contaminant, as a surrogate since we did not know the actual form of nickel emitted from Bullseye.
£Typical urban background concentrations were calculated by averaging the annual mean concentrations of each metal from five to 18 cities across the country using their National Ambient Air Toxics Trend Site monitoring data.
Rows with yellow shading indicate when the maximum concentration is above the screening level.
Bolded values indicate a concentration higher than the typical urban background.

Appendix F. Summary of soil data for areas sampled near the Bullseye Glass site

Table F-1. Summary of the soil data collected from Powell Park in February 2016† (13)

Contaminant	Number of detections and samples	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Mean concentration‡ (mg/kg)	Screening level (mg/kg)	Contaminant of concern?	Portland Basin background £ (mg/kg)
Aluminum	18/18	4,200	17,200	8,454	52,000[a]	No	ND
Arsenic	18/18	1.44	**10.7**	4.64	16[a,b]	No	8.8
Cadmium	18/18	0.18	**9.87**	**2.85**	5.2[a]	Yes	0.63
Chromium§	18/18	5.96	28.8	14.1	78,000[c]	No	76
Chromium, hexavalent	5/18	0.505	1.8	0.496	47[a]	No	ND
Cobalt	18/18	4.65	20.7	10.3	23[d]	No	ND
Iron	18/18	8,220	35,100	18,189	55,000[d]	No	ND
Lead	18/18	4.82	**258**	78.9	79[e]	Yes	79
Manganese	18/18	269	1,460	579	2,600[b]	No	1800
Mercury €	17/18	0.00393	0.116	0.0659	16[b]	No	0.23
Nickel	18/18	4.67	27.2	13.7	1,000[b]	No	47
Selenium	12/18	0.318	**3.48**	**0.968**	260[a,b]	No	0.71
Uranium ¥	2/2	0.662	0.727	0.695	160[b]	No	ND

Abbreviations: mg/kg = milligram per kilogram; ATSDR = Agency for Toxic Substances and Disease Registry; ND = No data on background concentrations

Screening level sources:

a. ATSDR Chronic Environmental Media Evaluation Guide for a child from January 2020
b. ATSDR Chronic Reference Dose Media Evaluation Guide for a child from December 2019
c. ATSDR Chronic Reference Dose Media Evaluation Guide for a child from January 2020
d. U.S. Environmental Protection Agency Regional Screening Level for residential soil, non-cancer, January 2020, and
e. Because no safe level of lead has been identified, OHA used the Portland urban background as a screening level.

† This summary table only includes the samples that we evaluated; it does not include subsurface or duplicate samples collected by the Oregon Department of Environmental Quality.
‡ To calculate the mean concentration for each contaminant, non-detect observations were replaced with concentrations equal to one-half the detection limit.
§ There is no screening level for chromium. So, we used the value for trivalent chromium as a surrogate.
€ There is no screening level for mercury. So, we used the value for mercuric chloride as a surrogate.
¥ There is no screening level for uranium. So, we used the value for uranium soluble salts as a surrogate.
£Oregon Department of Environmental Quality Background Estimate for Portland Basin
Rows with yellow shading indicate when the maximum concentration is above the screening level.
Bolded values indicate a concentration higher than the typical urban background for the Portland Basin.

Table F-2. Summary of the soil data collected from the Fred Meyer corporate offices [SE Powell and 22nd Avenue] in February 2016† (13)

Contaminant	Number of detections and samples	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Mean concentration‡ (mg/kg)	Screening level (mg/kg)	Contaminant of concern?	Portland Basin background£ (mg/kg)
Aluminum	18/18	3,270	18,100	9,620	800,000[a]	No	ND
Arsenic	18/18	1.86	**12.2**	5.46	240[a,b]	No	8.8
Cadmium	13/18	**1.07**	**15**	**4.37**	80[a]	No	0.63
Chromium§	18/18	7.38	63	17.1	1,200,000[c]	No	76
Chromium, hexavalent	2/18	0.871	1.96	0.398	720[a]	No	ND
Cobalt	18/18	7.54	70.4	20.9	350[d]	No	ND
Iron	18/18	9,640	50,900	23,636	820,000[d]	No	ND
Lead	18/18	4.2	73.5	28.2	79[e]	No	79
Manganese	18/18	307	**2,230**	834	40,000[b]	No	1800
Mercury €	18/18	0.00492	0.1	0.0347	240[b]	No	0.23
Nickel	18/18	6.58	40.2	19.4	16,000[b]	No	47
Selenium	2/18	**3.32**	**4.42**	**1.59**	4,000[a,b]	No	0.71
Uranium ¥	0/2	-	-	0.575	2,400[b]	No	ND

Abbreviations: mg/kg = milligram per kilogram; ATSDR = Agency for Toxic Substances and Disease Registry; ND = No data on background concentrations

Screening level sources:

a. ATSDR Chronic Environmental Media Evaluation Guide for an adult from January 2020
b. ATSDR Chronic Reference Dose Media Evaluation Guide for an adult from January 2020
c. ATSDR Chronic Reference Dose Media Evaluation Guide for an adult from January 2020
d. U.S. Environmental Protection Agency Regional Screening Level for composite worker soil, non-cancer, January 2020, and
e. Because no safe level of lead has been identified, OHA used the Portland urban background as a screening level.

† This summary table only includes the samples that we evaluated; it does not include subsurface or duplicate samples collected by the Oregon Department of Environmental Quality.
‡ To calculate the mean concentration for each contaminant, non-detect observations were replaced with concentrations equal to one-half the detection limit.
§ There is no screening level for chromium. So, we used the value for trivalent chromium as a surrogate.
€ There is no screening level for mercury. So, we used the value for mercuric chloride as a surrogate.
¥ There is no screening level for uranium. So, we used the value for uranium soluble salts as a surrogate.
£Oregon Department of Environmental Quality Background Estimate for Portland Basin
Bolded values indicate a concentration higher than the typical urban background for the Portland Basin.

Table F-3. Summary of the soil data collected from the daycare center in February 2016† (13)

Contaminant	Number of detections and samples	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Mean concentration‡ (mg/kg)	Screening level (mg/kg)	Contaminant of concern?	Portland Basin background£ (mg/kg)
Aluminum	12/12	4,020	11,400	8,355	52,000[a]	No	ND
Arsenic	12/12	2.52	**42.6**	**11.8**	16[a,b]	Yes	8.8
Cadmium	12/12	0.398	**5.29**	**2.38**	5.2[a]	Yes	0.63
Chromium§	12/12	7.68	22.3	17.2	78,000[c]	No	76
Chromium, hexavalent	10/12	0.284	2.99	1.25	47[a]	No	ND
Cobalt	12/12	6.2	16.7	10.4	23[d]	No	ND
Iron	12/12	9,620	24,300	16,293	55,000[d]	No	ND
Lead	12/12	7.78	**122**	48.2	79[e]	Yes	79
Manganese	12/12	278	793	474	2,600[b]	No	1800
Mercury €	12/12	0.0133	0.0526	0.0302	16[b]	No	0.23
Nickel	12/12	7.83	17.3	11.3	1,000[b]	No	47
Selenium	12/12	0.328	**1.36**	**0.858**	260[a,b]	No	0.71
Uranium ¥	4/4	1.03	1.69	1.40	160[b]	No	ND

Abbreviations: mg/kg = milligram per kilogram; ATSDR = Agency for Toxic Substances and Disease Registry; ND = No data on background concentrations

Screening level sources:

a. ATSDR Chronic Environmental Media Evaluation Guide for a child from January 2020
b. ATSDR Chronic Reference Dose Media Evaluation Guide for a child from January 2020
c. ATSDR Chronic Reference Dose Media Evaluation Guide for a child from January 2020
d. U.S. Environmental Protection Agency Regional Screening Level for residential soil, non-cancer, January 2020, and
e. Because no safe level of lead has been identified, OHA used the Portland urban background as a screening level.

† This summary table only includes the samples that we evaluated; it does not include subsurface or duplicate samples collected by the Oregon Department of Environmental Quality.
‡ To calculate the mean concentration for each contaminant, non-detect observations were replaced with concentrations equal to one-half the detection limit.
§ There is no screening level for chromium. So, we used the value for trivalent chromium as a surrogate.
€ There is no screening level for mercury. So, we used the value for mercuric chloride as a surrogate.
¥ There is no screening level for uranium. So, we used the value for uranium soluble salts as a surrogate.
£Oregon Department of Environmental Quality Background Estimate for Portland Basin
Rows with yellow shading indicate when the maximum concentration is above the screening level.
Bolded values indicate a concentration higher than the typical urban background for the Portland Basin.

Table F-4. Summary of the soil data collected northwest of the Bullseye Glass site in July 2016† (14)

Contaminant	Number of detections and samples	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Mean concentration‡ (mg/kg)	Screening level (mg/kg)	Contaminant of concern?	Portland Basin background£ (mg/kg)
Aluminum	15/15	14,300	27,700	19,967	52,000[a]	No	ND
Arsenic	15/15	4.67	**12.8**	7.21	16[a,b]	No	8.8
Beryllium	15/15	0.313	0.699	0.537	100[a,b]	No	2.0
Cadmium	15/15	0.275	**35.8**	**6.08**	5.2[a]	Yes	0.63
Chromium	15/15	19.8	71.3	30.4	-	No	76
Chromium, hexavalent	5/15	0.434	11.3	1.30	47[a]	No	ND
Chromium, trivalent	15/15	19.8	60.1	29.4	78,000[b]	No	ND
Cobalt	15/15	10.6	23.1	16.5	23[c]	Yes	ND
Iron	15/15	28,300	51,500	38,867	55,000[c]	No	ND
Lead	15/15	20.0	**377**	**148**	79[d]	Yes	79
Manganese	15/15	398	978	710	2,600[b]	No	1800
Mercury €	15/15	0.0234	**0.332**	0.0794	16[b]	No	0.23
Nickel	15/15	18.5	30.1	23.5	1,000[b]	No	47
Selenium	15/15	**0.894**	**19.9**	**3.89**	260[a,b]	No	0.71
Zinc	15/15	73.5	**407**	**196**	16,000[a,b]	No	180

Abbreviations: mg/kg = milligram per kilogram; ATSDR = Agency for Toxic Substances and Disease Registry; ND = No data on background concentrations

Screening level sources:

a. ATSDR Chronic Environmental Media Evaluation Guide for a child from January 2020
b. ATSDR Chronic Reference Dose Media Evaluation Guide for a child from January 2020
c. U.S. Environmental Protection Agency Regional Screening Level for residential soil, non-cancer, January 2020, and
d. Because no safe level of lead has been identified, OHA used the Portland urban background as a screening level.

