Cleaner Air Oregon Modeling Protocol and Level-4
Risk Assessment Work Plan

# Owens-Brockway Plant 21
# Portland, Oregon

Prepared for:

Owens-Brockway Glass Container Inc.

September 20, 2021

Revised January 5, 2022

BRIDGEWATER GROUP, INC.

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# 1.0 Introduction

Owens-Brockway Glass Container Inc. (O-B) owns and operates a glass container manufacturing plant (Plant 21) located at 9710 NE Glass Plant Road in Portland, Oregon. The site occupies approximately 43 acres as shown in Figure 1-1. The facility is adjacent to Interstate 205, Killingworth Street and Johnson Lake Natural Area. The facility is located at a latitude of N 45° 33′ 46.1″ and longitude of W122° 33′ 50.2″, which correspond to Universal Transverse Mercator (UTM – NAD 83) Zone 10 coordinates of 534,030 meters Easting by 5,045,566 meters Northing. The site has an approximate elevation of 36 feet above sea level.

Plant 21 produces a variety of glass containers from post-consumer recycled glass with other essential raw materials such as sand and limestone. The glass manufacturing process is comprised of the following areas of operations: raw material and cullet receiving and storage, materials blending and transport, glass melting furnace, glass forming, final bottle treatment, and the maintenance and support systems.

Plant 21 was called into Oregon's Department of Environmental Quality's (DEQ) Cleaner Air Oregon (CAO) Program (OAR-340-245) on March 4, 2019. CAO is a health-based permitting program that regulates emissions of toxic air contaminants from facilities based on risk to nearby communities. CAO requires facilities to report toxic air contaminant emissions, assess potential health risks to people nearby and reduce toxic air contaminant risk if it exceeds specified risk action levels (RALs). The risk assessment procedure of defined under OAR-340-245-0050.

When Plant 21 was called in, the facility was operating two furnaces ("A" and "D"). Subsequently, in June 2020, O-B fully shutdown Furnace A. DEQ was notified of the shutdown at that time. Since then, O-B has decided not to restart Furnace A and, on July 27, 2021, submitted and administrative amendment application to remove Furnace A from their air permit. On May 10, 2021, DEQ requested that Furnace A be removed from the previously submitted emissions inventory (EI), modeling protocol and risk assessment workplan. Since then, O-B decided to conduct a level-4 risk assessment, which incorporates site-specific considerations to more accurately represent risk that may be over-estimated by default assumptions used to develop RBCs, and to incorporate more refined bioavailability estimates for arsenic. On August 11, 2021, DEQ provided O-B until September 20, 2021 to complete and submit this Cleaner Air Oregon Modeling Protocol and Level-4 Risk Assessment Work Plan. O-B retained Bridgewater Group to assist with the revised emissions inventory and Level-4 risk assessment. A revised modeling protocol and Level-4 risk assessment workplan, along with a Level-4 risk assessment, were submitted on September 20, 2021. Most of the assumptions from the previously approved modeling protocol (January 18, 2021 approval date) and risk assessment workplan (April 21, 2021 approval date) have been retained in this modeling protocol and workplan. Besides the removal of Furnace A, the following additional changes were made to the prior modeling configuration to better represent the Plant 21 facility:

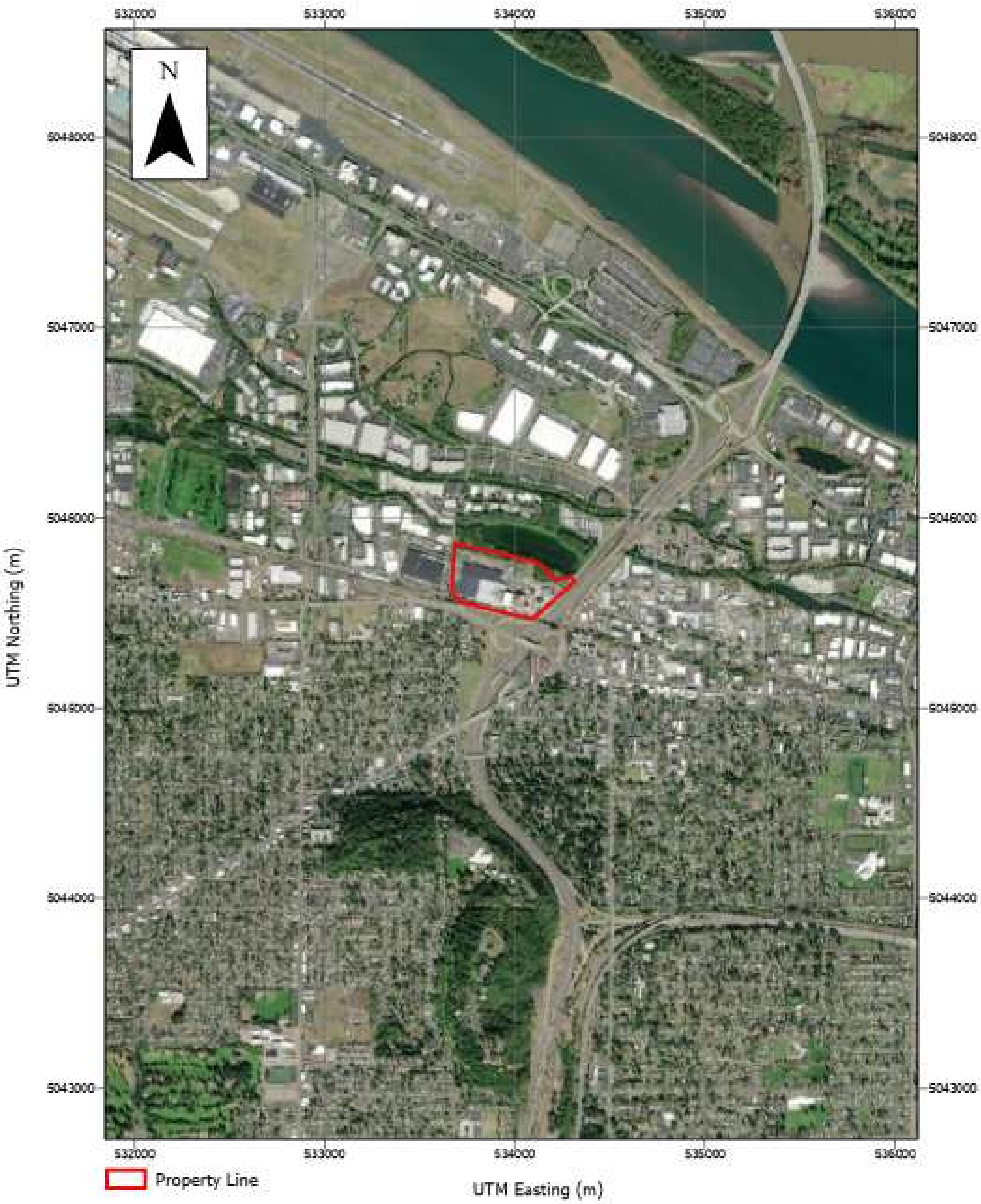
- Updated Furnace D stack parameters based on recent source tests and design drawings. The previous parameters were based on an old furnace configuration. A drawing showing Furnace D's stack design is provided in Appendix B
- Recharacterized Building 1 to better reflect actual building layout. In the previously approved protocol, the upper tier was bigger than what actually exists and was sized so that the Furnace D stack was right next to the upper tier. In actuality, the stack is approximately 15 feet from the edge of the upper tier. The upper tier of building consists to two Robertson roof monitors which protrude above the roof, and not a single structure as indicated previously. Since the downwash calculation can be sensitive to the tier dimensions, this analysis utilizes the actual building configuration to provide more accurate modeled impact results.
- The emissions inventory provides separate emission rates for amber and green glass manufactured in Furnace D. For the annual emissions, the pollutant emission rates used to estimate chronic risk were based on the higher pollutant emission rates of the two glasses. For the daily emissions, the pollutant emissions will be based on the higher of the two glasses.
- Changed the boiler (EU7) type from POINT to POINTCAP due to a raincap on the stack.
- Added material handing houses (RMBH1 and RMBH2) along with appropriate silica emissions. These sources are in the Title V permit but were not included previously in the CAO modeling.
- Updated the truck and railcar unloading building heights, which were incorrect.
- Removed certain smaller support buildings from the downwash analysis that are too small or too far away to impact the downwash.
- Added the mold bench dust collector (MBD1) as a source based on information confirmed from a recent site visit that MBD1 vents to the outside through a discreet stack.
- Changed some of the building and modeling ID's.
- The Level 4 risk assessment and workplan included adjustment to the deposition rate, arsenic oral RBA, and various ingestion rates.

DEQ and OHA reviewed the modeling protocol and workplan and the Level-4 risk assessment and provided comments in a letter dated December 6, 2021. DEQ requested O-B obtain onsite measurements to establish the heights of the Building 1 roof vent and the height of furnace D. DEQ also state it would accept the following multipathway adjustments:

- Oral RBA of 60% instead of the proposed 44%,
- OEHHA's 75$^{th}$ percentile ingestion rates for produce by age group instead of the mean,
- The default homegrown ingestion rate of 13.7% instead of the West region rate of 5.95%,
- Provided better documentation for the weight-adjusted ingestion rates by age group from OHA for ages 0 to 70, and the mean ingestion rate from OEHHA for the 3rd trimester, and
- Correct calculation errors in the multipathway spreadsheet.

This document is the revised Modeling Protocol and Level-4 Risk Assessment Workplan for the O-B facility, which incorporates DEQ's comments. Changes are highlighted with red text.

## Figure 1-1.  Site Location



# 2.0 Source Description

## 2.1 Process Description

Railcars and trucks deliver the raw materials (e.g., sand and limestone) to the plant. Raw materials are gravity fed into an unloading pit and the elevators transport the materials to designated storage silos in the batch house. Cullet (recycled glass) is delivered by truck and stored in piles by color at the facility. The cullet is processed through an enclosed onsite crusher and conveyed to storage silos. Individual components are weighed on scales located under each silo and conveyed to the mixer where cullet (i.e., recycled glass) is added. The batch is then transferred to the furnace. Baghouses are used to control particulate-dust generated during the raw materials transport and mixing operations.

The facility operates one glass-melting furnace (Furnace D) that burns natural gas as its primary fuel. Furnace D is an end-port furnace with a single stack. The batch-mixture is charged into the furnace at the same rate as molten-glass is pulled out to achieve steady-state operation. As a batch is added to the furnace, it initially floats on the top of the molten glass already in the furnace. Raw materials melt into the molten glass and eventually flow through a "throat" at the bottom of furnace that leads into the refiner. As the molten glass flows through the refiner, the glass temperature decreases and becomes more uniform prior to entering the forehearths. Molten glass flows gravitationally from the refiner through the forehearths, where it is cooled to a uniform temperature and desirable viscosity. Semi-molten glass from the forehearths is sheared (forming gobs), and the gobs travel on delivery chutes to the forming machine molds where the containers are formed. The molds are periodically swabbed by an operation with a graphite/oil solution as needed. This swabbing activity accounts for the emissions from the forming machines.

After the glass containers are formed, the hot end surface treatment (HEST) process applies mono-butyl-tin trichloride (MBTT) which deposits a layer of tin oxide (SnO2) onto the glass surface. The exhaust from the HEST process vents through an abatement device. Ammonia is added to HEST hood exhaust prior to the abatement device so it can react with the excess MBTT to form solid particulate matter (PM) that is collected in the baghouse. Following the HEST process, the bottles are annealed in the lehr, which is a long oven that reheats and cools the containers in a way that relieves stresses in the glass.

Finally, the finished containers are coded and packaged for shipping. A bottle coder (ink-jet printer) prints tiny identification numbers on the glass containers as they rapidly move through the conveyor.

## 2.2 Toxic Emission Unit Descriptions

Figure 2-1 shows the conceptual site model for the CAO process. As per OAR 340-245-0020(5), emissions from the combustion of natural gas will be segregated into a distinct TEU (or TEUs) and the risk at each exposure location from those TEUs will be determined separately.

## Figure 2-1. CAO Conceptual Site Model

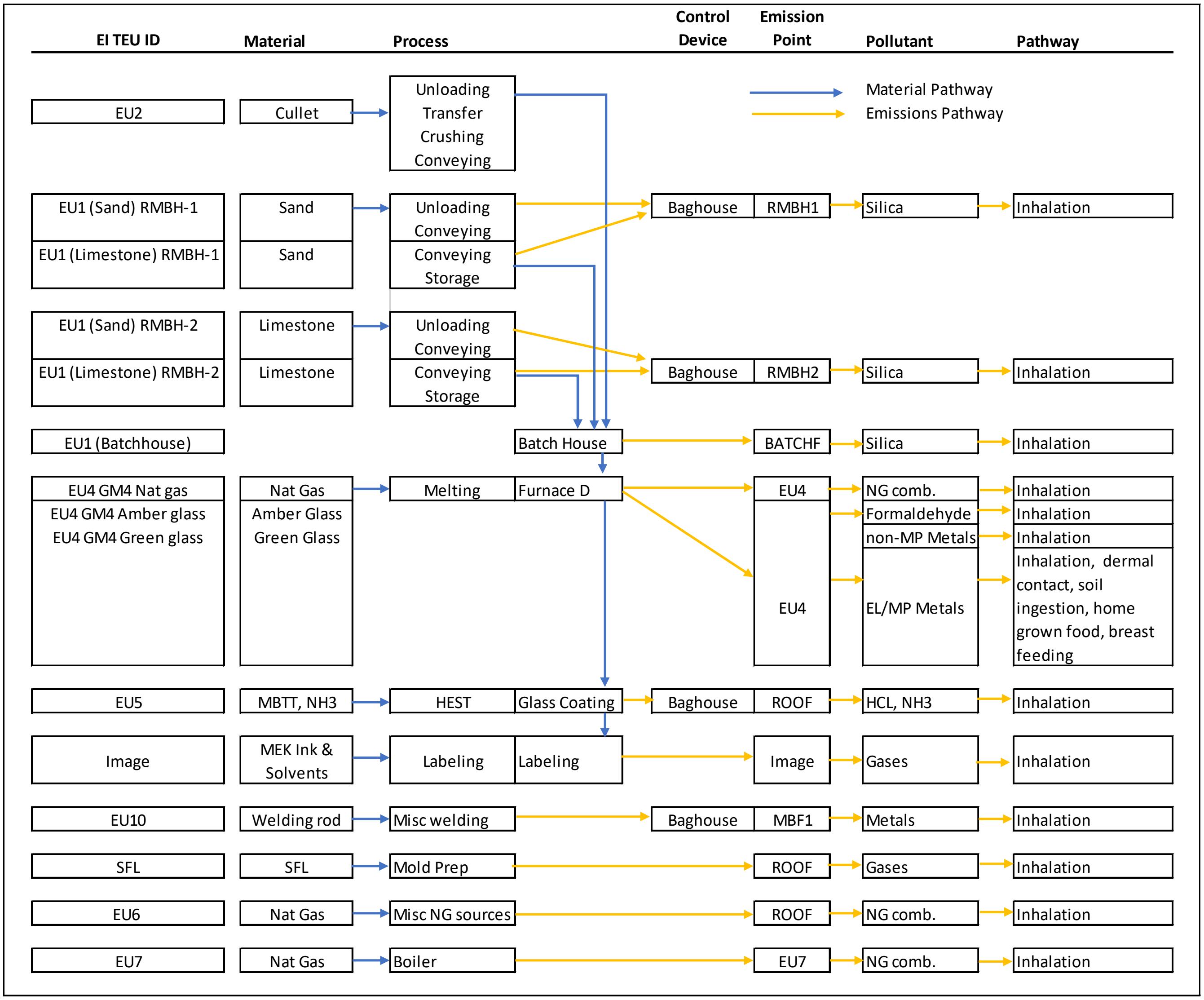



Table 2-1 shows the TEU labeling between the EI, modeling and risk assessment. The TEU groups represent the sources identified in the Title V permit. A description of each TEU group and the sub processes is provided below. The EI provides greater detail and breaks out emissions by process within each TEU group. For example, Furnace D (EU4) emissions from amber glass, green glass, and natural gas are explicitly specified. The model ID identifies the name of the exhaust point used in the model. For example, several TEUs may exit out of a common exhaust point (for example, the roof monitor). Figure 2-2 shows the modeling exhaust locations. The Risk ID shows the groupings of sources for purposes of the risk assessment. For example, ID EU1RM1 is the combined emissions from TEUs "EU1 (Sand) RMBH-1" and "EU1 (Limestone) RMBH-1", which both exhaust out of RMBH-1. Each set of the combined TEUs are shown by colored cells. For all risk groups other than EU4, the annual and daily TAC emissions will be summed. For Furnace D (EU4), for annual emissions, the pollutant emission rates used to estimate chronic risk will be based on the higher pollutant emission rates of the two glasses. For the daily emissions, the pollutant emission rates used estimate acute risk will be based on the higher pollutant emission rate of the two glasses. This way, the calculated risk from daily emission from EU4 is representative of both green or amber glass.