† This summary table only contains the samples that we evaluated. This includes the following samples collected by the Oregon Department of Environmental Quality in July 2016:

1. All of the surface samples collected from northwest of the Bullseye Glass site, and
2. Two surface samples (SS-15 and SS-16) collected from southeast of the Bullseye Glass site. It does not include subsurface or duplicate samples.

‡ To calculate the mean concentration for each contaminant, non-detect observations were replaced with concentrations equal to one-half the detection limit.

€ There is no screening level for mercury. So, we used the value for mercuric chloride as a surrogate.

£Oregon Department of Environmental Quality Background Estimate for Portland Basin

Rows with yellow shading indicate when the maximum concentration is above the screening level.

Bolded values indicate a concentration higher than the typical urban background for the Portland Basin.

Table F-5. Summary of the soil data collected southeast of the Bullseye Glass site in July 2016† (14)

Contaminant	Number of detections and samples	Minimum concentration (mg/kg)	Maximum concentration (mg/kg)	Mean concentration‡ (mg/kg)	Screening level (mg/kg)	Contaminant of concern?	Portland Basin background£ (mg/kg)
Aluminum	7/7	12,100	20,300	15,614	52,000[a]	No	ND
Arsenic	7/7	5.33	**22.9**	**9.15**	16[a,b]	Yes	8.8
Beryllium	7/7	0.466	0.614	0.540	100[a,b]	No	2.0
Cadmium	7/7	0.554	**1.94**	**1.08**	5.2[a]	No	0.63
Chromium	7/7	22.7	42.4	28.7	-	No	76
Chromium, hexavalent	2/7	0.721	6.60	1.45	47[a]	No	ND
Chromium, trivalent	7/7	16.5	42.4	27.6	78,000[b]	No	ND
Cobalt	7/7	11.2	22.6	15.6	23[c]	No	ND
Iron	7/7	25,700	39,600	31,414	55,000[c]	No	ND
Lead	7/7	27.4	**332**	**164**	79[d]	Yes	79
Manganese	7/7	347	1,440	637	2,600[b]	No	1800
Mercury €	7/7	0.0260	**0.610**	0.139	16[b]	No	0.23
Nickel	7/7	11.8	27.2	18.2	1,000[b]	No	47
Selenium	7/7	0.570	**1.60**	**1.02**	260[a,b]	No	0.71
Zinc	7/7	123	**223**	164	16,000[a,b]	No	180

Abbreviations: mg/kg = milligram per kilogram; ATSDR = Agency for Toxic Substances and Disease Registry; ND = No data on background concentrations

Screening level sources:

a. ATSDR Chronic Environmental Media Evaluation Guide for a child from January 2020
b. ATSDR Chronic Reference Dose Media Evaluation Guide for a child from January 2020
c. U.S. Environmental Protection Agency Regional Screening Level for residential soil, non-cancer, January 2020, and
d. Because no safe level of lead has been identified, OHA used the Portland urban background as a screening level.

† This summary table only contains the samples that we evaluated. This includes seven of nine surface samples collected from southeast of the Bullseye Glass site by the Oregon Department of Environmental Quality in July 2016; surface samples SS-15 and SS-16 were excluded from this analysis since they were included in our evaluation of the soil from northwest of the Bullseye Glass site. It does not include subsurface or duplicate samples.
‡ To calculate the mean concentration for each contaminant, non-detect observations were replaced with concentrations equal to one-half the detection limit.
€ There is no screening level for mercury. So, we used the value for mercuric chloride as a surrogate.
£Oregon Department of Environmental Quality Background Estimate for Portland Basin
Rows with yellow shading indicate when the maximum concentration is above the screening level.
Bolded values indicate a concentration higher than the typical urban background for the Portland Basin.

Appendix G. Health effects of contaminants of concern (COC)

Arsenic

Arsenic is a naturally-occurring metal widely distributed in soil. Most arsenic compounds have no smell or special taste. (45) Arsenic's toxicity has been recognized since ancient times. Scientists are continuing to learn more about how it works and its toxic effects on human health. Arsenic is a known cancer-causing chemical. The types of cancer most often associated with arsenic exposure are:

- Skin cancer
- Bladder cancer, and
- Lung cancer (from inhaled arsenic). (45)

At higher doses, arsenic can cause skin conditions such as:

- Discoloration and hardening, and
- Appearance of corns or warts on the palms, soles, and torso.

Arsenic can also cause nerve damage (numbness in the extremities) at high doses and more subtle effects on the brain at lower doses over a long time. (45)

Toxicity studies in ATSDR's Toxicological Profile for Arsenic indicate that inhaling inorganic arsenic can increase the risk of health effects in:

- The respiratory system
- Heart
- Immune system
- Lungs, and
- Fetal development. (45)

However, these effects have not been observed in animals or humans at arsenic concentrations less than 78,000 ng/m^3. Most non-cancer health effects associated with arsenic have been studied in settings where exposure occurred through drinking water as opposed to inhaling air. It is from these studies that California's Environmental Protection Agency extrapolated air concentrations that would result in internal concentrations of arsenic that would be expected to result in the same health effects found in human drinking water studies. OHA used those California-derived air concentrations as health guideline values in this PHA.

State and federal environmental agencies base their arsenic cleanup standards on workplace studies and laboratory animal studies. Because of uncertainties in these studies, these cleanup standards include large safety factors to ensure the public's health. Soil sampling from around Bullseye Glass showed that for a few samples, levels of arsenic were above background levels measured in the Portland area (8.8 ppm).

Cadmium
Cadmium is a soft, silver-white metal that occurs naturally in the earth's crust. Cadmium is not usually present in the environment as a pure metal, but as a mineral combined with other elements. It is most often present in nature as:

- Complex oxides
- Sulfides, and
- Carbonates in zinc, lead, and copper ores.

Cadmium has many industrial uses. It is used in consumer products, including batteries, pigments, metal coatings, plastics, and some alloys. (24)

Low levels of cadmium are present in most foods. The highest levels are present in shellfish, liver, and kidney meats. (24) Ingestion of high levels of cadmium in contaminated food or water can severely irritate the stomach. This leads to vomiting and diarrhea, and sometimes death. Cadmium is a cumulative toxicant and inhalation of lower levels for a long period (above the chronic minimal risk level [MRL] of 10 ng/m^3) of time can lead to a buildup of cadmium in the kidneys and, possibly, kidney damage. Cadmium interferes with the proper functioning of the kidney by damaging the proximal tubules. This impairs the kidney's ability to retain and reabsorb large molecules. Cadmium also prevents the kidney from retaining calcium, so prolonged exposure can lead to calcium depletion and loss of bone density. (24) Cigarette smoke contains cadmium and can double the daily intake when compared to a non-smoker. Inhaled cadmium above the acute MRL (30 ng/m^3) can increase the risk of respiratory irritation, such as coughing and throat irritation. Cadmium toxicity results when there is chronic-duration exposure by both oral and inhalation routes. The kidney is the main organ that is targeted.

There is some evidence to suggest an association between cadmium and breast cancer. One analysis of multiple case-control studies in people found that each 0.5-µg/g creatinine increment of urinary cadmium concentration was associated with a 66% increased risk of breast cancer. (46) The evidence from epidemiological studies has been inconsistent. However, the association is plausible based on evidence from laboratory studies that indicate cadmium may influence estrogen signaling. (47) (48)

There is also some evidence that cadmium may impair brain development. Young animals exposed to cadmium before birth have shown effects on behavior and learning. (24) Recent epidemiological studies found limited evidence of similar effects in people. For example, a study in China found an association between cadmium in mothers' blood during pregnancy and delayed development in infants. (49) In a study of children in Greece, elevated maternal urinary cadmium concentrations (≥0.8 µg/L) during pregnancy were associated with lower cognitive scores. However, in that study the effect was limited to mothers who smoked (50). There is also evidence that exposure to lead and cadmium during pregnancy may act synergistically to affect brain development. (51)

There is insufficient peer-reviewed data on the association between:

- Cadmium and breast cancer, and
- Cadmium and brain development.

Therefore, it is impossible for OHA to quantitatively evaluate their risks in this PHA. The potential effect of cadmium on these should be evaluated in the context of potential cumulative effects from other chemicals. For example, if cadmium affects brain development, concurrent exposures to cadmium and lead in the air around Bullseye Glass could have had cumulative or synergistic effects.

The exposure route of concern for cadmium in this PHA is the inhalation of contaminated air. The EPA has classified cadmium as a probable human carcinogen by inhalation. This is based on limited evidence of an increase in lung cancer in humans from occupational exposure to cadmium fumes and dust. This is further supported by evidence of lung cancer in rats. (24)

Chromium

Chromium is a naturally occurring element found in rocks, animals, plants, and soil. It can exist in several different forms. The most common forms of chromium measured in the environment are:

- The trivalent form, and
- The hexavalent form.

Hexavalent chromium is substantially more toxic than trivalent. (52) Small amounts of trivalent chromium are considered to be a necessity for human health. Chromium can easily change from one form to another in water and soil. It depends on the conditions present. Chromium is widely used in manufacturing. Chromium is in such products as treated wood, tanned leather, and stainless-steel cookware. (52)

The main health problems seen in animals following ingestion of high amounts of hexavalent chromium are:

- Anemia, and
- Irritation and ulcers in the stomach and small intestine.

Trivalent chromium compounds are much less toxic. They do not appear to cause these problems. Laboratory animals exposed to hexavalent chromium have had:

- Sperm damage, and
- Damage to the male reproductive system.

Skin contact with certain hexavalent chromium compounds can cause skin ulcers. (52) Some people are extremely sensitive to hexavalent chromium or trivalent chromium. Allergic reactions of severe redness and swelling of the skin have been noted.

ATSDR, the International Agency for Research on Cancer (IARC), and EPA have determined that hexavalent chromium compounds are “known” human carcinogens through the exposure route of inhalation. Inhalation of hexavalent chromium has been shown to cause lung cancer in workers and in animals. An increase in stomach tumors was observed in humans and animals exposed to hexavalent chromium in drinking water. (52)

ATSDR's MRL for hexavalent chromium is based on a study of chrome plating facility workers where the measured air concentration of hexavalent chromium was 500 ng/m^3. (53) Workers exposed at 500 ng/m^3 experienced:

- Respiratory irritation
- Mucosal atrophy (reduced function of the mucous membranes in the mouth and throat), and
- Poorer lung function.

In this study (53), workers were exposed to a form of hexavalent chromium called chromic acid mist. Other forms of hexavalent chromium, such as sodium dichromate particles, are much less (60 times less) toxic. Air monitoring cannot differentiate between chromic acid mist and sodium dichromate particles. However, the chemistry of glass making is different from chrome plating. Chrome platers normally use an acid bath (hydrogen chloride, hydrogen fluoride, sulfuric acid with trivalent chromium, but can use chromic acid with hexavalent chromium). The acid bath is used with an electrical current to deposit the chromium compound on the surface of the part. The chromate conversion process uses a chromic acid solution to coat parts by spraying or dipping without electrical current (Chromic acid is a form of hexavalent chromium). Colored glass uses powdered chromium (normally as chromite – trivalent chromium) to melt into the process and produce the green color. It is known that conditions in the furnace convert trivalent chromium to hexavalent chromium. However, it is not known whether that hexavalent chromium is in the form of chromic acid or other forms, like dichromate particles.

Children are more sensitive than adults to the cancer effects because hexavalent chromium has a "mutagenic mode of action". This means that the carcinogen reacts and binds to the DNA in our cells. (54) Children are assumed to be at increased risk for cancer and tumor development following exposure to mutagenic compounds. This is because their bodies are growing – their cells are rapidly replicating during this time. It is thought that a child's DNA repair mechanisms may not be able to keep up with the rapid cell replication. (54)

Scientific studies of chromium haven't fully demonstrated if exposure to chromium could result in birth defects or other developmental effects in people. Some developmental effects have been observed in animals exposed to hexavalent chromium. In animals, some studies show that exposure to high doses during pregnancy may cause:

- Miscarriage
- Low birth weight, and
- Some changes in the development of the skeleton and reproductive system.

Birth defects in animals may be related, in part, to chromium toxicity in the mothers. (52)

Cobalt

Cobalt is a naturally occurring element that has properties similar to iron and nickel. There are radioactive forms of cobalt. However, the naturally occurring form and the form used by Bullseye Glass are not radioactive. Some cobalt is essential to good health as it is a component of vitamin B12. Industries use cobalt in alloys with other metals and to color glass as in the case of Bullseye Glass. (55)

Cobalt can enter the body when it is inhaled or swallowed. Cobalt is not a contaminant of concern in the air around Bullseye. However, it was above screening levels in some soil samples. Cobalt can be absorbed into the blood when swallowed. People who are deficient in iron absorb more cobalt. People rapidly excrete some of the cobalt they absorb through feces, while the remainder tends to concentrate in the liver, kidneys, and bone. (55)

Breathing very high concentrations of cobalt in the air (38,000 ng/m^3) caused workers exposed for six hours to have difficulty breathing. Workers exposed to concentrations from 5,000-7,000 ng/m^3 have developed:

- Wheezing
- Asthma
- Pneumonia
- Allergies, and
- Skin rashes.

Much of what we know about the health effects of swallowed cobalt is from the 1960s. This was when some breweries added cobalt to beer as a foam stabilizer. Some people who drank a lot of this beer (8-25 pints per day) experienced:

- Nausea
- Vomiting, and
- Heart problems, some of which resulted in death.

Other studies have found that negative effects on the thyroid (decreased iodine uptake) in people who ingested cobalt over several weeks. Some studies in animals have suggested that cobalt exposure during pregnancy could affect the health of the developing fetus. However, this has not been shown in humans. The doses that caused these effects in animals were much higher than the doses people are typically exposed to and people around Bullseye Glass could have had (see health evaluation section).

Some animal studies have shown an increase in cancer risk when cobalt is inhaled or placed directly under the skin. Because of these studies, IARC considers cobalt to be “possibly carcinogenic to humans.” There is no evidence of cobalt causing cancer by ingestion (swallowing).

Lead

Lead is a naturally-occurring bluish-gray metal found in small amounts in the soil. Lead can be found in all parts of our environment. A lot of lead comes from human activities including burning fossil fuels, mining, and manufacturing. Because of health concerns, lead from paints, ceramic products, caulking, and pipe solder has been dramatically reduced in recent years. In 1996, the U.S. government banned the use of lead as an additive to gasoline in the United States.

Adults and children may be exposed to lead by hand-to-mouth contact after exposure to lead that contains soil or dust. Most exposure to lead (and the health effects that can follow) comes from accidental ingestion rather than skin exposure. Environmental exposure to lead has long been recognized as a public health problem, particularly among children. High levels of lead in soil have been shown to increase blood lead levels in young children. (56)

Exposure to lead can happen from breathing workplace air or dust, eating contaminated foods, or drinking contaminated water. Children can be exposed from eating lead-based paint chips or playing in contaminated soil. Lead can damage the nervous system, kidneys, and reproductive system. Signs and symptoms associated with lead toxicity include:

- Decreased learning capacity and memory
- Lowered Intelligence Quotient (IQ)
- Speech and hearing impairments
- Fatigue and lethargy.

Protecting children from exposure to lead is important to their lifelong good health. No safe blood lead level in children has been identified. Even low blood lead levels have been shown to affect IQ, ability to pay attention, and academic achievement. Effects of lead exposure are permanent. The goal is to prevent lead exposure to children before they are harmed. There are many ways parents can reduce a child’s exposure to lead. The most important is to stop children from coming into contact with lead. (57) Soil sampling from around Bullseye Glass showed concentrations of lead that were not different from background levels measured in the Portland area. Likely, risks calculated from lead levels seen around Bullseye Glass would not be different from other places in the city. Therefore, the safeguards OHA recommends to prevent lead exposure near Bullseye Glass would not be different than recommendations for all people in urban areas. These recommendations include:

- Thorough handwashing before eating, and
- Washing produce from home gardens.

Nickel

Pure nickel is a naturally occurring hard, silvery-white metal, which has properties that make it very desirable for combining with other metals to form mixtures called alloys. Some metals that nickel can be alloyed with are iron, copper, chromium, and zinc. The toxicity of nickel varies with the specific form it takes. Nickel alloys are typically less able to gain access to the body than pure nickel. Therefore, nickel alloys may be less toxic. Nickel and its compounds have no characteristic odor or taste. Nickel that comes out of the stacks of power plants:

- Attaches to small particles of dust that settle to the ground, or
- Are taken out of the air in rain or snow.

It usually takes many days for nickel to be removed from the air. If the nickel attaches to very small particles, it can take more than a month to settle out of the air. (58)

Primary targets of toxicity appear to be:

- The respiratory tract following inhalation exposure
- The immune system following inhalation, oral, or dermal exposure, and
- Possibly the reproductive system and the developing fetus following oral exposure.

The most common harmful health effect of nickel in humans is an allergic reaction. Approximately 10–20% of the population is sensitive to nickel. Once a person is sensitized to nickel, further contact with the metal may produce a reaction. The most serious harmful health effects from exposure to nickel, have occurred in people who have breathed dust containing certain nickel compounds while working in nickel refineries or nickel-processing plants. Examples of these harmful effects are chronic bronchitis, reduced lung function, and cancer of the lung and nasal sinus. The levels of nickel in these workplaces were much higher than usual (background) levels in the environment. (58)

We do not know whether children differ from adults in their susceptibility to nickel. Human studies that examined whether nickel could harm the developing fetus are inconclusive. Animal studies found ingesting nickel:

- Increases in newborn deaths, and
- Decreases in newborn weight.

These doses are 1,000 times higher than levels typically found in drinking water. It is likely that nickel can be transferred from the mother to an infant in breast milk and can cross the placenta.

Appendix H. Exposure concentration, hazard quotient, and cancer risk calculations for air

This appendix describes the formulas, methods, and assumptions used to calculate for contaminants of concern in the air the:

- Concentrations
- Hazard quotients, and
- Cancer risk estimates.

The information presented in this appendix was used to determine whether a person exposed to air through the scenarios shown in Table 6 is at increased risk of:

- Getting cancer, or
- Experiencing adverse health effects that are not cancer.

Methods for calculating exposure concentrations

J) Chronic and intermediate exposures

OHA used the following equation to calculate an exposure concentration for chronic and intermediate exposure to each contaminant of concern (e.g., arsenic, cadmium, hexavalent chromium, nickel):

$$EC = \frac{C \times CF \times ET \times EF \times ED}{AT}$$

Where:

Variable	Description
EC	= exposure concentration
C	= contaminant concentration
CF	= conversion factor
ET	= exposure time
EF	= exposure frequency
ED	= exposure duration
AT	= averaging time[1]

[1] The method for calculating a non-cancer and cancer averaging time is different. For non-cancer (chronic exposures), we multiply the exposure duration (ED), 365 days a year, and 24 hours a day. For non-cancer (intermediate exposures), we multiply the exposure duration (ED), 7 days a week, and 24 hours a day. For cancer, we multiply adult lifetime (78 years), 365 days a year, and 24 hours a day. The value for an adult lifetime is taken from ATSDR's Exposure Dose Guidance for Determining Life Expectancy and Exposure Factor and it represents the average life expectancy for men and women combined. (16) (17) (18)

2) Acute exposures

OHA used the following equation to calculate an exposure concentration for acute exposure to cadmium:

$$EC = C \ x \ CF$$

Where:

Variable	Description
EC	= exposure concentration
C	= contaminant concentration
CF	= conversion factor

Methods for calculating health risks

After OHA calculated exposure doses for each exposure scenario, OHA estimated people's risk of getting cancer or of experiencing adverse health effects that are not cancer.