### Table 2-1. TEU Groups with EI, Modeling and Risk Assessment IDs

| TEU Group | EI TEU ID | Description | Model ID | Risk ID |
|---|---|---|---|---|
| EU1 | EU1 (Sand) RMBH-1<br>EU1 (Limestone) RMBH-1 | Raw Material Handling Truck (sand)<br>Raw Material Handling Truck (limestone) | RMBH1 | EU1RM1 |
| | EU1 (Batchhouse) | Batch House Fugitive | BATCHF | EU1BF |
| | EU1 (Sand) RMBH-2<br>EU1 (Limestone) RMBH-2 | Raw Material Handling Batch House (sand)<br>Raw Material Handling Batch House (limestone) | RMBH2 | EU1RM2 |
| EU4 | EU4 GM4 Green glass<br>EU4 GM4 Amber glass | Furnace D (green glass)<br>Furnace D (amber glass) | EU4 | EU4 |
| | EU4 GM4 Nat gas | Furnace D Nat gas | EU4 | EU4NG |
| EU5 | EU5 | Hot End Surface Treatment | ROOF | EU5 |
| EU6 | EU6 | Misc Natural Gas Equipment | ROOF | EU6 |
| EU7 | EU7 | Boiler (Natural Gas) | EU7 | EU7 |
| EU10 | EU-10 Nickel Spray Welding<br>EU-10 SMAW welding<br>EU-10 GTAW welding<br>EU-10 GMAW welding | Nickel Spray Welding plus grinding<br>SMAW welding plus grinding<br>GMAW welding plus grinding<br>GTAW welding plus grinding | MBD1 | EU10 |
| IMAGE | IMAGE | Image printing | IMAGE | IMAGE |
| SFL | SFL | Solid film lubrication (mold prep) | ROOF | SFL |

## TEU1: Raw Material Handling

Railcars and trucks deliver the raw materials (e.g., sand and limestone) to the plant. Raw materials are gravity fed into an unloading pit and the elevators transport the materials to designated storage silos in the batch house. Baghouses are used to control emissions at the railcar and truck unloading areas.

The rail track unloading baghouse is contained within the unloading pit and exhausts into the pit. Since it is completely enclosed, it is not considered a source of TACs. The truck unloading baghouse is contained within the truck unload shed and exhausts out the side of the shed (emission point: RMBH1). Both the railcar and truck unload baghouses operate simultaneously during unloading. RMBH1 was not identified as an emission point in the previous modeling protocol.

The material is conveyed to the batch house for storage. When a batch is prepared, individual components are weighed on scales located under each silo and conveyed to the mixer where cullet (i.e., recycled glass) is added. The batch baghouse (emission point: RMBH2) is the main dust collector that operates continuously to abate particulate-dust generated during the raw materials transport and mixing operations. RMBH2 is located at the top of the batch house.

There is a third baghouse on top of the batchhouse and its exhaust is routed through RMBH2. Thus, this third baghouse was not explicitly modeled.
Fugitive emissions from wind blowing silica out of the batch house openings (EU1BF) are identified and modeled as a volume source (Emission point: BATCHF).

## TEU4: Glass Melting Furnace “D”

The facility operates one glass-melting furnace (Furnace D) that burns natural gas as its primary fuel. Furnaces A, B and C have been permanently shutdown. Furnace D is an end-port furnace with a single stack (emission point: EU4). The natural gas combustion contribution is identified as EU4NG.

## TEU5: Hot End Surface Treatment (HEST)

Semi-molten glass from the forehearths is sheared (forming gobs), and the gobs travel on delivery chutes to the forming machine molds. Once the glass containers are formed, the HEST process applies MBTT to the bottles. When the MBTT contacts the hot bottle, it decomposes, resulting in a layer of tin oxide ($SnO_2$) on the glass surface. Hydrogen Chloride (HCl) is a byproduct is this decomposition process, which is emitted from the unit.

The exhaust from the HEST process is collected in a hood, where ammonia is added to so it can react with the excess MBTT to form solid particulate matter (PM). The PM is then collected in a baghouse, which exhausts back into the glass melting furnace building (Building 1). Because of the heat generated in Building 1 by the furnace and bottle forming and annealing processes, air with Building 1 is advected upward and exhausted out of the roof monitor vents at the top of Building 1. Thus, ammonia and HCl emissions from the HEST process are released through the roof monitors (emission point: ROOF).

## TEU6: Natural Gas Burning Equipment

This TEU is the various natural gas burning equipment used at the facility, which includes furnace refiners (Rl to R4), forehearth (FH1 to FH4), Lehrs (LH1 to LH3), Mold burnout and curing oven (MO-1), Mold heat oven (MH-1), Quick fire oven (QF-1), and space heaters. Emissions from these process are released into building 1 and are carried up and out through the roof monitors (emission point: ROOF).

## TEU7: Natural Gas Burning Equipment

TEU7 is a "Kewanee, Type-C" boiler with the rated capacity of 10.5 MMBtu/hr and is fueled by natural gas. The boiler is used for space heating and hot water. The emission exhaust through a stack which has a rain-cap (emission point: EU7)

## TEU10: Machine Repair and Mold Grinding Equipment

TEU10 consists of machine repair and mold grinding operations that are done sporadically on as-needed basis. Emissions from these operations are controlled by the mold bench dust collector. In the previous protocol, this TEU was identified as exhausting into building 1. However, a recent site visit determined that this TEU exhausts to atmosphere through a stack located just west of building 1 (emission point: MBD1). The stack exhausts downward toward the roof, and thus, is treated as horizontal release.

## IMAGE: Bottle Labeling

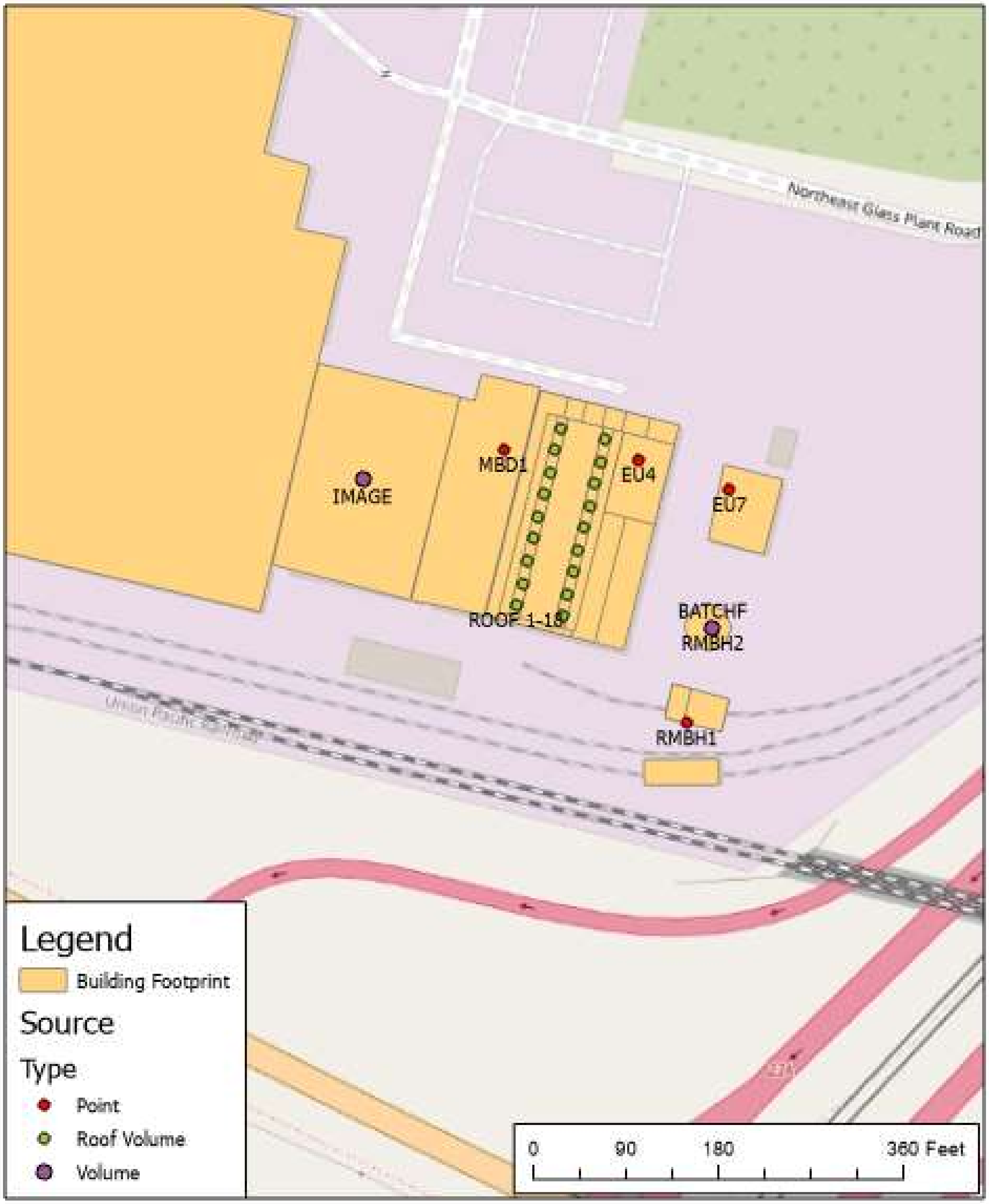
The finished bottles are coded and packaged for shipping. A bottle coder (ink-jet printer) prints tiny identification numbers on the glass containers as they rapidly move through the conveyor. Methyl ethyl ketone (MEK) is used as cleanup solvent and as the ink (carrier) solvent. MEK emissions are grouped under aggregate insignificant activities.

The labeling activities are not located in close proximity to the roof vents and/or building openings. Thus, the MEK fugitive emissions are dispersed in to the general facility from the ink jet printers when in use and when maintenance is done on the printers. As a result, the emissions from the image printing operation will be represented as a volume source (emission pint: IMAGE).

## SFL: Solid film lubrication

Mold preparation is an inherent part of the bottle-forming process. The mold preparation involves cleaning, lubricating, curing and heating molds when they are not being used in the forming machines. Molds are cleaned in the burnout ovens and grit blasters, and then solid film lubricant (SFL) is applied in the mold coating spray booth and cured in the mold curing ovens. Emissions from the SFL operation is understood to vent into Building 1 and exhaust through the roof monitor.

## Figure 2-2. O-B Plant 21 TEU exhaust locations



## 2.3 Compounds Emitted

Table 2-2 shows the toxics air pollutants emitted from the facility, along with the form of the pollutant (particulate or volatile gas), whether the pollutant has an early-life (EL) or multipath way (MP) adjustment made to its Risk Based Concentrations (RBCs), and what the respective non-cancer TBACT RAL is (either 3 or 5). The lower part of the table shows compounds which are emitted but do not have RBCs.

### Table 2-2. Compound emitted from Plant 21.

| CAS # | Name | Type | EL, MP Adjustments | TBACT RAL |
|---|---|---|---|---|
| **Compounds emitted with RBCs** | | | | |
| 75-07-0 | Acetaldehyde | Volatile | -- | HI3 |
| 107-02-8 | Acrolein | Volatile | -- | HI5 |
| 7664-41-7 | Ammonia | Volatile | -- | HI3 |
| 7440-36-0 | Antimony and compounds | Particulate | -- | HI3 |
| 7440-38-2 | Arsenic and compounds | Particulate | Yes | HI3 |
| 71-43-2 | Benzene | Volatile | -- | HI3 |
| 7440-41-7 | Beryllium and compounds | Particulate | -- | HI3 |
| 78-93-3 | 2-Butanone (Methyl ethyl ketone) | Volatile | -- | HI3 |
| 7440-43-9 | Cadmium and compounds | Particulate | Yes | HI3 |
| 18540-29-9 | Chromium VI, chromate, and dichromate particulate | Particulate | Yes | HI3 |
| 7440-48-4 | Cobalt and compounds | Particulate | -- | HI3 |
| 7440-50-8 | Copper and compounds | Particulate | -- | HI3 |
| 100-41-4 | Ethyl benzene | Volatile | -- | HI3 |
| 50-00-0 | Formaldehyde | Volatile | -- | HI3 |
| 110-54-3 | Hexane | Volatile | -- | HI3 |
| 7647-01-0 | Hydrochloric acid | Volatile | -- | HI3 |
| 67-63-0 | Isopropyl alcohol | Volatile | -- | HI3 |
| 7439-92-1 | Lead and compounds | Particulate | Yes | HI3 |
| 7439-96-5 | Manganese and compounds | Particulate | -- | HI3 |
| 7439-97-6 | Mercury and compounds | Particulate | Yes | HI3 |
| 108-10-1 | Methyl isobutyl ketone (MIBK, Hexone) | Volatile | -- | HI3 |
| 91-20-3 | Naphthalene | Volatile | -- | HI3 |
| C365 | Nickel and compounds | Particulate | -- | HI3 |
| 56-55-3 | Benz[a]anthracene | Volatile | -- | -- |
| 50-32-8 | Benzo[a]pyrene | Volatile | Yes | HI3 |
| 205-99-2 | Benzo[b]fluoranthene | Volatile | -- | -- |
| 191-24-2 | Benzo[g,h,i]perylene | Volatile | -- | -- |
| 207-08-9 | Benzo[k]fluoranthene | Volatile | -- | -- |
| 218-01-9 | Chrysene | Volatile | -- | -- |
| 206-44-0 | Fluoranthene | Volatile | -- | -- |
| 193-39-5 | Indeno[1,2,3-cd]pyrene | Volatile | -- | -- |
| 7782-49-2 | Selenium and compounds | Particulate | -- | HI3 |
| 7631-86-9 | Silica, crystalline (respirable) | Particulate | -- | HI5 |
| 1310-73-2 | Sodium hydroxide | Volatile | -- | HI3 |
| 108-88-3 | Toluene | Volatile | -- | HI3 |
| 7440-62-2 | Vanadium (fume or dust) | Particulate | -- | HI3 |
| 1330-20-7 | Xylene (mixture), including m-xylene, o-xylene, p-xylene | Volatile | -- | HI3 |

| CAS # | Name | Type | EL, MP Adjustments | TBACT RAL |
|---|---|---|---|---|
| **Compounds emitted without RBCs** | | | | |
| 7440-39-3 | Barium and compounds | Particulate | -- | -- |
| 1313-27-5 | Molybdenum trioxide | Particulate | -- | -- |
| 83-32-9 | Acenaphthene | Volatile | -- | -- |
| 208-96-8 | Acenaphthylene | Volatile | -- | -- |
| 120-12-7 | Anthracene | Volatile | -- | -- |
| 86-73-7 | Fluorene | Volatile | -- | -- |
| 91-57-6 | 2-Methyl naphthalene | Volatile | -- | -- |
| 85-01-8 | Phenanthrene | Volatile | -- | -- |
| 129-00-0 | Pyrene | Volatile | -- | -- |
| 57-97-6 | 7,12-Dimethylbenz[a]anthracene | Volatile | -- | -- |
| 56-49-5 | 3-Methylcholanthrene | Volatile | -- | -- |
| 7440-66-6 | Zinc and compounds | Particulate | -- | -- |
| 1333-82-0 | Chromium trioxide | Particulate | -- | -- |
| 71-36-3 | n-butyl alcohol | Volatile | -- | -- |

Emissions for each TEU are provided in the AQ405CAO Emissions Inventory form, which is included in this submittal.

# 3.0 Modeling Protocol

This section is a revised modeling protocol and is intended to outline the assumptions and methodologies that will be used in the air quality analysis to calculate 24-hour and annual risk values for each TEU for use in the Level-4 Risk Assessment Work Plan (Section 4). This modeling protocol retains much of the previous modeling protocol approved by DEQ. The changes in this protocol are primarily to correct source and building configurations to more accurately reflect Plant 21's actual configuration, as summarized in Section 1.

## 3.1 Source Characterization

Table 3-1 shows the source characteristics of the modeled sources. Text in red indicates changes or additions from the previously approved protocol. All coordinates are in Universal Transverse Mercator (UTM) NAD 83 Zone 10.

Emissions for each TEU are provided in the AQ405CAO form, which is included in this submittal. There are a couple data handling items between the AQ405 inventory form and the risk assessment emissions. For Furnace D, the emissions inventory has amber and green glass emission characterized separately. For the annual emissions, the pollutant emission rates used to estimate chronic risk were based on the higher pollutant emission rates of the two glasses. For the daily emissions, the pollutant emission rates used estimate acute risk were based on the higher pollutant emission rate of the two glasses. For EU1, the limestone and sand emissions were combined for the RMBH1 andRMBH2 sources.

The roof monitor will be modeled as a set of 18 volume sources, nine along each vent. Each volume source will be run with 1/18$^{th}$ of the total roof monitor emissions. The volumes will then be combined using AERMOD source group keyword (SRCGROUP) to provide the ROOF source.

Evaluation of building downwash on the adjacent stack is deemed necessary, since the stack height may be below Good Engineering Practice (GEP) heights. The formula for GEP height estimation is:

$$Hs = Hb + 1.50L_b$$

where: $H_s$ = GEP stack height
$H_b$ = building height
$L_b$ = the lesser building dimension of the height, length, or width

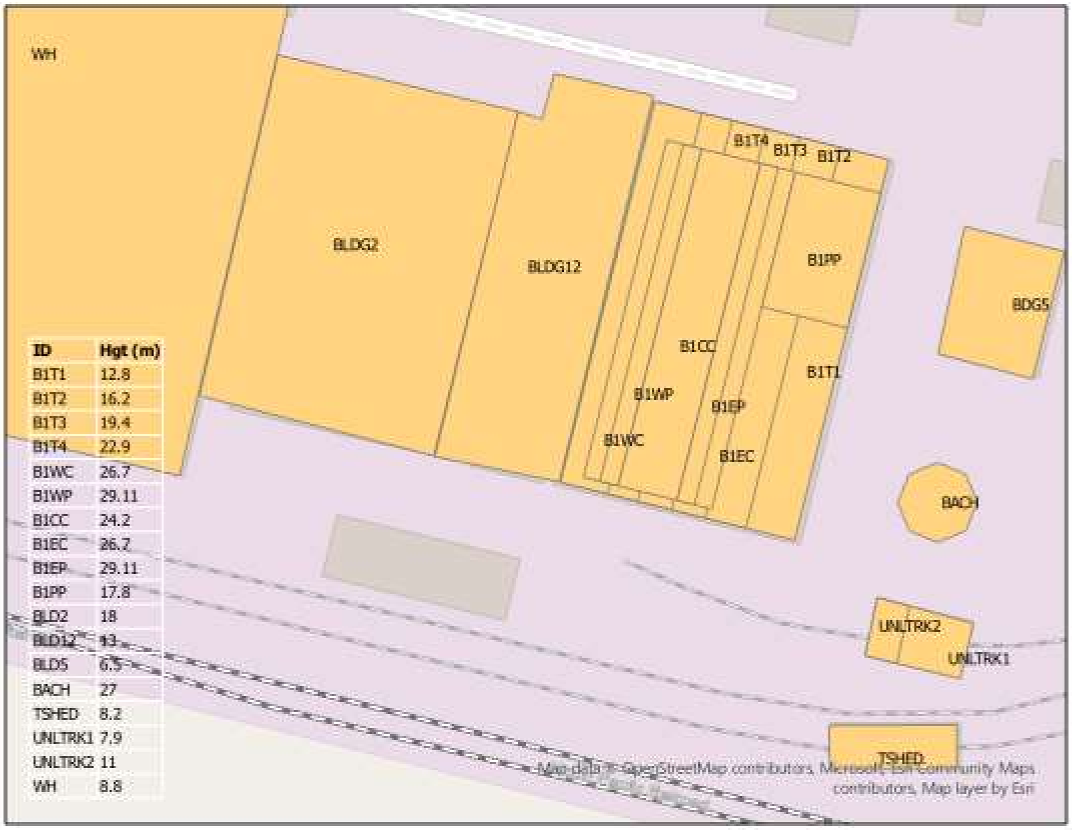
The effects of aerodynamic downwash due to buildings and other structures will be accounted for by using wind direction-specific building parameters calculated by the USEPA-approved Building Parameter Input Program Prime (BPIP-Prime) and the algorithms included in AERMOD. Based on examination of plot plans for the relationship of sources to the location of facility structures, the locations and dimensions of emission sources and facility structures will be input to the BPIP-Prime software package, which calculates the direction-specific building dimensions for input into AERMOD.

Figure 3-1 shows the building footprint and heights. As mentioned, Building 1 was recharacterized to better reflect actual building layout. In the previously approved protocol, the upper tier was bigger than what actually exists and was sized so that the Furnace D stack was right next to the upper tier In actuality, the center of the stack is about 28.5 feet from the edge of the roof vent opening. The upper tier of building consists to two Robertson roof monitors which protrude above the roof rather than a single structure, as shown in Figure 3-2. Since the downwash calculation can be sensitive to the tier dimensions, the more representative configuration will be used to more accurately predict modeled impacts. BPIP requires building be characterized as a series of block. For this assessment, blocks B1T1-4 are the base structure of Building 1. Blocks B1WC, B1WP, B1CC, B1EP and B1EC are the Robertson roof vent structures. B1PP is the flatter section where Furnace D exhaust is. . Because BPIP is sensitive to the building and stack heights, DEQ requested that O-B obtain onsite measurements to establish the heights of the Building 1 roof monitor vent and furnace D stack. A report documenting the work to obtain the onsite measurements is provided in Appendix B. The height of the roof monitor vent above ground was found to be 95’-6” (29.11 m) and the height of the furnace D stack was 100’-10.25” (30.74m). The edge of the stack was found to be 27’-4” from the edge of the roof vent opening. Thus, the center of the stack is 28.5’ (27.25’+1.2’) from the edge of the roof vent.

## Table 3-1. Source Parameters

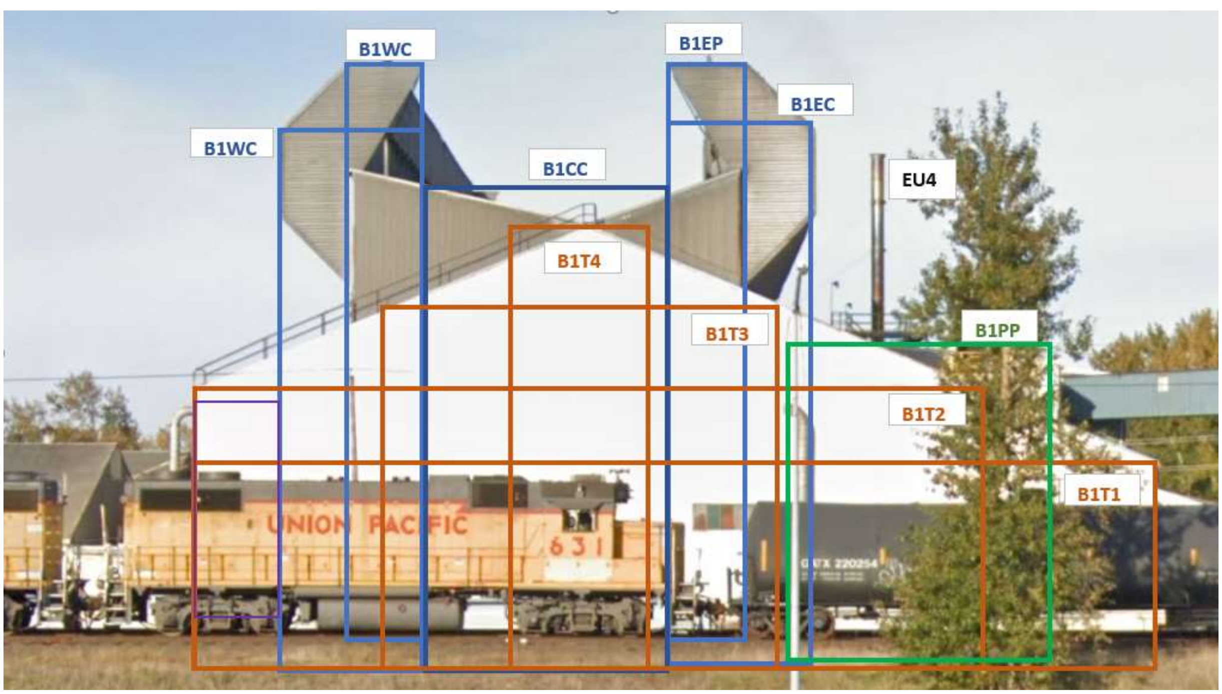
| Model ID | Description | Type | X (m) | Y(m) | Z(m) | Height (m) | Temp (K) | Vel (m/s) | Dia (m) |
|---|---|---|---|---|---|---|---|---|---|
| **POINT SOURCES** | | | | | | | | | |
| EU4 | Furnace D | POINT | 534052 | 5045579 | 12.19 | 30.74 | 647.65 | 16.97 | 0.74 |
| EU7 | Boiler | POINTCAP | 534080 | 5045570 | 12.08 | 24.41 | 773.15 | 1.72 | 0.79 |
| MBD1 | Machine Dust Collector | POINTHOR | 534013 | 5045582 | 12.23 | 13.11 | Ambient | 13.58 | 0.30 |
| RMBH1 | Truck-Unload RM Baghouse | POINTHOR | 534067 | 5045501 | 12.25 | 6.40 | Ambient | 4.66 | 0.15 |
| RMBH2 | Batch house RM Baghouse | POINTHOR | 534075 | 5045529 | 12.37 | 27.15 | Ambient | 14.55 | 0.61 |
| **VOLUME SOURCES** | | | **X (m)** | **Y (m)** | **Z (m)** | **Height (m)** | **Sigma Y (m)** | **Sigma Z (m)** | |
| BATCHF | Batch House Fugitive | VOLUME | 534075 | 5045529 | 12.37 | 27.15 | 2.977 | 12.63 | |
| IMAGE | Image Labeling Area | VOLUME | 533971 | 5045573 | 12.23 | 9.09 | 11.63 | 8.46 | |
| ROOF | Roof Monitor (18 volumes sources) | | | | | | | | |
| | ROOF_1 | VOLUME | 534030 | 5045588 | 12.27 | 29.11 | 4.57 | 13.96 | |
| | ROOF_2 | VOLUME | 534028 | 5045582 | 12.29 | 29.11 | 4.57 | 13.96 | |
| | ROOF_3 | VOLUME | 534026 | 5045575 | 12.31 | 29.11 | 4.57 | 13.96 | |
| | ROOF_4 | VOLUME | 534025 | 5045569 | 12.32 | 29.11 | 4.57 | 13.96 | |
| | ROOF_5 | VOLUME | 534023 | 5045562 | 12.32 | 29.11 | 4.57 | 13.96 | |
| | ROOF_6 | VOLUME | 534022 | 5045555 | 12.32 | 29.11 | 4.57 | 13.96 | |
| | ROOF_7 | VOLUME | 534020 | 5045549 | 12.31 | 29.11 | 4.57 | 13.96 | |
| | ROOF_8 | VOLUME | 534018 | 5045542 | 12.31 | 29.11 | 4.57 | 13.96 | |
| | ROOF_9 | VOLUME | 534017 | 5045536 | 12.30 | 29.11 | 4.57 | 13.96 | |
| | ROOF_10 | VOLUME | 534043 | 5045585 | 12.21 | 29.11 | 4.57 | 13.96 | |
| | ROOF_11 | VOLUME | 534042 | 5045578 | 12.26 | 29.11 | 4.57 | 13.96 | |
| | ROOF_12 | VOLUME | 534040 | 5045572 | 12.33 | 29.11 | 4.57 | 13.96 | |
| | ROOF_13 | VOLUME | 534038 | 5045565 | 12.31 | 29.11 | 4.57 | 13.96 | |
| | ROOF_14 | VOLUME | 534037 | 5045559 | 12.28 | 29.11 | 4.57 | 13.96 | |
| | ROOF_15 | VOLUME | 534035 | 5045552 | 12.30 | 29.11 | 4.57 | 13.96 | |
| | ROOF_16 | VOLUME | 534033 | 5045545 | 12.30 | 29.11 | 4.57 | 13.96 | |
| | ROOF_17 | VOLUME | 534032 | 5045539 | 12.29 | 29.11 | 4.57 | 13.96 | |
| | ROOF_18 | VOLUME | 534030 | 5045532 | 12.27 | 29.11 | 4.57 | 13.96 | |

## Figure 3-1. Building ID's and Heights




| ID | Hgt (m) |
|---|---|
| B1T1 | 12.8 |
| B1T2 | 16.2 |
| B1T3 | 19.4 |
| B1T4 | 22.9 |
| B1WC | 26.7 |
| B1WP | 29.11 |
| B1CC | 24.2 |
| B1EC | 26.7 |
| B1EP | 29.11 |
| B1PP | 17.8 |
| BLD2 | 18 |
| BLD12 | 13 |
| BLD5 | 6.5 |
| BACH | 27 |
| TSHED | 8.2 |
| UNLTRK1 | 7.9 |
| UNLTRK2 | 11 |
| WH | 8.8 |

## Figure 3-2. Building 1 Downwash Characterization



## 3.2 Model Selection

Air quality dispersion modeling will be conducted to simulate the downwind transport of toxic air contaminants emitted by the TEUs at the facility. The analysis will estimate maximum off-site concentrations using the AERMOD (AMS [American Meteorological Society]/EPA [Environmental Protection Agency] Regulatory Model), which follows the procedure requirements as specified in 40 CFR Part 51, Appendix W, "Guidelines on Air Quality Models (Revised)". AERMOD incorporates air dispersion for both surface and elevated sources, and accounts for differing terrain (i.e., simple and/or complex). AERMOD includes three components: a meteorological data preprocessor, AERMET; a terrain data preprocessor, AERMAP; and the air dispersion model, AERMOD. The dispersion model will be performed using the following versions for AERMOD and all preprocessors:

- AERMOD: 19191
- AERMET: 19191
- AERMINUTE: 15272
- AERMAP: 18081
- AERSURFACE: 13016
- BPIP: 04274

AERMOD modeling will be performed using regulatory default options, which include stack tip downwash, buoyancy-induced dispersion, upper-bound downwash concentrations, default wind speed profile exponents and vertical potential temperature gradients, and a routine for processing concentration averages during calm winds and when there are missing meteorological data. The effects from local terrain will also be incorporated.