J) Hazard quotients for non-cancer health effects

Non-cancer risk is evaluated by comparing calculated exposure doses with health-based guideline concentrations identified by authoritative bodies like EPA and ATSDR. A health guideline is the daily dose of a chemical, below which scientists consider it unlikely to harm people's health. (Examples of health guidelines are ATSDR's Minimal Risk Levels [MRLs] or EPA's Reference Doses.) Non-cancer risk is described by a hazard quotient (HQ), which is the ratio of an air exposure dose over a health guideline.

An HQ less than one indicates that sensitive health effects used as the basis for health guideline values are not expected to occur at the predicted dose. An HQ greater than one requires further investigation. Health guidelines for different chemicals are based on different health outcomes of varying severity and incorporate different levels of uncertainty. Therefore, the risks associated with hazard quotients above one are evaluated on a chemical by chemical basis.

Below is the step OHA took to calculate hazard quotients:

Step 1. OHA used the following equation to calculate a hazard quotient for each contaminant of concern (e.g., arsenic, cadmium, hexavalent chromium, nickel):

$$HQ = \frac{EC}{Health\ guideline\ (e.g., MRL) \times 1{,}000\ \mu g/mg}$$

Where:

Variable	Description
HQ	= Hazard Quotient
EC	= exposure concentration

2) Cancer risk

For cancer-causing chemicals, EPA uses evidence from scientific research to estimate the amount of increased lifetime cancer risk associated with each additional unit of exposure. For chemicals that people are exposed to by breathing air, these estimates are known as Inhalation Unit Risks (IURs).

Cancer risk for children was weighted by age for hexavalent chromium. This is because they cause cancer by what is known as a "mutagenic mode of action." Mutagenic chemicals are those that can make multiple changes to genes in a cell. Mutagens pose a higher risk of cancer when exposures occur early in life. Age-dependent adjustment factors (ADAFs) were applied to reflect the potential for early-life exposure to mutagens to make a greater contribution to lifetime cancer risk. (59) For exposures before 2 years of age, a 10-fold adjustment was made. For exposures between 2 and <16 years of age, a three-fold adjustment was made. For exposures after 16 years of age, no further adjustment was made.

Below are the steps OHA took to calculate cancer risk from exposure to a contaminant of concern:

Step 1. OHA used the following equations to calculate cancer risk for chemicals *with* and *without* a mutagenic mode of action:

Chemicals without a mutagenic mode of action

$$Cancer\ risk = EC \times IUR$$

Where:

Variable	Description
EC	= exposure concentration
IUR	= inhalation unit risk

Chemicals with a mutagenic mode of action

$$Cancer\ risk = EC \times IUR \times ADAF$$

Where:

Variable	Description
EC	= exposure concentration
IUR	= inhalation unit risk
ADAF	= age-dependent adjustment factor

Step 2a. OHA used the following equation to calculate a lifetime cancer risk for each scenario for a chemical with a mutagenic mode of action (hexavalent chromium):

$$Lifetime\ cancer\ risk = Cancer\ risk_{birth\ to<2\ year} + Cancer\ risk_{2\ to<16\ years} + Cancer\ risk_{\geq 16\ years}$$

Step 2b. Next, OHA used the following equation to calculate a cumulative cancer risk across multiple chemicals in a pathway:

$$Cumulative\ cancer\ risk = Cancer\ risk_{chemical\ 1} + Cancer\ risk_{chemical\ 2} + \cdots + Cancer\ risk_{chemical\ n}$$

Table H-1a. Exposure factors by exposure scenario for air

Variables	Descriptions	Residents (birth to <78 years)	Units
C	= contaminant concentration[1]	Chemical dependent. See table H-2.	ng/m^3
CF	= conversion factor	0.001	µg/ng
ET	= exposure time	24	hours/day
$EF_{chronic}$	= exposure frequency for chronic exposure[2]	365	days/year
$ED_{chronic}$	= exposure duration for chronic exposure[3]	78	years
AT_{NC}	= averaging time for non-cancer health effects[6]	683,280	hours
AT_C	= averaging time for cancer[6]	683,280	hours
$MRL_{As,\ chronic}$	= Minimal Risk Level for chronic arsenic exposure[7]	0.000015	mg/m^3
$MRL_{Cd,\ chronic}$	= Minimal Risk Level for chronic cadmium exposure[8]	0.00001	mg/m^3
$MRL_{Cr+6,\ chronic}$	= Minimal Risk Level for chronic hexavalent chromium exposure[9]	0.000005	mg/m^3
$MRL_{Ni,\ chronic}$	= Minimal Risk Level for chronic nickel exposure[10]	0.00009	mg/m^3
$MRL_{Cd,\ acute}$	= Minimal Risk Level for acute cadmium exposure[11]	n/a	mg/m^3
IUR_{As}	= inhalation unit risk for arsenic[12]	0.0043	$(\mu g/m^3)^{-1}$
IUR_{Cd}	= inhalation unit risk for cadmium[13]	0.0018	$(\mu g/m^3)^{-1}$
IUR_{Cr+6}	= inhalation unit risk for hexavalent chromium[14]	0.012	$(\mu g/m^3)^{-1}$
IUR_{Ni}	= inhalation unit risk for nickel[15]	0.00024	$(\mu g/m^3)^{-1}$

Abbreviations: < = less than; n/a = not applicable; As = arsenic; Cd = cadmium; Cr+6 = hexavalent chromium; Ni = nickel; ng/m^3 = nanogram per cubic meter; µg/ng = microgram per nanogram; mg/m^3 = milligram per cubic meter; $\mu g/m^3$ = microgram per cubic meter

Note: For intermediate (non-cancer) exposures, the units for exposure frequency (EF) and exposure duration (ED) are days a week and weeks, respectively. Additionally, the averaging time (AT) is calculated by multiplying the exposure duration ($ED_{intermediate}$), 7 days a week, and 24 hours a day.

[1] OHA used the 95% upper confidence limit of the arithmetic mean as the exposure point concentration for each contaminant of concern. See Table H-2 for the contaminant concentrations used to calculate exposure concentrations for air.

[2] For chronic exposure, OHA assumed residents might be exposed to air near Bullseye every day (365 days) of the year.

[3] OHA assumed a 78-year lifetime of exposure, which is the average life expectancy for men and women combined. (16) (17) (18)

[6] The method for calculating a non-cancer and cancer averaging time is different. For non-cancer (chronic exposures), OHA multiplied the exposure duration (ED), 365 days a year, and 24 hours a day. For cancer, OHA multiplied adult lifetime (78 years), 365

days/year, and 24 hours/day. The value for an adult lifetime is taken from ATSDR's Exposure Dose Guidance for Determining Life Expectancy and Exposure Factor and it represents the average life expectancy for men and women combined. (16) (17) (18)

[7] ATSDR does not have a Minimal Risk Level for inhalation exposure to arsenic (45). OHA used a toxicity value from Oregon's Cleaner Air Oregon program called a toxicity reference value. DEQ established this value in rule in Oregon in 2018. California Office of Environmental Health Hazard Assessment derived it.

[8] OHA used ATSDR's Minimal Risk Level for chronic inhalation exposure to cadmium. (24)

[9] OHA used ATSDR's Minimal Risk Level for chronic inhalation exposure to hexavalent chromium (aerosol mists). (52) For air sampled in October 2015, we assumed that 100% of the total chromium measured was hexavalent chromium in aerosol mist form.

[10] OHA used ATSDR's Minimal Risk Level for chronic inhalation exposure to nickel. (58)

[11] OHA used ATSDR's Minimal Risk Level for acute inhalation exposure to cadmium. (24)

[12] We used EPA's Inhalation Unit Risk for arsenic. (60)

[13] We used EPA's Inhalation Unit Risk for cadmium. (61)

[14] We used EPA's Inhalation Unit Risk for hexavalent chromium. (62)

[15] We used EPA's Inhalation Unit Risk for nickel refinery dust. (63) We used this value since it is the most toxic form of nickel. We do not know the actual form of nickel emitted from Bullseye Glass.

Table H-2. The exposure point concentrations used to calculate air exposure concentrations

No intervention exposure (Oct. 6, 2015 to Nov. 2, 2015)			
Data source	Contaminant	Exposure point concentration (95% UCL)[1] (ng/m^3)	Exposure point concentration (Maximum)[2] (ng/m^3)
Fred Meyer corporate offices, SE Powell and 22nd Avenue	Arsenic	99.7	101
	Cadmium	84.2	195
	Nickel	9.495	16.99

Current exposure (March 1, 2016 to March 30, 2017)[3]		
Data source	Contaminant	Exposure point concentration (95% UCL) (ng/m^3)
Daycare center	Arsenic	0.927
	Cadmium	0.963
	Chromium, hexavalent	0.221
	Nickel	0.99
Winterhaven School	Arsenic	0.51
	Cadmium	0.116
	Chromium, hexavalent	0.082
	Nickel	0.943
SE Powell and SE 22nd Avenue	Arsenic	0.735
	Cadmium	0.396
	Chromium, hexavalent	0.163
	Nickel	0.834
SE Haig and SE 20th Avenue	Arsenic	0.748
	Cadmium	0.352
	Chromium, hexavalent	0.166
	Nickel	1.109

Abbreviations: 95% UCL = 95% upper confidence limit of the arithmetic mean; ng/m^3 = nanogram per cubic meter
Cells with shading indicate the exposure point concentrations that we used to calculate hazard quotients and cancer risk estimates.

[1] OHA used the 95% upper confidence limit of the arithmetic mean as the exposure point concentrations for each contaminant of concern for evaluation of chronic risk.

[2] OHA used the maximum concentrations as the exposure point concentration for acute risk scenarios.

[3] To evaluate current exposure, OHA screened air data collected between March 1, 2016 and March 30, 2017 from the following four air monitors: the daycare center, the Winterhaven School, SE Powell and SE 22nd Avenue, and SE Haig and SE 20th Avenue. OHA also calculated exposure point concentrations for each of these locations. However, OHA used the exposure point concentrations for only the daycare center to calculate hazard quotients and cancer risk estimates. This is because the exposure point concentrations for the daycare center were generally higher than those for the other three locations; there was one instance where the 95% upper confidence limit of the arithmetic mean for nickel was slightly higher at SE Haig and SE 20th Avenue as compared to the daycare center (1.109 and 0.99, respectively).