The land use surrounding the O-B facility is mostly characterized by the urban land use categories (industrial, commercial, and mixed use residential). Therefore AERMOD will be run with urban dispersion coefficients. Selection of the urban boundary layer option in AERMOD also requires an estimate of the population of the urban area. For this analysis, a value of 632,309 will be used based on the population in the City of Portland proper.

## 3.3 Meteorological Data

In preparation for air dispersion modeling, the following meteorological and terrain data files were obtained: five years of meteorological data (2014 to 2018) from the Portland International Airport (KPDX) meteorological tower surface data (Station #24229) in combination with the upper air data from Salem, Oregon (Station #24232), which can be obtained from National Weather Service. Both met stations represents the closest meteorological stations to the facility location with publicly available data to download. A windrose for the KPDX data set is shown in Figure 3-3.

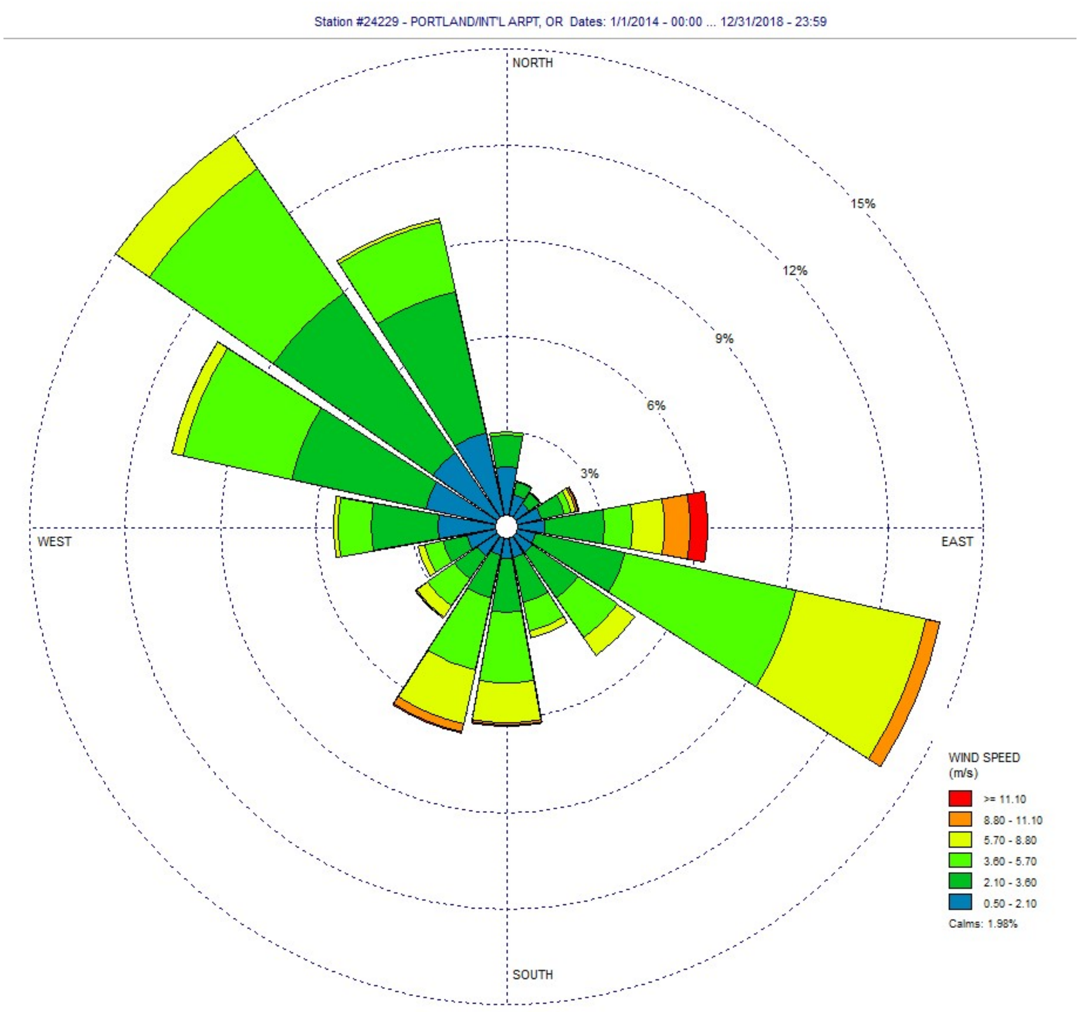
The surface parameters (surface roughness, Bowen ratio, and albedo) for the Portland International Airport station was determined using AERSURFACE, which accounts for surface moisture conditions on a monthly basis for 12 evenly-spaced sectors. A 30-year moisture analysis for the Portland area was also conducted to determine the wetness condition for each month and is presented in Table 3-2. The months of December to February were assumed as "winter." March to May were assumed as "spring", June to August were assumed as "summer", and September to November were assumed as "autumn". The data was processed using the AERMET program with the adjust "U*" selected.

**Table 0-2. Surface Soil Moisture Condition Assessment**

| | Meteorological Years | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| Annual Precipitation (in)[(a)] | 40.13 | 40.41 | 43.37 | 45.84 | 27.31 |
| Soil Moisture Condition[(b)] | Average | Average | Wet | Wet | Average |

*(a) Climatological data obtained from National Oceanic and Atmospheric Administration National Climatic Data Center for Portland International Airport (WBAN: 24229).*
*(b) Surface moisture conditions correspond to "Dry", "Average" or "Wet" soil content determined by comparing annual precipitation to 30-year climatological period. This method is consistent with the methodology set forth in the current version of the US EPA AERSURFACE User's Guide dated January 16, 2013. Based on the available 30-year climatological period between 1981 and 2010 data, the lower 30th percentile annual precipitation is 27.16 inches. The upper 70th percentile annual precipitation is 43.31 inches.*

## Figure 3-3. Portland Airport Wind Rose



## 3.4 Receptor Grid

Modeling will be conducted using a sufficient number of receptor locations to ensure that the maximum estimated impacts are identified. Following U.S. Environmental Protection Agency (USEPA) guidelines, receptor locations will be identified with sufficient density and spatial coverage to isolate the area with the highest impacts.

The following receptor grid spacing was used in the modeling analyses:

- 25-meter spacing along the property boundary,
- 25-meter spacing out to 200 m from the property boundary,
- 50-meter spacing out to 1.0 kilometers,
- 100-meter spacing out to 2.0 kilometers,
- 200-meter spacing out to 5.0 kilometers,
- 500-meter spacing out to 10.0 kilometers.

Receptor locations will be provided in the UTM coordinate system. Receptor elevations will be obtained from the USEPA website located at https://www.epa.gov/scram/interim-access-and-process-use-1992-nlcd-and-ned. The U.S. Geological Service national elevation data system (NEDS) is no longer providing the 1992 National Land Cover Dataset (NLCD) or the NED in a format (i.e., GeoTIFF) that can be processed directly with the AERSURFACE and AERMAP programs, respectively. USEPA has provided an interim solution for these changes on its website.

As part of the AERMOD modeling system, AERMAP will be run to calculate terrain maximum heights for each modeled receptor using 1/3-Arc-Second NED elevation data. The results from AERMAP will be used as input to the AERMOD runstream file for each modeling run.

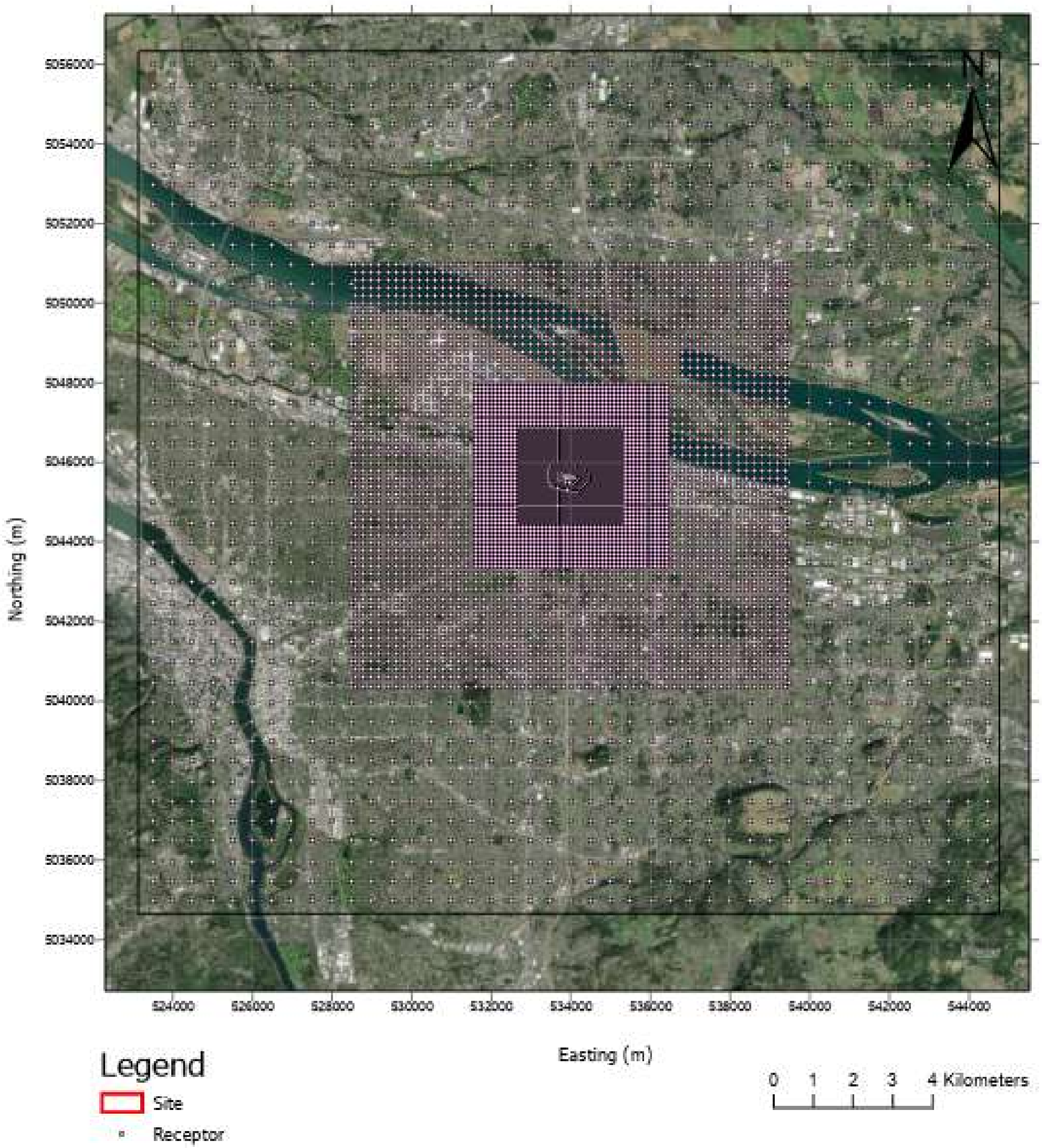
Far-field and near-field receptor grids are shown in Figure 3-4 and 3-5. Child receptors (e.g., schools/daycares) located within approximately 1 kilometer (km) from the facility property boundary were identified and are presented in Table 3-3 below.

### Table 0-3. Child Receptors Locations

| Receptor | UTM Easting (X) (m) | UTM Northing (Y) (m) |
|---|---|---|
| Helensview School | 533,218 | 5,045,383 |
| Prescott Elementary | 534,594 | 5,044,705 |
| Joyful Heart Day School | 533,441 | 5,044,932 |
| Airport Learning Tree | 535,990 | 5,045,873 |
| Discovery Gardens Childcare | 532,943 | 5,044,403 |

*UTM = Universal Transverse Mercator*

## Figure 3-4. Far-Field Receptor Grid



## Figure 3-5. Near Field Receptor Grid

## 3.5 Model Execution

AERMOD will be run to model each source separately using a 1 g/s unit emission. Thus, the outputs will be plot files of the maximum 24-hour concentrations and the 5-year average annual concentrations at each receptor for each source. These plot files will then be used in the risk assessment for the risk calculations as described below.

The air quality analysis submittal will consist of a report and electronic modeling files, which will include:

- AERMAP, BPIP, and AERMOD input and output files;
- AERSURFACE files;
- Downwash files including building heights and locations; and
- Meteorological data.

# 4.0 Risk Assessment Work Plan

## 4.1 Methodology

Figure 4-1 shows the Level-4 Risk Assessment process. A Level-4 is identical to a Level-3 risk assessment except that a level-4 Risk Assessment allows for site specific adjustments to the RBCs to provide a more representative risk estimate. Types of Level-4 adjustments available include: (1) changes in exposure time and frequencies, (2) the inclusion of relative bioavailability for certain chemicals including metals, and (3) site specific adjustments used in determining the multipathway factors (e.g. site specific deposition rates, and uptakes rates).

For this risk assessment, the following site-specific adjustments are proposed:

- Deposition Rate: Incorporate a site specific deposition rate based on the particle size distributions unique to glass manufacturing.
- Bioavailability: Incorporate the oral relative bioavailability (RBA) of arsenic.
- Intake Rates: Incorporate adjustment to the default soil and home grown produce ingestion and consumption rates.

These adjustments are described in more detail below.