Calculations

J) Hazard quotients for non-cancer health effects

a) Acute past exposure (non-cancer health effects)

Table H-3. Exposure concentrations and hazard quotients for non-cancer health effects for acute past exposure to air from near Bullseye (Fred Meyer corporate offices from Oct. 6, 2015 through Nov. 2, 2015)§

Contaminant	Contaminant concentration* (ng/m^3)	Conversion factor (µg/ng)	Exposure concentration ($µg/m^3$)	Health Guideline[1] (mg/m^3)	(µg/mg)	Hazard quotient
Arsenic	101	0.001	0.101	0.0002	1,000	0.5
Cadmium	195	0.001	0.1950	0.00003	1,000	**6.5**
Nickel	16.99	0.001	0.01699	0.0002	1,000	0.1

Abbreviations: ng/m^3 = nanogram per cubic meter; µg/ng = microgram per nanogram; $µg/m^3$ = microgram per cubic meter; mg/m^3 = milligram per cubic meter; µg/mg = microgram per milligram

* For acute exposures, OHA used the maximum measured concentration of each contaminant to calculate risk.

[1] For arsenic and nickel the health guideline for acute non-cancer risk were developed by California Office of Environmental Health Hazard Assessment. For cadmium, the health guideline for acute non-cancer risk was developed by ATSDR.

§ See Tables H-1 to H-2 for more information about the values and sources that we used to calculate the exposure concentrations and hazard quotients.

Bold text indicates a hazard quotient greater than 1, indicating the need for an in-depth analysis.

b) No intervention chronic exposure had emissions not been reduced (non-cancer health effects)

Table H-4. Exposure concentrations and hypothetical hazard quotients for non-cancer health effects for residents' (birth to <78 years old) had Bullseye's emissions not been reduced (based on measurements from near Fred Meyer corporate offices from Oct. 6, 2015 through Nov. 2, 2015 before interventions had been implemented)§

Contaminant	Contaminant concentration* (ng/m^3)	Conversion factor (µg/ng)	Exposure time (hours/day)	Exposure frequency (days/year)	Exposure duration (years)	Averaging $time_{NC}$ (hours)	Exposure concentration ($µg/m^3$)	Minimal risk level (mg/m^3)	(µg/mg)	Hazard quotient
Arsenic	99.7	0.001	24	365	78	683,280	0.09970	0.000015	1,000	**6.6**
Cadmium	84.2	0.001	24	365	78	683,280	0.08420	0.00001	1,000	**8.4**
Nickel	9.49	0.001	24	365	78	683,280	0.00950	0.00009	1,000	0.1

Abbreviations: ng/m^3 = nanogram per cubic meter; µg/ng = microgram per nanogram; $µg/m^3$ = microgram per cubic meter; mg/m^3 = milligram per cubic meter; µg/mg = microgram per milligram

*For chronic exposures, OHA used the 95% UCL for each contaminant to calculate risk.

§ See Tables H-1 to H-2 for more information about the values and sources that we used to calculate the exposure concentrations and hazard quotients.

Bold text indicates a hazard quotient greater than 1, indicating the need for an in-depth analysis.

c) Chronic current exposure (non-cancer health effects)

Table H-5. Exposure concentrations and hazard quotients for non-cancer health effects for residents' (birth to <78 years old) current exposure to air from near Bullseye (the daycare center from March 1, 2016 through March 30, 2017)§

Contaminant	Contaminant concentration* (ng/m^3)	Conversion factor (µg/ng)	Exposure time (hours/day)	Exposure frequency (days/year)	Exposure duration (years)	Averaging $time_{NC}$ (hours)	Exposure concentration ($\mu g/m^3$)	Minimal risk level (mg/m^3)	(µg/mg)	Hazard quotient
Arsenic	0.927	0.001	24	365	78	683,280	0.000927	0.000015	1,000	0.062
Cadmium	0.963	0.001	24	365	78	683,280	0.000963	0.00001	1,000	0.096
Chromium VI	0.221	0.001	24	365	78	683,280	0.000221	0.000005	1,000	0.044
Nickel	0.99	0.001	24	365	78	683,280	0.00099	0.00009	1,000	0.011

Abbreviations: ng/m^3 = nanogram per cubic meter; µg/ng = microgram per nanogram; $\mu g/m^3$ = microgram per cubic meter; mg/m^3 = milligram per cubic meter; µg/mg = microgram per milligram

*For chronic exposures, OHA used the 95% UCL for each contaminant to calculate risk.

§ See Tables H-1 to H-2 for more information about the values and sources that we used to calculate the exposure concentrations and hazard quotients.

2) Cancer risk

d) No intervention chronic exposure (cancer risk)

Table H-6. Exposure concentrations and hypothetical cancer risk estimates for residents' (birth to <78 years old) had Bullseye's emissions not been reduced (Calculated using data from air monitor located at Fred Meyer corporate offices from Oct. 6, 2015 through Nov. 2, 2015 before interventions were implemented)§

Contaminant	Contaminant concentration* (ng/m^3)	Conversion factor ($\mu g/ng$)	Exposure time (hours/day)	Exposure frequency (days/year)	Exposure duration (years)	Averaging $time_C$ (hours)	Exposure concentration ($\mu g/m^3$)	Inhalation unit risk $(\mu g/m^3)^{-1}$	Age-dependent adjustment factor	Cancer risk
Arsenic	99.7	0.001	24	365	78	683,280	0.0997	0.0043	-	4E-04
Cadmium	84.2	0.001	24	365	78	683,280	0.0842	0.0018	-	2E-04
Nickel	9.49	0.001	24	365	78	683,280	0.0095	0.00024	-	2E-06
									Cumulative cancer risk	**6E-04**

Abbreviations: ng/m^3 = nanogram per cubic meter; $\mu g/ng$ = microgram per nanogram; $\mu g/m^3$ = microgram per cubic meter
*For chronic exposures, OHA used the 95% UCL for each contaminant to calculate risk.
§ See Tables H-1 to H-2 for more information about the values and sources that we used to calculate the exposure concentrations and risk estimates for cancer.

b) Chronic current exposure (cancer risk)

Table H-7. Exposure concentrations and cancer risk estimates for residents' (birth to <78 years old) current exposure to air from near Bullseye (the daycare center from March 1, 2016 through March 30, 2017)§

Contaminant	Contaminant concentration* (ng/m^3)	Conversion factor (µg/ng)	Exposure time (hours/day)	Exposure frequency (days/year)	Exposure duration (years)	Averaging time$_C$ (hours)	Exposure concentration ($\mu g/m^3$)	Inhalation unit risk $(\mu g/m^3)^{-1}$	Age-dependent adjustment factor	Cancer risk
Arsenic	0.927	0.001	24	365	78	683,280	0.000927	0.0043	-	4E-06
Cadmium	0.963	0.001	24	365	78	683,280	0.000963	0.0018	-	2E-06
Chromium VI (birth to <2 years)	0.221	0.001	24	365	2	683,280	0.000006	0.012	10	7E-07
Chromium VI (2 to <16 years)	0.221	0.001	24	365	14	683,280	0.00004	0.012	3	1E-06
Chromium VI (16 to <78 years)	0.221	0.001	24	365	62	683,280	0.000176	0.012	1	2E-06
Nickel	0.99	0.001	24	365	78	683,280	0.00099	0.00024	-	2E-07
									Cumulative cancer risk	**1E-05**

Abbreviations: ng/m^3 = nanogram per cubic meter; µg/ng = microgram per nanogram; $\mu g/m^3$ = microgram per cubic meter

*For chronic exposures, OHA used the 95% UCL for each contaminant to calculate risk.

§ See Tables H-1 to H-2 for more information about the values and sources that we used to calculate the exposure concentrations and risk estimates for cancer.

Appendix I. Exposure dose, hazard quotient, and cancer risk calculations for soil

This appendix describes the formulas, methods, and assumptions for contaminants of concern in soil used to calculate:

- Doses
- Hazard quotients, and
- Cancer risk estimates.

The information presented in this appendix was used to determine whether a person exposed to the soil through the scenarios shown in Table 6 is at increased risk of:

- Getting cancer, or
- Experiencing adverse health effects that are not cancer.

Methods for calculating (chronic) exposure doses

OHA used the following equation to calculate an exposure dose for each age group (i.e., birth to <1 year, 1 to <2 years, 2 to <6 years, 6 to <11, 11 to <16 years, 16 to <21 years, ≥21 years) and each contaminant of concern (*i.e.*, arsenic, cadmium, cobalt):

$$D = \frac{C \times CF \times IR \times BAF \times F \times ED}{BW \times AT}$$

Where:

Variable	Description
D	= exposure dose
C	= contaminant concentration
CF	= conversion factor
IR	= ingestion rate
BAF	= bioavailability factor
F	= frequency of exposure
ED	= exposure duration
BW	= body weight
AT	= averaging time[1]

[1] The method for calculating a non-cancer and cancer averaging time is different. For non-cancer, we multiply the exposure duration (ED) and 365 days a year. For cancer, OHA multiplied adult lifetime (78 years) and 365 days a year. The value for an adult lifetime is taken from ATSDR's Exposure Dose Guidance for Determining Life Expectancy and Exposure Factor and it represents the average life expectancy for men and women combined. (16) (17) (18)

Methods for calculating health risks
After OHA calculated exposure doses for each exposure scenario, OHA estimated people's risk of getting cancer or of experiencing adverse health effects that are not cancer.

J) Hazard quotients for non-cancer health effects

Non-cancer risk is evaluated by comparing calculated exposure doses with health-based guideline concentrations identified by authoritative bodies like EPA and ATSDR. A health guideline is the daily dose of a chemical, below which scientists consider it unlikely to harm people's health. (Examples of health guidelines are ATSDR's Minimal Risk Levels [MRLs] or EPA's Reference Doses) Non-cancer risk is described by a hazard quotient, which is the ratio of a soil exposure dose over a health guideline.