### Figure 4-1. Level-4 Refined Risk Assessment

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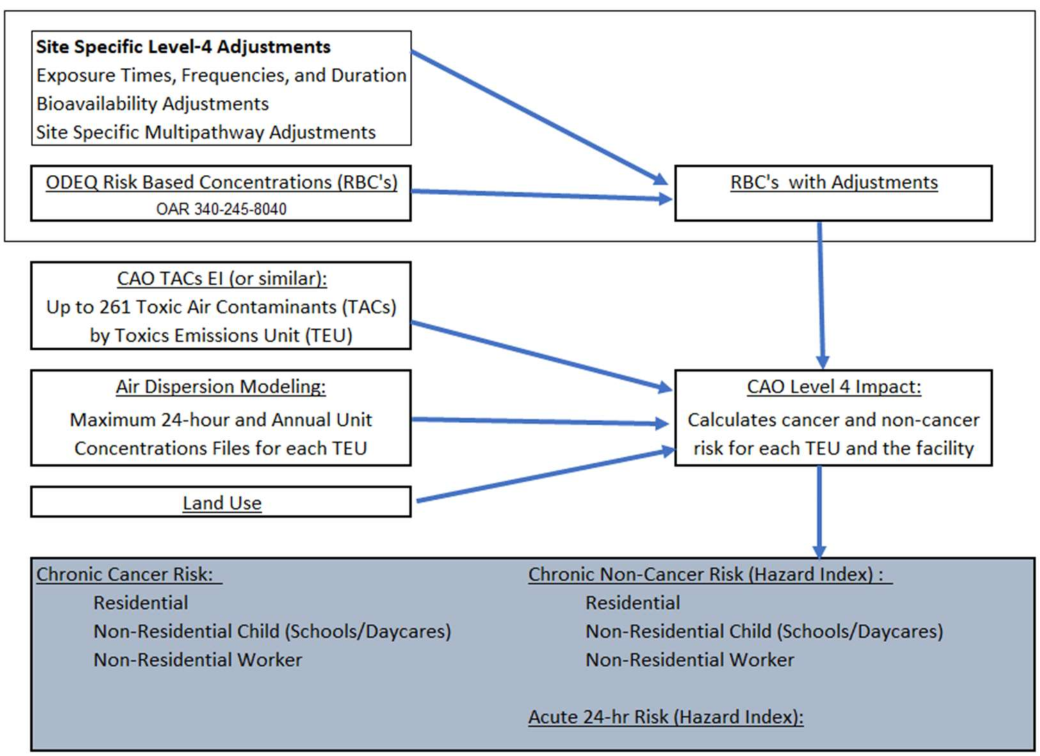

## 4.2 Level-4 RBC Adjustments

Table 4-1 shows the early-life and multipathway adjustments (MPA) used in CAO[1]. These adjustment factors are from the South Coast Air Quality Management District (SCAQMD), Permit Application Package "M", March 2016, Table 8-1. South Coast Air Quality Management District, Facility Prioritization Procedures for AB 2588 Program, Nov. 2016, Table 3.

### Table 4-1. SCAQMD Early-life and Multipathway Adjustment Factors

| Toxic Air Contaminant | Resident ELA | Non-Resident ELA | Cancer Resident MPA | Cancer Non-Resident MPA | Non-Cancer Resident MPA | Non-Cancer Non-Resident MPA |
|---|---|---|---|---|---|---|
| Arsenic | | | 9.7 | 4.5 | 88 | 28 |
| Cadmium | | | 1 | 1 | 2 | 1.2 |
| Chromium VI | 1.7 | 4.2 | 1.6 | 1 | 2.4 | 1 |
| Benzo[a]pyrene | 1.7 | 4.2 | 23 | 6.6 | | |
| Mercury | | | | | 3.9 | 2.1 |

SCAQMD generated these factors using the HARP2 Risk Assessment Standalone Tool (HARP2-RAST) based on exposures from inhalation, dermal contact, soil ingestion, consumption of home grown foods and consumption of breast milk and a deposition rate of 0.02 m/s. The HARP2-RAST assumes 100% bioavailability and accumulation of metals in the soils without losses. The SCAQMD multipathway factors for non-cancer residential exposure from arsenic is extremely high, with an 88-fold enhancement over the unadjusted inhalation non-cancer value.

Recently, the Oregon Health Authority (OHA) conducted a Public Health Assessment (PHA) on emissions of metals from the Bullseye Glass Plant in southwest Portland. OHA evaluated air quality data around Bullseye Glass facility before and after Bullseye Glass reduced emissions and also collected soil data to evaluate the safety of the consumption of foods grown around the facility. Since O-B is also a glass manufacturing facility, the findings from the Bullseye PHA are relevant.

OHA evaluated the soil ingestion and home-grown food consumption pathways in the PHA using soil samples from around the Bullseye facility. OHA noted 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 around Bullseye were not greater than what is typical for Portland area. For soil ingestion, OHA found that the arsenic non-cancer HQ was less than 1 and concluded that levels of metals measured in the soil in 2016 were too low to cause health effects.

For home grown food consumption, OHA concluded that it is unlikely that consumption of the produce from nearby gardens would pose a threat to the health of residents. They noted:

[1] Cleaner Air Oregon Spreadsheet for Calculation of Toxicity Reference Values and Risk-Based Concentration, July 2020.

> "The presence of metals in soils does not mean plants grown in them will contain high levels of those metals….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. Studies that examined metals in edible plants found the rate of metals uptake was not significant. This is because metals like arsenic, cadmium, chromium, and lead are not readily taken up by or accumulated in most garden plants."

Furthermore, OHA concluded that the health benefits of eating home grown produce outweigh any "negligible risks" from the levels of metals present in the soil around Bullseye.

Both the literature and OHA's assessment of a Portland-based glass manufacturing facility indicate the SCAQMD multipathway factors, without adjustment, would substantially overestimate the multipathway risk from a glass manufacturing facility like O-B's. Thus, the Level-4 multipathway adjustments are warranted.

O-B asked Tox Strategies, a California based risk assessment company, to evaluate the oral bioavailability and the homegrown produce and soil ingestion exposure pathways for the O-B facility. The Tox Strategies evaluation proposed alternatives to default assumptions for these factors as discussed below and described in more detail in their technical memorandum provided in Appendix C.

## Deposition Rate

The amount of contaminants that are available for soil ingestion, dermal contact or home-grown food consumption are dependent on the airborne deposition rates of those contaminants to the area surrounding an air emission source. The HARP2-RAST model calculates deposition based on a simple flux equation given by:

$$D \text{ (mass/area/year)} = C \text{ (mass/volume)} * DR\text{(m/s)} * A$$

where D is the deposition over an area for a specified time (usually based on annual average), C is the average concentration over that deposition time period, DR is the deposition rate (a.k.a. fall velocity), and A is a scaling constant for converting to consistent units. The HARP2-RAST model assumes a default deposition rate of 0.02 m/s rate in its calculations used to determine the deposition over an area. AERMOD can be used to determine a more accurate deposition rate for use in HARP2-RAST calculations based on glass manufacturing specific particle size distribution, which is available from EPA's Compilation of Emissions Factors (AP-42) Chapter 11.15 and is shown in Table 4-2.

## Table 4-2. Proposed Particle Distribution

| AP-42 Particle Diameter (microns) | AP-42 Cumulative Mass (%) | Bin Range (microns) | Representative Bin Diameter (microns) | Bin Mass Fraction (%) |
|---|---|---|---|---|
| 2.5 | 91 | 0-2.5 | 1.98 | 91 |
| 6 | 93 | 2.5-6 | 4.87 | 2 |
| 10 | 95 | 6-10 | 8.47 | 2 |
| >10 | 100 | 10-20 | 16.51 | 5 |

Table 4-2 provides the range of each size bin. For the ">10" bin, the upper size was set to 20 microns, which was a linear interpolation from the 6 micron and 10 micron mass fractions. For AERMOD, each bin is represented by a representative bin diameter (RBD) which derived using the volumetric weighted mean of the upper and lower bin sizes, and is given by:

$$RBD = \left((LD^3 + UD^3)/2\right)^{1/3}$$

where LD and UD are the lower and upper sizes of the bin, respectively. Using this RBD and associate mass fractions, AERMOD will be used to calculate the deposition at the residential receptors around the facility. For the calculation, AERMOD also requires the particle density. Finished container glass has a density of 2.5 to 2.8 $g/cm^3$. Thus, the upper bound glass density of 2.8 $g/cm^3$ was used. provides a very conservative estimate of particle density as the particles that actually escape the glass making furnace will be less dense. AERMOD will be run with the CONC and DEPOS keywords and to get a consistent set of wet and dry depositions and concentrations. Note that since the concentration and deposition both scale linearly with emission rate, the deposition rate (fall velocity) is independent of the emission rate. The output at each receptor is the annual deposition averaged over 5 years (D) and the 5-year average annual concentration (C). From the output file, the residential receptor with the highest deposition will be identified, and the deposition rate (DR) will be determined using

$$DR(m/s) = D(g/m^2/year)/C(\mu g/m^3) / A$$

where A is a constant to convert µg to g and year to seconds. Since the furnace is the dominant source of arsenic, AERMOD will be run for the furnace alone. Using these settings, the deposition rate was found to be 0.0036 m/s and this rate will be applied to the cancer and non-cancer RBCs for arsenic, cadmium and chromium VI.

## Arsenic Bioavailability

The HAPR-RAST model assumes 100% bioavailability. In 2012, EPA compiled and reviewed data on the relative bioavailability (RBA) of arsenic in soils[2]. Based on that review, EPA set the default RBA for arsenic at 60%.

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[2] United States Environmental Protection Agency (U.S. EPA). 2012. Recommendations for Default Value for Relative Bioavailability of Arsenic in Soil. December. Compilation and Review of Data on Relative Bioavailability of Arsenic in Soil (epa.gov)

For OHA's PHA of the Bullseye facility, OHA provided EPA Region 10 with soil samples that were collected around the facility. EPA analyze the soil samples for arsenic bioavailability and calculated a 22 percent arsenic bioavailability factor. That factor was used in OHA's analysis of the Bullseye facility.

An additional arsenic RBA study was identified for a glass manufacturing site, the Ottawa Township Flat Glass in Ottawa Township, Illinois (Casteel, et al. 2006). Samples were taken at residential locations and on-site plots. The RBA for the residential soil sample was 26% (90%CI: 0.24-0.28) and the RBA for the on-site plots was 48%. The on-site location was located near settling ponds, which would not be representative of residential soils.

At this time O-B specific soil bioavailability data is not available. Nonetheless, ToxStrategies recommends using the 22% factor from the OHA Bullseye assessment, as it best represents a Portland specific glass-plant sample. This assessment proposes a residential soil RBA for arsenic of 44% or double the Bullseye PHA values. This conservative approach acknowledges the published glass-plant bioavailability results but accounts for the uncertainty of not having a O-B specific value.

## Intake rates

The SCAQMD multipathway factor for non-cancer residental exposure from arsenic is extremely conservative, resulting in an overall multipathway adjustment factor (MPAF) of 88. Over half of the SCAQMD MPAF is due to consumption of home grown produce while slightly less than half is from consumption of soil.

As mentioned above, OHA concluded recently (consistent with the literature) that it is unlikely that consumption of the produce from nearby Portland-area gardens would pose a threat to the health of residents. In contrast, the HARP2-RAST model assumes high-end produce and soil ingestion and food consumption for all days of the year. As ToxStrategies has noted: "Total fruit and vegetable ingestion of 1,288 g/day of produce is equivalent to almost 3 pounds of produce per day, every day of the year, compared to 1 pound of produce per day based on the mean ingestion rates." Since Portland has a shorter growing season and cooler winter temperatures than Southern California, the use of the mean, rather than high-end, produce consumption is justified in this analysis.

ToxStrategies also noted that the percentage of homegrown produce ingested relative to total produce ingested, which is 13.7% in the OEHHA guidelines, is based on a national survey, which includes rural non-metropolitan areas, which have the highest percentages of homegrown produce ingestion of all areas surveyed across the entire country. As such, the OEHHA percentages based on the entire United States will likely overestimate the fraction of homegrown fruits and vegetables consumed by residents near O-B's facility. According to EPA's Exposure Factors Handbook (Table 13-68), the value of the ingestion of homegrown fruits and vegetables is 2.7% of total fruits and vegetables in a diet in metropolitan city areas, as compared to 14.4% for rural non-metropolitan areas.

ToxStrategies recommended using this 2.7% factor. The national survey also found higher rates of homegrown produce consumption in the South and Midwest than in the West and Northeast. Thus, as an alternative, regional consumption fractions could be employed (e.g., values for the West Region), which are more conservative than the city estimates as they include the rural contribution. Bridgewater considered the available options and has decided to propose the West Region value from Table 13-68 of 5.95%.

Similar to the produce ingestion pathway, the OEHHA guidance used for the MP factor provides an option for 95th percentile and mean incidental ingestion rates. Use of a 95$^{th}$ percentile incidental ingestion rate along with consideration of the inhalation, dermal contact, and produce ingestion pathways will create an unrealistic estimate of upper bound cumulative exposure. OHA, in its PHA for Bullseye Glass, used different values for the soil ingestion rates, which result in an age-weighted soil ingestion rate that falls between the OEHHA 95$^{th}$ percentile and the mean. For consistency with OHA's other glass manufacturing PHA's, we propose using the weight-adjusted soil ingestion rates from the PHA for this Level 4 risk assessment, which are shown Table 4-3. The OHA PHA did not include a value for the 3$^{rd}$ tri-semester, so the mean OEHHA values is selected.

## Table 4-3. Recommended Incidental Soil Ingestion Rates (mg/kg-day)

| Produce Type | 3$^{rd}$ Trimester[1] | 0 to <2 | 2 to <16 | 16 to 70 |
|---|---|---|---|---|
| Incidental Soil Ingestion Rate | NA | 15 | 6.8 | 1.4 |

For the Level 4 risk assessment, O-B proposed the following adjustments:

- Deposition rate of 0.0036 m/s for arsenic, cadmium and chromium VI,
- Oral RBA of 44%,
- OEHHA's mean ingestion rates for produce by age group (Table 2),
- West region 5.95% of produce consumption from a home garden, and
- Weight-adjusted soil ingestion rates by age group from PHA for ages 0 to 70, and the mean ingestion rate from OEHHA for the 3rd trimester (Table 4).

DEQ and OHA reviewed the proposed values and made the following determinations.

- Deposition Rate: DEQ accepted the use of the refined deposition rate.
- Arsenic RBA: Since site-specific soil RBA estimates were not available, DEQ will only accept the EPA default RBA of 60% for arsenic in soil. Although O-B believes this is an overly conservative assumption, the default EPA values will be used in the risk assessment.
- Produce Ingestion Rate: DEQ and OHA rejected the use of the mean produce ingestion rates, however, they would allow the use of the 75$^{th}$ percentile OEHHA values. O-B will use these values in the risk assessment.
- Home-Grown Produce Consumption Rate: DEQ and OHA rejected the use of the west region value of 5.95% for the produce consumption but instead would accept the default

value of 13.7%. O-B believes this is overly conservative as most residential plots impacted by O-B are urban (not rural) and thus would likely have lower consumption rates. However, O-B will use the default value in the risk assessment.

- Soil Ingestion Rates: DEQ accepted the use of the OHA Bullseye PHA soil ingestion rates with a couple corrections. The original protocol value for ages 2-16 was 5.4 mg/kg-day was not correct. This value has been updated to 6.8 mg/kg-day, as per DEQ and is reflected in Table 4-3. The calculation of this value will be included in the supporting calculation worksheet. A 3rd tri-semester value was provided but is not used in the adjustment calculations.

## Application of the Level 4 adjustments

For this assessment, no adjustments will be made to the early-life factors.