A hazard quotient less than one indicates that the sensitive health effects used as the basis for health guideline values are not expected to occur at the predicted dose. A hazard quotient greater than one requires further investigation. Health guidelines for different chemicals are based on different health outcomes of varying severity and incorporate different levels of uncertainty. Therefore, the risks associated with hazard quotients above one are evaluated on a chemical by chemical basis.

Below is the step OHA took to calculate hazard quotients:

Step 1. OHA used the following equation to calculate a hazard quotient (HQ) for each age group (i.e., birth to <1 year, 1 to <2 years, 2 to <6 years, 6 to <11, 11 to <16 years, 16 to <21 years, ≥21 years) and each contaminant of concern (i.e., arsenic, cadmium, cobalt):

$$HQ = \frac{Dose}{Health\ guideline\ (e.g., MRL)}$$

2) Cancer risk

For cancer-causing chemicals, EPA uses evidence from scientific research to estimate the amount of increased lifetime cancer risk associated with each additional unit of exposure. These estimates are known as cancer slope factors (CSF) for chemicals ingested.

Cancer risk is calculated separately for each age group (i.e., birth to <1 year, 1 to <2 years, 2 to <6 years, 6 to <11, 11 to <16 years, 16 to <21 years, ≥21 years) based on age-specific exposure factors (e.g., body weight, soil ingestion rate, etc.). For example, children consume more soil than adults so daily intake of soil or sediment is assumed to be higher for early life exposures. Lifetime cancer risk from many years of exposure is calculated by adding together cancer risks of all age ranges. This approach provides a lifetime cancer risk that accounts for changes in exposure that occur over a lifetime.

Below are the steps OHA took to calculate lifetime cancer risk:

$$Cancer\ risk = Dose\ \times Cancer\ Slope\ Factor\ (CSF)$$

Step 2. Then, OHA used the following equation to calculate a lifetime cancer risk for each exposure scenario (i.e., birth to <21 years, birth to <42 years, 21 to <63 years, birth to <78 years, 6 weeks to <6 years):

$$Lifetime\ cancer\ risk = Cancer\ risk_{birth\ to<1\ year} + Cancer\ risk_{1\ to<2\ years} + \cdots + Cancer\ risk_{n}$$

Table I-1. Exposure factors by exposure scenario for soil

Variables	Descriptions	Values			Units
		Resident near the Bullseye Glass site	Non-resident, child at daycare center (Scenario 4)	Non-resident, park user at Powell Park	
		Birth to <78 years	6 weeks to <6 years	Birth to <78 years	
C	= contaminant concentration[1]	EHAP used multiple values. See Table I-2.			mg/kg
CF	= conversion factor	0.000001	0.000001	0.000001	kg/mg
IR	= ingestion rate[2]	EHAP used multiple values. See Table I-3.			mg/day
BAF_{As}	= bioavailability factor for arsenic[3]	0.22	0.22	n/a	unitless
BAF_{Cd}	= bioavailability factor for cadmium[4]	1	1	1	unitless
BAF_{Co}	= bioavailability factor for cobalt[4]	1	n/a	n/a	unitless
F	= frequency of exposure[5]	EHAP used multiple values. See Table I-4.	250	28	days/year
ED	= exposure duration[6]	78	5.88	78	years
BW	= body weight[7]	OHA used multiple values. See Table I-3.			kg
AT_{NC}	= averaging time for non-cancer health effects[8]	28,470	2,146	28,470	days
AT_{C}	= averaging time for cancer[8]	28,470	28,470	n/a	days
MRL_{As}	= Minimal Risk Level for arsenic[9]	0.0003	0.0003	n/a	mg/kg/day
MRL_{Cd}	= Minimal Risk Level for cadmium[10]	0.0001	n/a	0.0001	mg/kg/day
MRL_{Co}	= Minimal Risk Level for cobalt[11]	0.01	n/a	n/a	mg/kg/day
CSF_{As}	= cancer slope factor for arsenic[12]	5.7	5.7	n/a	$mg/kg/day^{-1}$

Abbreviations: < = less than; n/a = not applicable; As = arsenic; Cd = cadmium; Co = cobalt; mg/kg = milligram per kilogram; kg/mg = kilogram per milligram; mg/day = milligrams per day; kg = kilogram; mg/kg/day = milligram per kilogram per day

[1] OHA used the 95% upper confidence limit of the arithmetic mean as the exposure point concentration for each contaminant of concern. See Table I-2 for the contaminant concentrations used to calculate soil exposure doses.

[2] The soil ingestion rate values are taken from Table 1 of ATSDR's Exposure Dose Guidance for Soil and Sediment Ingestion, V2 (Oct. 26, 2016). (64) These values represent the upper percentile (or the high end) of the exposure distribution. OHA used the upper percentile soil ingestion rates to assess exposures that are higher than average but are still within a realistic range of exposure. See Table I-3 for the soil ingestion rates used to calculate exposure doses.

[3] The bioavailability factor for arsenic is site-specific. DEQ collected samples and EPA Region 10 analyzed the samples for bioavailability.

[4] OHA assumed that 100% of the cadmium and cobalt in the soil would be absorbed into the bloodstream after ingestion. Therefore, OHA used a bioavailability factor of 1.

[5] The frequency of exposure values for residents are taken from Tables 16-1, 16-20, and 16-22 of the U.S. EPA's Exposure Factor Handbook (2011) (17). See Table I-4 for the frequency of exposure values used to calculate soil exposure doses for residents. OHA assumed children at the daycare might be exposed to the soil five days per week for 50 weeks (250 days) each year. OHA assumed park users might be exposed to the soil 28 days of the year; this value is based on local park use statistics. (65)

[6] For past exposure, OHA assumed the maximum exposure duration for residents and park users is 42 years. That is the length of time from when Bullseye Glass began operating at this facility to when the company installed their current institutional controls. (66) For current exposure, OHA assumed the maximum exposure duration for these two groups is 78 years. That is the average life expectancy for men and women combined. (16) (17) (18) OHA also used an exposure duration of 21 years for residents and park users (for both past and current exposure) since this period represents people that were or are born and raised near the facility and moved or move away as adults. OHA assumed the maximum exposure duration for children at the daycare is 5.88 years since a child can attend the center between six weeks and 5 years old.
[7] The body weight values are taken from Table 1 of ATSDR's Exposure Dose Guidance for Body Weight (Oct. 26, 2016) and Table 8-1 of the U.S. EPA's Exposure Factor Handbook (2011). (67) (17) They are based on NHANES 1999-2006 data. The values are time-weighted averages. See Table I-3 for the body weights used to calculate exposure doses.
[8] The method for calculating a non-cancer and cancer averaging time is different. For non-cancer, OHA multiplied the exposure duration (ED) and 365 days/year. For cancer, OHA multiplied adult lifetime (78 years) and 365 days a year. The value for an adult lifetime is taken from ATSDR's Exposure Dose Guidance for Determining Life Expectancy and Exposure Factor and it represents the average life expectancy for men and women combined. (16) (17) (18)
[9] OHA used ATSDR's Minimal Risk Level for chronic oral exposure to arsenic. (45)
[10] OHA used ATSDR's Minimal Risk Level for chronic oral exposure to cadmium. (24)
[11] OHA used ATSDR's Minimal Risk Level for intermediate oral exposure to cobalt. (55)
[12] EPA's Science Advisory Board Arsenic Review Panel recommends using a cancer slope factor of 5.7 $mg/kg/day^{-1}$ for arsenic. While this value differs from the cancer slope factor in EPA's Integrated Risk Information System of 1.5 (mg/kg/day)-1, OHA chose this value since it reflects more recent evaluations by EPA staff. Additionally, this value is based on the combined risk of lung and bladder cancer, which are more serious endpoints than skin cancer. (68) (69)

Table I-2. Exposure point concentrations used to calculate soil exposure doses

Data source	Contaminant	Exposure point concentration (95% UCL) (mg/kg)
Northwest of Bullseye	Cadmium	12.98
	Cobalt	17.97
Southeast of Bullseye	Arsenic	20.01
Daycare center	Arsenic	21.33
	Cadmium	4.759
Powell Park	Cadmium	6.401

Abbreviations: 95% UCL = 95% upper confidence limit of the arithmetic mean; mg/kg = milligrams per kilogram

Table I-3. Age-specific soil ingestion rates (IR) and body weights (BW)

Age group	Ingestion rate for soil[1] (mg/day)	Body weight[2] (kg)
Birth to <1 year	100	7.8
6 weeks to <1 year	100	8.2
1 to <2 years	200	11.4
2 to <6 years	200	17.4
6 to <11 years	200	31.8
11 to <16 years	200	56.8
16 to <21 years	200	71.6
≥21 years	100	80

Abbreviations: mg/day = milligrams per day; kg = kilogram; < = less than; ≥ = greater than or equal to

[1] The soil ingestion rate values are taken from Table 1 of ATSDR's Exposure Dose Guidance for Soil and Sediment Ingestion, V2 (Oct. 26, 2016). (64) These values represent the upper percentile (or the high end) of the exposure distribution. We used the upper percentile soil ingestion rates to assess exposures that are higher than average but are still within a realistic range of exposure.

[2] The body weight values are taken from Table 1 of ATSDR's Exposure Dose Guidance for Body Weight (Oct. 26, 2016) and Table 8-1 of the U.S. EPA's Exposure Factor Handbook (2011). (67) (17) They are based on NHANES 1999-2006 data. The values are time-weighted averages.

Table I-4. Age-specific frequencies of exposure (F) for *residents near the Bullseye Glass site (Scenarios 1, 2, and 3)*

Age group	Frequency of exposure (days/year)
Birth to <1 year[1]	19.6
1 to <2 years[2]	116.6
2 to <6 years[2]	116.6
6 to <11 years[2]	116.6
11 to <16 years[2]	116.6
16 to <21 years[2]	116.6
21 to <42 years[3]	110.3
21 to <63 years[3]	110.3
21 to <78 years[4]	112

Abbreviations: < = less than

[1] The frequency of exposure value for birth to <1 year is taken from Table 16-1 of the U.S. EPA's Exposure Factor Handbook (2011). (17) This frequency is a weighted average. The value is based on the average amount of time children from the following age groups spend outdoors: birth to <1 month, 1 to <3 months, 3 to <6 months, and 6 to <12 months. Note, the average amount of time a child from birth to <1 month spends outdoors is estimated to be zero minutes per day.