Also, as a simplification for all factors except non-cancer arsenic, only the deposition rate adjustment will be employed. Since the MP portion of the factor scales linearly with deposition rate and assuming the inhalation-only portion of the factor is 1, a revised MPAF will be scaled from the original MPAF factor. This adjustment will be:

$$MPFA_{mod} = 1 + [MPAF_{org} - 1]\left[\frac{DR}{0.02}\right]$$

For non-cancer arsenic, all of the previously described adjustments will be applied. For this calculation, a spreadsheet was prepared to show the original and revised MPA values. In the sheet, the concentration was set to the chronic REL so that the inhalation HQ is 1. The sheet then calculates the doses for the various pathways (inhalation, dermal, soil ingestion, and food consumption). Two calculation sheets were included, one with the original MPA calculation, and the other with the modified MPA values. The revised MPAFs resulting from this Level 4 analysis are shown in Table 4-4.

## Table 4-4. Revised Multipathway Adjustment Factors

| Toxic Air Contaminant | Resident ELA | Non-Resident ELA | Cancer Resident MPA | Cancer Non-Resident MPA | Non-Cancer Resident MPA | Non-Cancer Non-Resident MPA |
|---|---|---|---|---|---|---|
| Arsenic | -- | -- | 2.6 | 1.6 | 7.1 | 4.4 |
| Cadmium | -- | -- | 1 | 1 | 1.2 | 1 |
| Chromium VI | 1.7 | 4.2 | 1.1 | 1 | 1.3 | 1 |

Application of the proposed Level 4-driven modifications to the RBCs will be represented as:

$$RBC_{mod} = RBC_{org}[MPAF_{org}/MPAF_{mod}]$$

Table 4-5 shows the RBC's with adjustments applied. As part of the uncertainty analysis, O-B will show how final risk numbers are impacted by each variable's Level 4-adjusted value compared to the CAO default value.

## Table 4-5. RBCs With Level 4 Adjustments Applied

| | | Chronic Cancer RBC | | | Chronic Non-Cancer | | | |
|---|---|---|---|---|---|---|---|---|
| CAS# | Compound | Res. µg/m³ | Child µg/m³ | Worker µg/m³ | Res. µg/m³ | Child µg/m³ | Worker µg/m³ | Acute µg/m³ |
| 75-07-0 | Acetaldehyde | 0.45 | 12 | 5.5 | 140 | 620 | 620 | 470 |
| 107-02-8 | Acrolein | -- | -- | -- | 0.35 | 1.5 | 1.5 | 6.9 |
| 7664-41-7 | Ammonia | -- | -- | -- | 500 | 2200 | 2200 | 1200 |
| 7440-36-0 | Antimony and compounds | -- | -- | -- | 0.3 | 1.3 | 1.3 | 1 |
| 7440-38-2 | Arsenic and compounds | 0.000091 | 0.0036 | 0.0017 | 0.0021 | 0.015 | 0.015 | 0.2 |
| 71-43-2 | Benzene | 0.13 | 3.3 | 1.5 | 3 | 13 | 13 | 29 |
| 7440-41-7 | Beryllium and compounds | 0.00042 | 0.011 | 0.005 | 0.007 | 0.031 | 0.031 | 0.02 |
| 78-93-3 | 2-Butanone (Methyl ethyl ketone) | -- | -- | -- | 5000 | 22000 | 22000 | 5000 |
| 7440-43-9 | Cadmium and compounds | 0.00056 | 0.014 | 0.0067 | 0.0085 | 0.043 | 0.043 | 0.03 |
| 18540-29-9 | Chromium VI, chromate and dichromate particulate | 0.000045 | 0.00052 | 0.001 | 0.16 | 0.88 | 0.88 | 0.3 |
| 7440-48-4 | Cobalt and compounds | -- | -- | -- | 0.1 | 0.44 | 0.44 | -- |
| 7440-50-8 | Copper and compounds | -- | -- | -- | -- | -- | -- | 100 |
| 100-41-4 | Ethyl benzene | 0.4 | 10 | 4.8 | 260 | 1100 | 1100 | 22000 |
| 50-00-0 | Formaldehyde | 0.17 | 4.3 | 2 | 9 | 40 | 40 | 49 |
| 110-54-3 | Hexane | -- | -- | -- | 700 | 3100 | 3100 | -- |
| 7647-01-0 | Hydrochloric acid | -- | -- | -- | 20 | 88 | 88 | 2100 |
| 67-63-0 | Isopropyl alcohol | -- | -- | -- | 200 | 880 | 880 | 3200 |
| 7439-92-1 | Lead and compounds | -- | -- | -- | 0.15 | 0.66 | 0.66 | 0.15 |
| 7439-96-5 | Manganese and compounds | -- | -- | -- | 0.09 | 0.4 | 0.4 | 0.3 |
| 7439-97-6 | Mercury and compounds | -- | -- | -- | 0.077 | 0.63 | 0.63 | 0.6 |
| 108-10-1 | Methyl isobutyl ketone (MIBK, Hexone) | -- | -- | -- | 3000 | 13000 | 13000 | -- |
| 91-20-3 | Naphthalene | 0.029 | 0.76 | 0.35 | 3.7 | 16 | 16 | 200 |
| C365 | Nickel compounds, insoluble | 0.0038 | 0.1 | 0.046 | 0.014 | 0.062 | 0.062 | 0.2 |
| 56-55-3 | Benz[a]anthracene | 0.00021 | 0.0078 | 0.015 | -- | -- | -- | -- |
| 50-32-8 | Benzo[a]pyrene | 0.000043 | 0.0016 | 0.003 | 0.002 | 0.0088 | 0.0088 | 0.002 |
| 205-99-2 | Benzo[b]fluoranthene | 0.000053 | 0.002 | 0.0038 | -- | -- | -- | -- |
| 191-24-2 | Benzo[g,h,i]perylene | 0.0047 | 0.17 | 0.34 | -- | -- | -- | -- |
| 207-08-9 | Benzo[k]fluoranthene | 0.0014 | 0.052 | 0.1 | -- | -- | -- | -- |
| 218-01-9 | Chrysene | 0.00043 | 0.016 | 0.03 | -- | -- | -- | -- |
| 206-44-0 | Fluoranthene | 0.00053 | 0.02 | 0.038 | -- | -- | -- | -- |
| 193-39-5 | Indeno[1,2,3-cd]pyrene | 0.00061 | 0.022 | 0.043 | -- | -- | -- | -- |
| 7782-49-2 | Selenium and compounds | -- | -- | -- | -- | -- | -- | 2 |
| 7631-86-9 | Silica, crystalline (respirable) | -- | -- | -- | 3 | 13 | 13 | -- |
| 1310-73-2 | Sodium hydroxide | -- | -- | -- | -- | -- | -- | 8 |
| 108-88-3 | Toluene | -- | -- | -- | 5000 | 22000 | 22000 | 7500 |
| 7440-62-2 | Vanadium (fume or dust) | -- | -- | -- | 0.1 | 0.44 | 0.44 | 0.8 |
| 1330-20-7 | Xylene (mixture), including m-xylene, o-xylene, p-xylene | -- | -- | -- | 220 | 970 | 970 | 8700 |

## 4.3 Exposure Locations

Each receptor is assigned an exposure type based on its land use designation. Three source of land use data will be used:

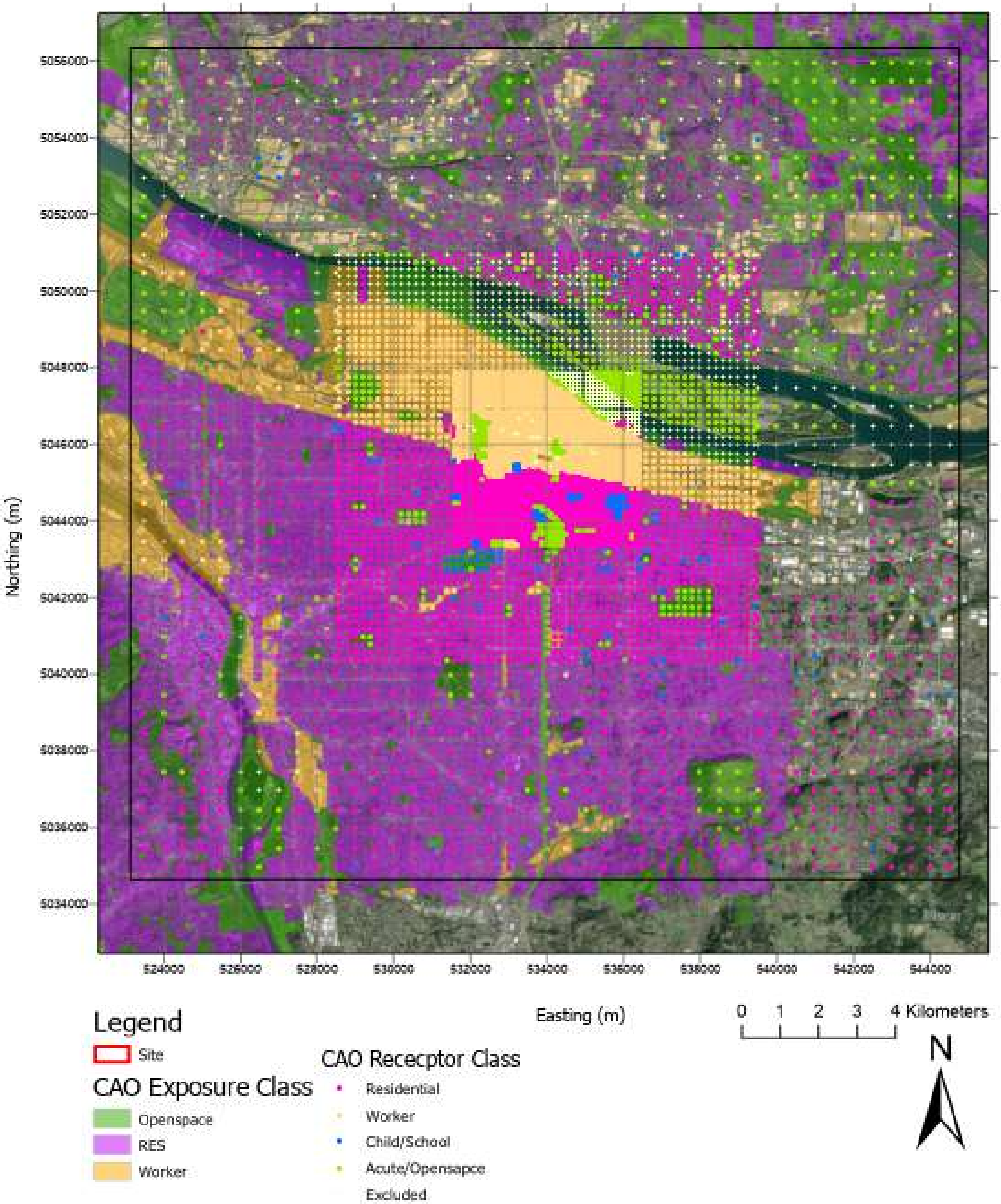
- Statewide 2017 Oregon Zoning data from the Oregon Department of Land Conservation and Development. This data layer is an element of the Oregon GIS Framework and is available through the Oregon Spatial Data Library. This feature class contains zoning data from 198 local jurisdictions, including the City of Portland and Multnomah County. The data set has 55 zoning classifications, which are binned into three categories: residential, industrial/commercial, and open space.
- A Portland zoning land use layer from Metro Portland Metro RLIS Discovery will be used to supplement the statewide layer in Oregon.
- Washington Department of Ecology State Land Use zoning data will be used for Washington State.

A crosswalk between the land use categories and the CAO classes is shown in Table 4-5. Receptors exposure classes are defined as residential, non-residential child (schools/daycares), non-residential worker, open space, and excluded. The excluded class applies to receptors where the risk is not calculated. Chronic exposure is only applicable to residential, non-residential child, and non-residential worker classes. The acute exposure is applied to all classes except the excluded class. The residential bin includes any category designating a residence. For example, mixed use commercial and residential areas and tribal reservation lands are defined as residential. The open space category includes parks, forests, beaches, public lands, and agricultural areas. Open space receptors will be evaluated for acute risk only.

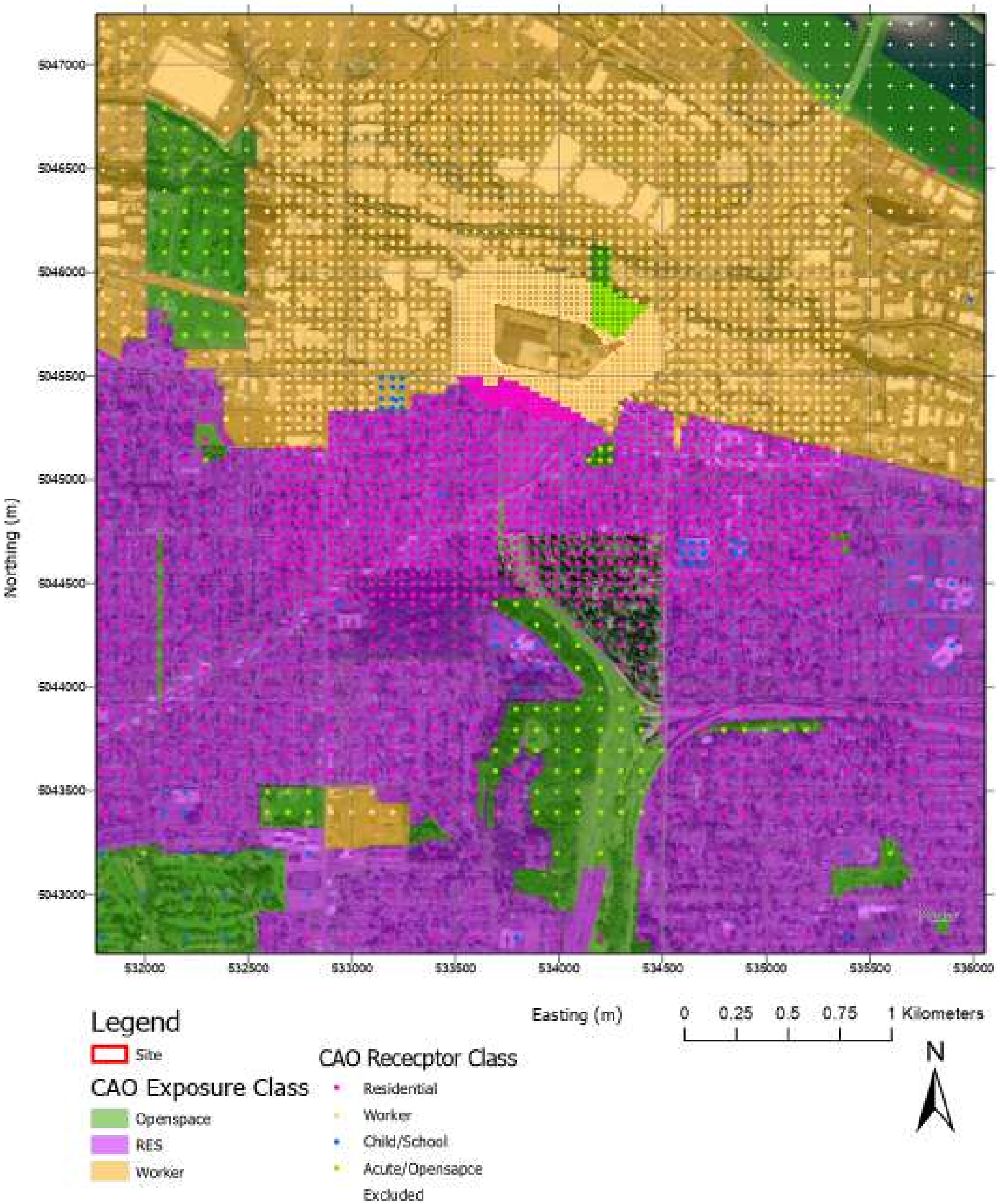
The zoning dataset does not identify schools or daycares. It also does not identify residences located in farmland or forested area. Thus, a manual search (e.g., using a search engine and Google Earth) was done to identify schools and daycares, sensitive receptors (e.g., hospitals), and residences residing in open spaces (e.g., farmlands).

Figure 4-2 and 4-3 shows the CAO classes around the facility. Maps of the original land use designation from the previously approved protocol are provided in Appendix A. A crosswalk of receptor IDs, UTM coordinates and proposed exposure locations for each receptor has been provided as an electronic file along with this protocol.

## Figure 4-2. Far-Field Receptors with CAO Exposure Classes



## Figure 4-3. Near-Field Receptors with CAO Exposure Class



## Table 4-5. Land Use Crosswalk

| LU Code | Description | CAO code | LU Code | Description | CAO code |
|---|---|---|---|---|---|
| BD | Beaches and Dunes | Openspace | MFL10 | Marginal Farm Land 10+ | Openspace |
| CC | Commercial - Central | Worker | MHDR | Medium High-density Res. | RES |
| CE | Coastal Estuarine | Openspace | MLDR | Medium Low-density Res. | RES |
| CEE | Combo equal emphasis | Worker | MUREH | Mixed-Use Com. & Res. Extremely High | RES |
| CG | Commercial - General | Worker | MURH | Mixed-Use Com. & Res. High | RES |
| CN | Commercial - Neighborhood | Worker | MURL | Mixed-Use Com. & Res. Low | RES |
| CO | Commercial - Office | Worker | MURM | Mixed-Use Com. & Res. Medium | RES |
| CPE | Combo with priority emphasis | Worker | MURMH | Mixed-Use Com. & Res. Med-high | RES |
| CS | Coastal Shorelands | Openspace | MURVH | Mixed-Use Com. & Res. V.High | RES |
| EFU160 | Exclusive Farm Use 160+ | Openspace | ND | No Data | Openspace |
| EFU20 | Exclusive Farm Use 20+ | Openspace | O | Other | Openspace |
| EFU40 | Exclusive Farm Use 40+ | Openspace | OSC | Open Space/Conservation | Openspace |
| EFU80 | Exclusive Farm Use 80 | Openspace | PF | Public & semi-public Uses | Openspace |
| FF160 | Mixed Farm-Forest 160+ | Openspace | PF80 | Prime Forest 80 | Openspace |
| FF20 | Mixed Farm-Forest 20 | Openspace | POS | Parks & Open Space | Openspace |
| FF40 | Mixed Farm-Forest 40 | Openspace | RC | Rural Commercial | Worker |
| FF80 | Mixed Farm-Forest 80 | Openspace | RI | Rural Industrial | Worker |
| FOR | Federal Forest | Openspace | RNG | Federal Range | Openspace |
| FUD | Future Urban Development | Openspace | RR1 | Rural Residential 1 acre | RES |
| HDR | High-density Res. | RES | RR10 | Rural Residential 10 acres | RES |
| IC | Industrial Campus | Worker | RR2 | Rural Residential 2-4 acres | RES |
| IH | Industrial - Heavy | Worker | RR5 | Rural Residential 5 acres | RES |
| IL | Industrial - Light | Worker | SF80 | Secondary Forest 80 | Openspace |
| IO | Industrial Office | Worker | UCRC | UC Rural Commercial | Worker |
| IRM | Indian reservation/tribal trust | Openspace | UCRI | UC Rural Industrial | Worker |
| LDR | Low-density Res. | RES | VHDR | Very High-density Res. | RES |
| MA | Mineral and Aggregate | Worker | VLDR | Very Low-density Res. | RES |
| MDR | Medium-density Res. | RES | | | |

## 4.4 Risk Evaluation

Using the CAO toxic air contaminant emissions inventory (e.g., AQ405CAO), the 24-hr and annual average concentration files from AERMOD runs, the RBCs with Level 4 adjustments applied, and the land use designations at each receptor, the chronic cancer, chronic non-cancer and acute hazard index risk was found at every receptor. The risk at each receptor from source ($R_{r,s}$) is given by:

$$R_{r,s} = \chi_{r,s}\, C \sum_{p} \frac{E_s TO_{p,o}}{RBC_{p,L(r)}}$$

where $\chi_{r,g}$ is the unit concentration for source $s$ at receptor $r$, C is a constant to convert g/s to either lbs/day or lbs/year, $Q_p$ is the pollutant emission rate from the AQ405CAO form, $TO_{p,o}$ is the target organ factor (0 or 1) for pollutant p and organ o, and $RBC_{p,L(r)}$ is the RBC for pollutant $p$ and land use $L$ at the receptor $r$ (Table 4-4). For non-cancer risk, different pollutants impact different parts of the body so the non-cancer risk is not additive. When applied, the target organ factor is set to 1 for pollutants that impacts a particular organ and zero otherwise. For cancer risk, TO is always 1.

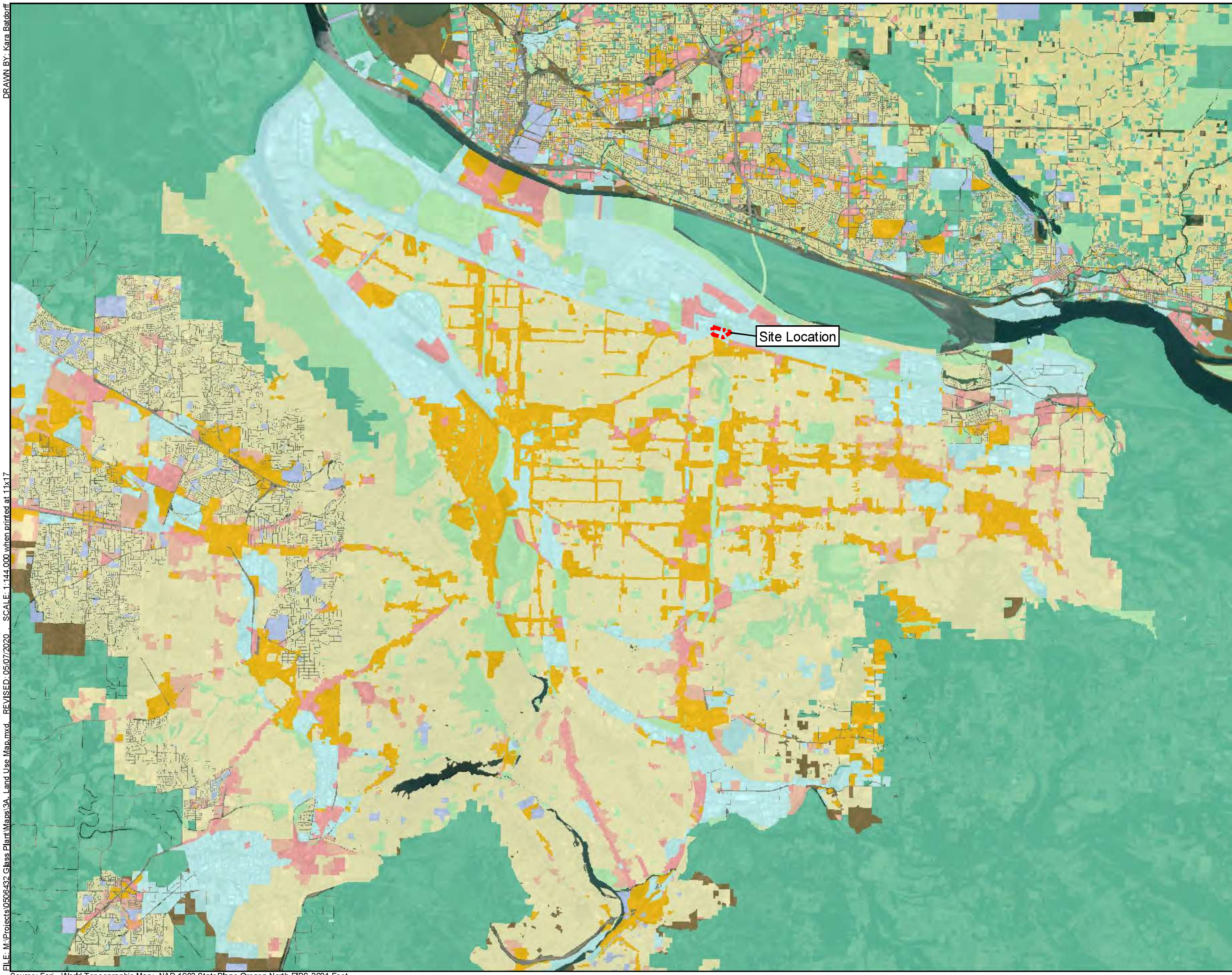
Each receptor will have three risk numbers for each source: chronic cancer risk, chronic non-cancer risk, and acute risk. For informational purposes, the chronic risk values will be grouped by exposure type (residential, non-residential child, and worker) from which the maximum risk will be determined. This results in seven risk levels being determined.

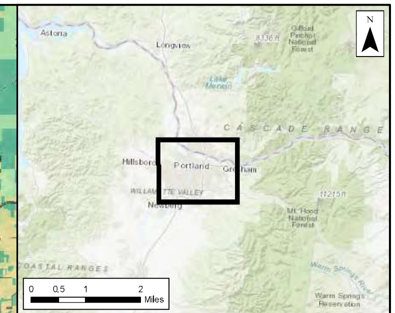
The risk calculations will be made in an Excel spreadsheet. The spreadsheet will have tabs for the RBCs, the target organ assignments, annual and 24-hr emissions, annual and 24-hr unit concentrations, receptors, seven risk evaluations, and a final summary. The spreadsheet will be provided as part of the submittal.

## 4.5 Uncertainty Analysis

CAO rules require that a quantitative or qualitative uncertainty evaluation be included in a Level 4 risk assessment. The uncertainty in the various elements of the analysis will be described.

# Appendix A. Land Use Maps




**Legend**

- Site Location
- Commercial
- Future Urban Development
- Industrial
- Multi Family
- Mixed Use Residential
- Public Facilities
- Parks and Open Spaces
- Rural
- Single Family

Notes:
Zoning data downloaded from Portland Metro RLIS Discovery and Washington Department of Ecology State Land use.

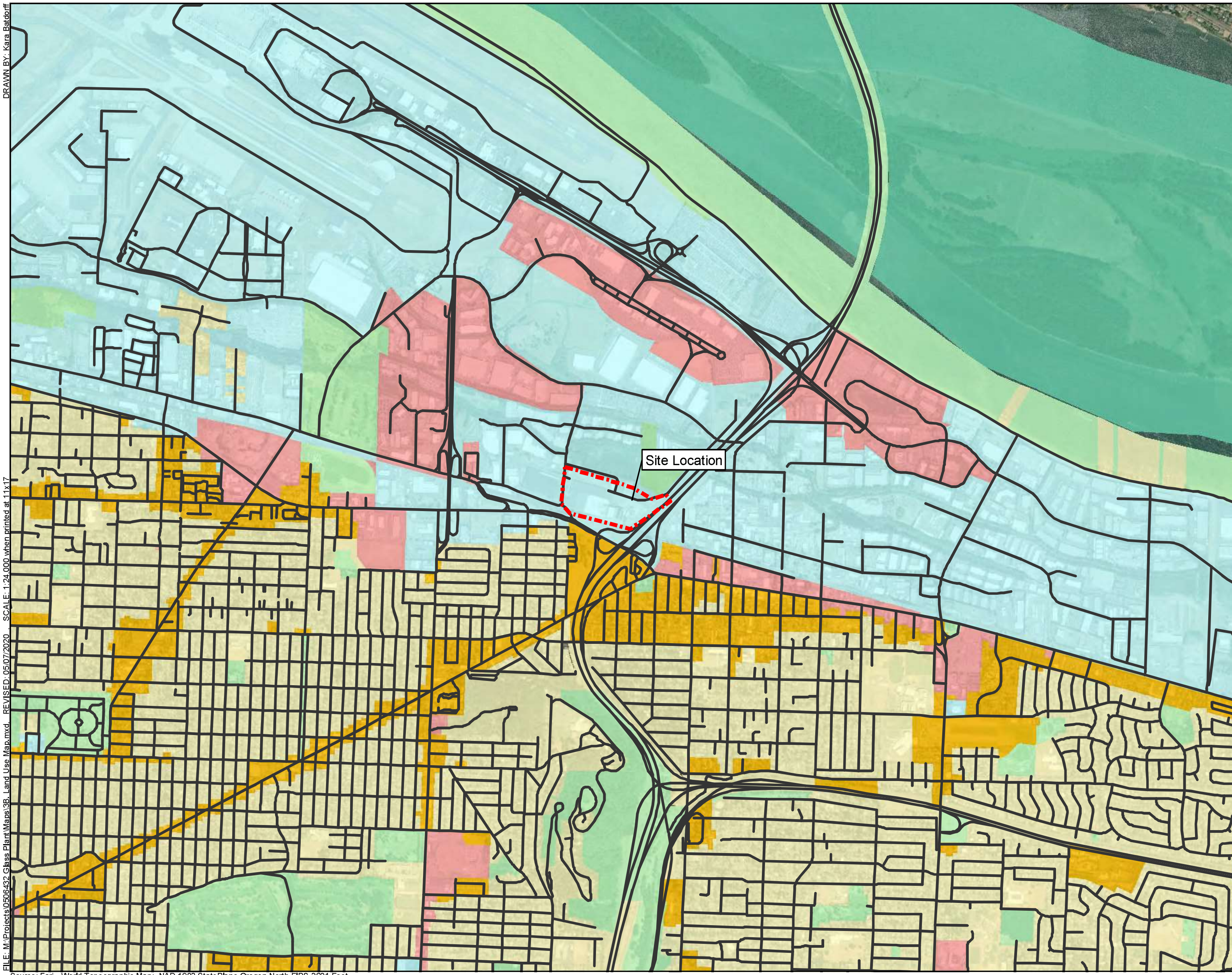
N

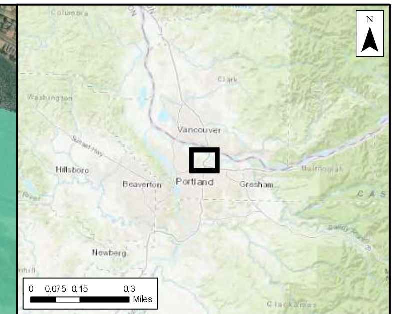
0 2 4
Miles

**Existing Land Use**
**Zoning Classifications**
Owens-Brockway Glass Container Inc
9710 NE Glass Plant Road
Portland, Oregon

Source: Esri - World Topographic Map; NAD 1983 StatePlane Oregon North FIPS 3601 Feet

FILE: M:\Projects\0506432 Glass Plant\Maps\3A. Land Use Map.mxd REVISED: 05/07/2020 SCALE: 1:144,000 when printed at 11x17 DRAWN BY: Kara Batdorff




**Legend**

- Site Location
- Commercial
- Industrial
- Mixed Use Residential
- Parks and Open Spaces
- Rural
- Single Family

Notes:
Zoning data downloaded from Portland Metro RLIS Discovery.