[2] The frequency of exposure value for 1 to <21 years is taken from Table 16-20 of the U.S. EPA's Exposure Factor Handbook. (2011) (17) This frequency is the amount of time children (1 to <21 years) spend at home in the yard or other areas outside the house and it is specific to the "west" census region. This value represents the 95th percentile.

[3] The frequency of exposure value for 21 to <42 years and 21 <63 years is taken from Table 16-22 of the U.S. EPA's Exposure Factor Handbook (2011). (17) This frequency is the amount of time adults (18 to <65 years) spend outside at their residence. This value represents the 95th percentile.

[4] The frequency of exposure value for 21 to <78 years is taken from Table 16-22 of the U.S. EPA's Exposure Factor Handbook (2011). (17) This frequency is a weighted average. The value is based on the amount of time (95 percentile) adults from the following age groups spend outside at their residence: 18 to <65 years and ≥65 years.

Calculations

J) ***Hazard quotients for non-cancer health effects***

Table I-5. Exposure doses and hazard quotients for non-cancer health effects (by age group) for residents with chronic exposure to soil northwest of Bullseye Glass that contains cadmium§

Age group	Contaminant concentration (mg/kg)	Conversion factor (kg/mg)	Ingestion rate (mg/day)	Bioavailability factor	Frequency of exposure (days/year)	Exposure duration (years)	Body weight (kg)	Averaging time$_{NC}$ (days)	Exposure dose (mg/kg/day)	Minimal risk level (mg/kg/day)	Hazard quotient
Birth to <1 year	12.98	0.000001	100	1	19.6	1	7.8	365	0.00000894	0.0001	0.089
1 to <2 years	12.98	0.000001	200	1	116.6	1	11.4	365	0.00007275	0.0001	0.73
2 to <6 years	12.98	0.000001	200	1	116.6	4	17.4	1,460	0.00004766	0.0001	0.48
6 to <11 years	12.98	0.000001	200	1	116.6	5	31.8	1,825	0.00002608	0.0001	0.26
11 to <16 years	12.98	0.000001	200	1	116.6	5	56.8	1,825	0.00001460	0.0001	0.15
16 to <21 years	12.98	0.000001	200	1	116.6	5	71.6	1,825	0.00001158	0.0001	0.12
21 to <78 years	12.98	0.000001	100	1	112	57	80	20,805	0.00000498	0.0001	0.050

Abbreviations: < = less than; mg/kg = milligram per kilogram; kg/mg = kilogram per milligram; mg/day = milligrams per day; kg = kilogram; NC = non-cancer; mg/kg/day = milligram per kilogram per day

§ See Tables I-1 to I-4 for more information about the values and sources that we used to calculate the exposure doses and hazard quotients.

Table I-6. Exposure doses and hazard quotients for non-cancer health effects (by age group) for residents with chronic exposure to soil northwest of Bullseye Glass that contains cobalt§

Age group	Contaminant concentration (mg/kg)	Conversion factor (kg/mg)	Ingestion rate (mg/day)	Bioavailability factor	Frequency of exposure (days/year)	Exposure duration (years)	Body weight (kg)	Averaging time$_{NC}$ (days)	Exposure dose (mg/kg/day)	Minimal risk level† (mg/kg/day)	Hazard quotient
Birth to <1 year	17.97	0.000001	100	1	19.6	1	7.8	365	0.00001237	0.01	0.0012
1 to <2 years	17.97	0.000001	200	1	116.6	1	11.4	365	0.00010071	0.01	0.010
2 to <6 years	17.97	0.000001	200	1	116.6	4	17.4	1,460	0.00006598	0.01	0.0066
6 to <11 years	17.97	0.000001	200	1	116.6	5	31.8	1,825	0.00003610	0.01	0.0036
11 to <16 years	17.97	0.000001	200	1	116.6	5	56.8	1,825	0.00002021	0.01	0.0020
16 to <21 years	17.97	0.000001	200	1	116.6	5	71.6	1,825	0.00001604	0.01	0.0016
21 to <78 years	17.97	0.000001	100	1	112	57	80	20,805	0.00000689	0.01	0.00069

Abbreviations: < = less than; mg/kg = milligram per kilogram; kg/mg = kilogram per milligram; mg/day = milligrams per day; kg = kilogram; NC = non-cancer; mg/kg/day = milligram per kilogram per day

§ See Tables I-1 to I-4 for more information about the values and sources that we used to calculate the exposure doses and hazard quotients.

† We used ATSDR's Minimal Risk Level for intermediate oral exposure to cobalt. (55)

Table I-7. Exposure doses and hazard quotients for non-cancer health effects (by age group) for residents with chronic exposure to soil southeast of Bullseye Glass that contains arsenic§

Age group	Contaminant concentration (mg/kg)	Conversion factor (kg/mg)	Ingestion rate (mg/day)	Bioavailability factor	Frequency of exposure (days/year)	Exposure duration (years)	Body weight (kg)	Averaging time$_{NC}$ (days)	Exposure dose (mg/kg/day)	Minimal risk level (mg/kg/day)	Hazard quotient
Birth to <1 year	20.01	0.000001	100	0.22	19.6	1	7.8	365	0.0000030	0.0003	0.010
1 to <2 years	20.01	0.000001	200	0.22	116.6	1	11.4	365	0.0000247	0.0003	0.082
2 to <6 years	20.01	0.000001	200	0.22	116.6	4	17.4	1,460	0.0000162	0.0003	0.054
6 to <11 years	20.01	0.000001	200	0.22	116.6	5	31.8	1,825	0.0000088	0.0003	0.029
11 to <16 years	20.01	0.000001	200	0.22	116.6	5	56.8	1,825	0.0000050	0.0003	0.017
16 to <21 years	20.01	0.000001	200	0.22	116.6	5	71.6	1,825	0.0000039	0.0003	0.013
21 to <78 years	20.01	0.000001	100	0.22	112	57	80	20,805	0.0000017	0.0003	0.0056

Abbreviations: < = less than; mg/kg = milligram per kilogram; kg/mg = kilogram per milligram; mg/day = milligrams per day; kg = kilogram; NC = non-cancer; mg/kg/day = milligram per kilogram per day

§ See Tables I-1 to I-4 for more information about the values and sources that we used to calculate the exposure doses and hazard quotients.

Table I-8. Exposure doses and hazard quotients for non-cancer health effects (by age group) for non-resident, children (6 weeks to <6 years old) with chronic exposure to the soil at the daycare center that contains arsenic§

Age group	Contaminant concentration (mg/kg)	Conversion factor (kg/mg)	Ingestion rate (mg/day)	Bioavailability factor	Frequency of exposure (days/year)	Exposure duration (years)	Body weight (kg)	Averaging $time_{NC}$ (days)	Exposure dose (mg/kg/day)	Minimal risk level (mg/kg/day)	Hazard quotient
6 weeks to <1 year	21.33	0.000001	100	0.22	250	0.88	8.2	321	0.0000392	0.0003	0.13
1 to <2 years	21.33	0.000001	200	0.22	250	1	11.4	365	0.0000564	0.0003	0.19
2 to <6 years	21.33	0.000001	200	0.22	250	4	17.4	1,460	0.0000369	0.0003	0.12

Abbreviations: < = less than; mg/kg = milligram per kilogram; kg/mg = kilogram per milligram; mg/day = milligrams per day; kg = kilogram; NC = non-cancer; mg/kg/day = milligram per kilogram per day

§ See Tables I-1 to I-3 for more information about the values and sources that we used to calculate the exposure doses and hazard quotients.

Table I-9. Exposure doses and hazard quotients for non-cancer health effects (by age group) for non-resident, children (6 weeks to <6 years old) with chronic exposure to the soil at the daycare center that contains cadmium§

Age group	Contaminant concentration (mg/kg)	Conversion factor (kg/mg)	Ingestion rate (mg/day)	Bioavailability factor	Frequency of exposure (days/year)	Exposure duration (years)	Body weight (kg)	Averaging $time_{NC}$ (days)	Exposure dose (mg/kg/day)	Minimal risk level (mg/kg/day)	Hazard quotient
6 weeks to <1 year	4.759	0.000001	100	1	250	0.88	8.2	321	0.0000398	0.0001	0.40
1 to <2 years	4.759	0.000001	200	1	250	1	11.4	365	0.0000572	0.0001	0.57
2 to <6 years	4.759	0.000001	200	1	250	4	17.4	1,460	0.0000375	0.0001	0.37

Abbreviations: < = less than; mg/kg = milligram per kilogram; kg/mg = kilogram per milligram; mg/day = milligrams per day; kg = kilogram; NC = non-cancer; mg/kg/day = milligram per kilogram per day

§ See Tables I-1 to I-3 for more information about the values and sources that we used to calculate the exposure doses and hazard quotients.

Table I-10. Exposure doses and hazard quotients for non-cancer health effects (by age group) for non-resident, park users with chronic exposure to the soil at Powell Park that contains cadmium§

Age group	Contaminant concentration (mg/kg)	Conversion factor (kg/mg)	Ingestion rate (mg/day)	Bioavailability factor	Frequency of exposure (days/year)	Exposure duration (years)	Body weight (kg)	Averaging time$_{NC}$ (days)	Exposure dose (mg/kg/day)	Minimal risk level (mg/kg/day)	Hazard quotient
Birth to <1 year	6.401	0.000001	100	1	28	1	7.8	365	0.0000063	0.0001	0.063
1 to <2 years	6.401	0.000001	200	1	28	1	11.4	365	0.0000086	0.0001	0.086
2 to <6 years	6.401	0.000001	200	1	28	4	17.4	1,460	0.0000056	0.0001	0.056
6 to <11 years	6.401	0.000001	200	1	28	5	31.8	1,825	0.0000031	0.0001	0.031
11 to <16 years	6.401	0.000001	200	1	28	5	56.8	1,825	0.0000017	0.0001	0.017
16 to <21 years	6.401	0.000001	200	1	28	5	71.6	1,825	0.0000014	0.0001	0.014
21 to <78 years	6.401	0.000001	100	1	28	57	80	20,805	0.0000006	0.0001	0.0061

Abbreviations: < = less than; mg/kg = milligram per kilogram; kg/mg = kilogram per milligram; mg/day = milligrams per day; kg = kilogram; NC = non-cancer; mg/kg/day = milligram per kilogram per day

§ See Tables I-1 to I-3 for more information about the values and sources that we used to calculate the exposure doses and hazard quotients.

2) Cancer risk

Table I-13. Dose and risk estimates for cancer for residents (birth to <78 years old) exposed to arsenic-contaminated soil southeast of Bullseye Glass§

Age group	Contaminant concentration (mg/kg)	Conversion factor (kg/mg)	Ingestion rate (mg/day)	Bioavailability factor	Frequency of exposure (days/year)	Exposure duration (years)	Body weight (kg)	Averaging time$_{C}$ (days)	Exposure dose (mg/kg/day)	Cancer slope factor (mg/kg/day^{-1})	Cancer risk
Birth to <1 year	20.01	0.000001	100	0.22	19.6	1	7.8	28,470	0.000000039	5.7	2E-07
1 to <2 years	20.01	0.000001	200	0.22	116.6	1	11.4	28,470	0.000000316	5.7	2E-06
2 to <6 years	20.01	0.000001	200	0.22	116.6	4	17.4	28,470	0.000000829	5.7	5E-06
6 to <11 years	20.01	0.000001	200	0.22	116.6	5	31.8	28,470	0.000000567	5.7	3E-06
11 to <16 years	20.01	0.000001	200	0.22	116.6	5	56.8	28,470	0.000000317	5.7	2E-06
16 to <21 years	20.01	0.000001	200	0.22	116.6	5	71.6	28,470	0.000000252	5.7	1E-06
21 to <78 years	20.01	0.000001	100	0.22	112	57	80	28,470	0.000001234	5.7	7E-06
					Total exposure duration	**78**				Total lifetime cancer risk	**2E-05**

Abbreviations: < = less than; mg/kg = milligram per kilogram; kg/mg = kilogram per milligram; mg/day = milligrams per day; kg = kilogram; C = cancer; mg/kg/day = milligram per kilogram per day

§ See Tables I-1 to I-4 for more information about the values and sources that we used to calculate the dose and risk estimates for cancer.

Table I-14. Dose and risk estimates for cancer for non-resident, children at the daycare center (6 weeks to <6 years old) exposed to arsenic-contaminated soil at the daycare center§

Age group	Contaminant concentration (mg/kg)	Conversion factor (kg/mg)	Ingestion rate (mg/day)	Bioavailability factor	Frequency of exposure (days/year)	Exposure duration (years)	Body weight (kg)	Averaging time$_C$ (days)	Exposure dose (mg/kg/day)	Cancer slope factor (mg/kg/day^{-1})	Cancer risk
6 weeks to <1 year	21.33	0.000001	100	0.22	250	0.88	8.2	28,470	0.000000442	5.7	3E-06
1 to <2 years	21.33	0.000001	200	0.22	250	1	11.4	28,470	0.000000723	5.7	4E-06
2 to <6 years	21.33	0.000001	200	0.22	250	4	17.4	28,470	0.000001895	5.7	1E-05
					Total exposure duration	**5.88**				Total lifetime cancer risk	**2E-05**

Abbreviations: wks = weeks; < = less than; mg/kg = milligram per kilogram; kg/mg = kilogram per milligram; mg/day = milligrams per day; kg = kilogram; C = cancer; mg/kg/day = milligram per kilogram per day

§ See Tables I-1 to I-3 for more information about the values and sources that we used to calculate the dose and risk estimates for cancer.

Appendix J. Glossary of terms

Absorption:	The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the: • Eyes • Skin • Stomach • Intestines, or • Lungs.
Acute exposure:	Contact with a substance that occurs once or for only a short time (up to 14 days).
Adverse health effect:	A change in body function or cell structure that might lead to disease or health problems.
Averaging time (AT):	The period over which the exposure is averaged to arrive at a time-weighted exposure factor. For assessing cancer risks, AT is averaged over a lifetime (78 years). For assessing non-cancer risks, AT is averaged over the exposure duration (years), which may or may not be a lifetime.
Background level:	An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.
Bioavailability:	In environmental science, the bioavailability of a contaminant is the degree and rate at which the substance is absorbed into living organisms.
Cancer:	Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.
Cancer risk:	A theoretical risk for getting cancer if exposed to a substance every day for 78 years (a lifetime exposure). The true risk might be lower.

Cancer Risk Guides (CREGs):	The estimated contaminant concentrations expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed during their lifetime (78 years). The Agency for Toxic Substances and Disease Registry's CREGs are calculated from the U.S. Environmental Protection Agency's (EPA's) cancer slope factors for oral exposures or unit risk values for inhalation exposures. These values are based on EPA's evaluations and assumptions about hypothetical cancer risks at low levels of exposure.
Cancer slope factor (CSF):	A value used to estimate the risk of cancer associated with exposure to a cancer-causing substance. It is based on the probability of the risk of cancer over a person's lifetime (78 years).
Carcinogen:	A substance that causes cancer.
Comparison value (CV):	The calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening-level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Completed exposure pathway:	See exposure pathway.
Concentration:	The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.
Contaminant:	A substance that is either: • Present in an environment where it does not belong, or • Present at levels that might cause harmful (adverse) health effects.
Dermal contact:	Contact (touching) with the skin (see route of exposure).
Detection limit:	The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Dose:	The amount of a substance to which a person is exposed over some period. The dose is a measurement of exposure. The dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that got into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental justice (EJ):	Environmental justice means that all people, regardless of race, color, national origin, or income are treated fairly. Also, that they are involved in a meaningful way in the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including a racial, ethnic, or socioeconomic group, should bear a disproportionate share of the negative environmental consequences that result from: • Industrial • Municipal, and • Commercial operations, or • The implementation of government programs and policies.
Environmental media:	Soil, water, air, biota (plants and animals), or any other parts of the environment can contain contaminants. Environmental media is the second part of an exposure pathway.
Environmental Media Evaluation Guides (EMEGs):	The estimated contaminant concentrations that are not expected to result in adverse non-cancer health effects based on the Agency for Toxic Substances and Disease Registry's (ATSDR's) evaluation. EMEGs are based on ATSDR's Minimal Risk Levels and conservative assumptions about exposure, such as: • Intake rate • Exposure frequency and duration, and • Body weight.
Exposure:	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be: • Short-term (acute exposure), of intermediate duration, or • Long-term (chronic exposure).
Exposure duration (ED):	The number of years that exposure occurred.

Exposure pathway:	The route a substance takes from its source (where it began) to its end point (where it ends). Also, how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: 1. A source of contamination, 2. An environmental media, 3. A point of exposure, 4. A route of exposure, and 5. A receptor population. When all five parts are present, the exposure pathway is termed a completed exposure pathway.
Frequency of exposure:	How often a person is exposed to a chemical over time, for example, every day, once a week, or twice a month.
Health guideline:	See minimal risk level (MRL).
Hazard index (HI):	The sum of hazard quotients for all contaminants in the same medium (air, water, soil). Because different pollutants can cause similar negative health effects, combining hazard quotients associated with different contaminants is often appropriate. An HI of 1.0 indicates the need for further evaluation.
Hazard quotient (HQ):	A value used to quantify non-cancer hazard where an exposure dose is compared to a health guideline. Specifically, the value is the result of dividing an exposure dose by a health guideline. When an HQ is less than or equal to 1.0 (the exposure dose is lower than or equal to the health guideline), it is unlikely that non-cancer health effects will occur. If the HQ is greater than 1.0 (the exposure dose is higher than the health guideline), an exposed person could experience adverse health effects that are not cancer.
Ingestion:	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way (see route of exposure).
Ingestion rate (IR):	The amount of soil, sediment, or water that is swallowed in a day. It is usually expressed as liters per day or L/day for water and grams/day or g/day for soil and sediment.
Inhalation:	The act of breathing. A hazardous substance can enter the body this way (see route of exposure).

Intermediate duration exposure:	Contact with a substance that occurs for more than 14 days and less than a year.
Kg	Kilogram or 1,000 grams. Usually used here as part of the dose unit mg/kg/day meaning mg (contaminant)/kg (body weight)/day.
µg	Microgram or 1 millionth of 1 gram.
Mg	Milligram or 1 thousandth of 1 gram. Usually used here as in a concentration of contaminant in soil mg contaminant/kg soil or as in the dose unit mg/kg/day meaning mg (contaminant)/kg (body weight)/day.
Minimal Risk Level (MRL):	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects.
Point of exposure:	The place where someone can come into contact with a substance present in the environment (see exposure pathway).
Population:	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
Potential exposure pathway:	See exposure pathway.
Receptor population:	People who could come into contact with hazardous substances (see exposure pathway).
Reference dose (RfD):	A numerical estimate of daily oral exposure to the human population, including sensitive subgroups such as children, that is not likely to cause harmful effects during a lifetime.
Risk:	The probability that something will cause injury or harm.

Route of exposure:	The way people come into contact with a hazardous substance. The three common routes of exposure are: 1. Breathing (inhalation), 2. Eating or drinking (ingestion), and 3. Contact with the skin (dermal contact).
Source (of contamination):	The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.
Special populations:	People who might be more sensitive or susceptible to exposure to hazardous substances (for example, cigarette smoking) because of factors such as age, occupation, sex, or behaviors. Children, pregnant women, and older people are often considered special populations.
Standardized incidence ratio (SIR):	To evaluate cancer incidence (how many people get a particular type of cancer), a statistic known as a standardized incidence ratio (SIR) is calculated. An SIR is the ratio of the observed number of cancer cases to the predicted number of cases multiplied by 100.
Substance:	A chemical, element, metal, or radiation
Upper confidence limit (UCL)	The number that specifies the endpoint of a confidence interval (an estimated range of values that is likely to include an unknown population parameter).

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