N

0 2,200 4,400
Feet

**Existing Land Use Zoning**
**Classifications in the Immediate Area**
Owens-Brockway Glass Container Inc
9710 NE Glass Plant Road
Portland, Oregon

Source: Esri - World Topographic Map; NAD 1983 StatePlane Oregon North FIPS 3601 Feet

FILE: M:\Projects\0506432 Glass Plant\Maps\38, Land Use Map.mxd REVISED: 05/07/2020 SCALE: 1:24,000 when printed at 11x17

DRAWN BY: Kara Batdorff

# Appendix B. O-B Onsite Height Measurements

STREIMER

740 N Knott St, Portland, OR 97227
T (503) 288-9393 F (503) 288-3327

**DATE:** 12/3/21

**ESTIMATE #:** N/A

**SUBJECT:** Field Measurements
Owens Illinois
Portland Or

**ATTENTION:** David Smith
Owens Illinois

In response to your request, the below contains field measurements taken at Owens Illinois from the 30" round exhaust stack to the top of the gravity roof vent opening. Results are that the 30" exhaust stack is terminated 5'-4 ¼" above the elevation of the top of gravity vent and is 27'-4" to the east of the vent opening.

**Stack Elevation above Vent:**
Accessed the vent using 180' boom lift and placed a Dewalt DW0825LG self-leveling laser to the side of the vent. Positioned the laser beam to hit the upper guide wire flange on the stack so I could than use it as a good reference when measuring to the top of stack. Once positioned I measured up to the top of the vent from this location and it was 3'-11" to top of vent. (See Photo 1) Went over to the stack, confirmed laser was still hitting the upper guide wire flange (See Photo 2) and measured down from the top of the stack using Standard 30' tape measure and it measured 9'-3 ¼" above. (See Photo 3) Using 9'-3 ¼" top of 30" stack and subtracting 3'-11" to top of vent that places the 30" exhaust stack at 5'-4 ¼" above the top of vent opening.

**Elevation to Ground:**
Relocated Dewalt DWO825LG self-leveling laser to the top elevation of the vent and shot laser to the north. Positioned lift to the exterior plane of the building and made a reference mark on the boom. Then using a Dewalt DW03101 laser distance measurer to shoot distance to ground. Repeated this 4x to the same point on the ground confirming each measurement was +/- 1/4" of each other to validate the dimension. Top of vent to ground elevation was 95'-6". (See Photo 4) Using measurements taken above the stack is at 100'-10.25" above ground elevation. (See Photo 6)

**Stack Distance East of the Vent:**
Using 180' boom lift to access stack at top of vent elevation I used a Dewalt DWO3101 laser distance measurer and shot from the west edge of 30" stack perpendicular to the vent opening getting a measurement of 27'-4". (See Photo 5) Repeated this 4x to validate the distance all within +/- 1/4" of each other

***The accuracy of the DW03101 unit is +/- 1/32 in or 1mm and the operating range is approximately 330 feet***

***Accuracy of DWO825LG is 1/8 Inch at 30 Feet (longest distance shot was roughly 33'-38'***

## Photos


Looking back from
exhaust stack at
DW0825LG @ 3'-11"
below Gravity Vent
opening

**Photos**

Laser Beam
Highlighted for
clarity

**Photos**

**Gravity Vent to Ground 95’-6”**

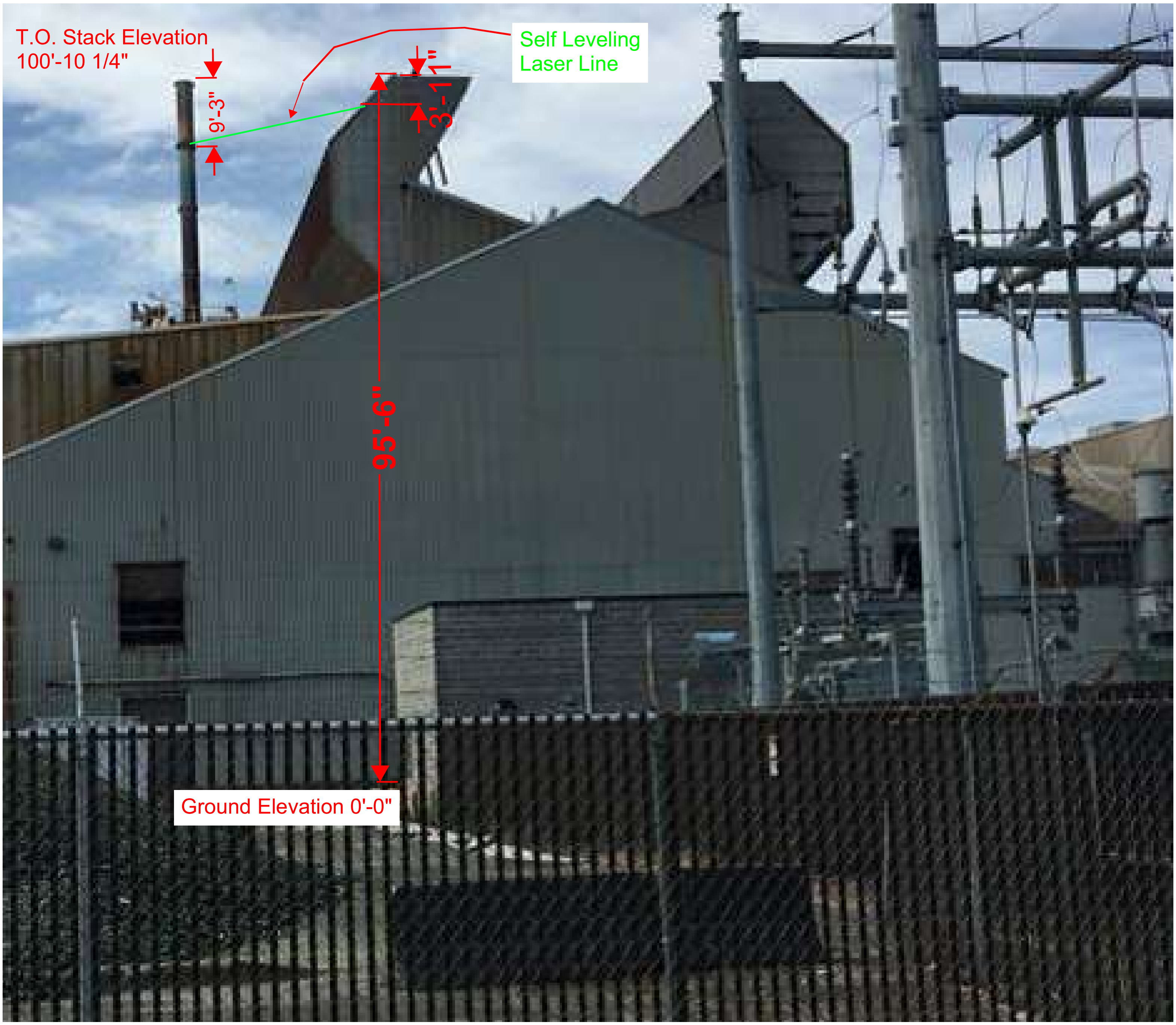
**Stack Distance East of the Vent**

**Stack Elevation above Vent and Final Elevations above ground elevation**

**Stack above Vent 9’-3 ¼”-3’-11”= 5’-4 ¼”**

**Gravity Vent to Ground 95’-6”**

**Stack to ground 95’-6”+5’-4 ¼”= 100’-10 ¼”**



# Appendix C. Tox Strategies Memo: Evaluation of Bioavailability, Soil Ingestion, and Homegrown Produce Consumption for Owens-Brockway Glass in Portland, Oregon

Tox Strategies

Innovative solutions
Sound science

# Memorandum

September 17, 2021

| | |
|---|---|
| To: | Kent Norville and John Browning, Bridgewater Group |
| From: | Deborah Proctor and Ann Verwiel |
| Subject: | Evaluation of Bioavailability, Homegrown Produce Consumption, and Incidental Soil Ingestion Rates for Owens-Brockway Glass in Portland, Oregon |

ToxStrategies has prepared this evaluation of oral bioavailability, the homegrown produce exposure pathway, and the incidental soil ingestion pathway for the Owens-Brockway Glass facility at 9710 NE Glass Plant Road in Portland, Oregon. Herein, we propose alternatives to default assumptions for these factors to be included in a Level 4 risk analysis of air emissions. In support of this effort, we reviewed the public health assessments (PHAs) for Bullseye Glass Co. (manufacturing site) (2021) and Uroboros Glass Manufacturing Site (2019), both in Portland, Oregon. Both PHAs were performed by the Oregon Health Authority (OHA), and our review assessed the potential for exposure to arsenic from emissions related to glass manufacturing.[1] While the results of the PHAs are specific to conditions at Bullseye Glass and Uroboros Glass, the use of site-specific oral bioaccessibility for arsenic in soil and the approach to the homegrown produce exposure pathway are also relevant to emissions from other glass manufacturing sources, particularly in the Portland area, including Owens-Brockway Glass. We also considered alternatives to the upper-bound soil ingestion rates used by the California Office of Environmental Health Hazard Assessment (OEHHA) in its guidance for air toxics risk assessment, and we recommend using the ingestion rates used by OHA for the PHAs.

The authors of this memorandum each have been practicing in the field of human health risk assessment for more than 20 years and have performed numerous air toxics risk assessments. Ms. Verwiel and Ms. Proctor have both conducted multiple air toxic hot spot risk assessments for facilities in California and specifically with the South Coast Air Quality Management District (SCAQMD). The multi-pathway (MP) exposure factors that are used by Cleaner Air Oregon are based on the AB2588 air toxics program in California

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[1] Oregon Health Authority, Public Health Division, 2021, Public Health Assessment, Initial and Public Comment Release. Bullseye Glass Company. 3722 SE 21st Avenue, Portland, OR. 97202.

as implemented by SCAQMD. Ms. Verwiel and Ms. Proctor have also conducted relative bioavailability and bioaccessibility studies for metals in environmental media. Their resumes are included as Attachment A.

## Oral Bioavailability of Arsenic in Soil

The Cleaner Air Oregon rule specifically allows relative bioavailability (RBA) measures to be included for Level 4 risk assessments. Arsenic is a multi-pathway chemical in the Cleaner Air Oregon regulations—meaning that cancer and non-cancer risk is assessed by both oral and inhalation exposure pathways, and the contribution of increased exposure is significant from the ingestion pathway for arsenic in the Cleaner Air Oregon Level 1 risk assessment. Therefore, we recommend including an RBA estimate for the oral pathway in the Level 4 risk assessment for Owens-Brockway Glass as an important, and specifically allowed, refinement. In risk assessments and embedded in the multi-pathway (MP) factor for Level 1 risks assessments in Oregon, the default assumption for oral RBA is 100%, unless chemical-specific information indicates that it should be lower for a Level 4 risk assessment.

For arsenic, U.S. EPA has recommended a default RBA of 60%[2] for use in risk assessments, which is the 95$^{th}$ percentile of 103 RBA estimates from Agency-reviewed and vetted animal bioassays. U.S. EPA has also developed sufficient data to calculate RBA from *in vitro* bioaccessibility (IVBA) measures to quantify the relationship of IVBA to RBA from *in vivo* animal studies.[3] Therefore, measurements of IVBA can be used to predict RBA for arsenic.

In the PHA for Bullseye Glass, a site-specific oral RBA of 22% for arsenic was used, based on samples collected by Oregon Department of Environmental Quality (DEQ) and analyzed by U.S. EPA Region 10. Although no specific details are provided in the PHA regarding the number of samples, sample collection methods, or sample analysis methods, it is expected that the RBA values were derived using IVBA measures. However, because the samples were from soil in the vicinity of a glass factory, the source of arsenic in soil would be very similar to conditions in neighborhoods surrounding Owens-Brockway Glass.

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[2] United States Environmental Protection Agency (U.S. EPA). 2012. Recommendations for Default Value for Relative Bioavailability of Arsenic in Soil. December. Compilation and Review of Data on Relative Bioavailability of Arsenic in Soil (epa.gov)

[3] U.S. EPA, 2017. Release of Standard Operating Procedure for an In Vitro Bioaccessibility Assay for Lead and Arsenic in Soil. STANDARD OPERATING PROCEDURE (corrected) FOR IN VITRO BIOACCESSIBILITY FOR LEAD AND ARSENIC IN SOIL (WITH MAY 5, 2017, TRANSMITTAL MEMO ATTACHED) (epa.gov)

An additional arsenic RBA study was identified for a glass manufacturing site, the Ottawa Township Flat Glass in Ottawa Township, Illinois (2006).[4] This work was performed by Dr. Stan Casteel at the University of Missouri, who also conducted much of the RBA research used by U.S. EPA in 2012 to develop its position on the RBA for arsenic. Although the Ottawa Township RBAs were not specifically reviewed in the 2012 EPA guidance, the RBA estimates were calculated using the Repeated Dose Steady-State Urinary Excretion Fraction Method, which is approved as a "Key Study Method" in the EPA 2012 guidance.[2]

For the Ottawa Township Flat Glass facility, two test materials—on-site soil and residential soil—were studied. The RBA for the residential soil sample was 26% (90%CI: 0.24–0.28), and the concentration of arsenic in the residential test soil was 4,201 mg/kg. The RBA from the on-site soil sample was 48% (90%CI: 0.45–0.51), and the concentration of arsenic in the on-site soil was 4,345 mg/kg. The on-site soil sample was from affected areas near settling ponds,[5] and the RBA for residential soil is considered more informative regarding the RBA of arsenic in residential soil near Owens-Brockway Glass, which is for arsenic deposited from airborne emissions, rather than from settling ponds.

In consideration of the supporting RBA data from the Ottawa Township Plate Glass site and in lieu of current IVBA data for Owns-Brockway Glass specifically, it is reasonable to assume that the oral RBA of arsenic associated with emissions from Owens-Brockway would be similar to that for Bullseye Glass (22%). For this reason, we recommend using the 22% oral RBA developed for Bullseye Glass in the Level 4 risk assessment for Owens-Brockway Glass, to be consistent with the approach used by OHA in the 2021 PHA for Bullseye Glass. Both glass manufacturing plants are geographically close in Portland, and the Bullseye Glass RBA estimate is based on current data and analytical methods.

## Exposure via Ingestion of Homegrown Produce

The default screening MP factor for arsenic noncancer effects in the Cleaner Air Oregon regulations is 88 and includes a contribution from potential ingestion of homegrown produce grown in soil affected by deposition from glass manufacturing emissions. As part of the Level 4 risk assessment, modifications may be proposed for "multipathway considerations for persistent, and bioaccumulative and toxic chemicals."[6] In this case, we

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4 Casteel, et al. 2006. Final Relative Bioavailability of arsenic in soils from the Ottawa Township Flat Glass Site, Ottawa Township, Illinois. Baseline Human Health Risk Assessment, OU-1, Residential Soils. Appendix F. Available at: Records Collections | US Environmental Protection Agency (epa.gov)

5 Hull & Associates. 2005. Workplan for the Soil Bioavailability Study. In Support of the Baseline Human Health Risk Assessment for the Ottawa Township Flat Glass Site, La Salle County, Illinois. CERCLIS ID# 950 996 219. Available at: Records Collections | US Environmental Protection Agency (epa.gov)

6 Oregon Department of Environmental Quality, Chapter 340, Division 245, Cleaner Air Oregon (340-245-0210 (2)(f)(C).

propose to eliminate the homegrown produce ingestion pathway using the rationale provided in the PHA for Bullseye Glass[7] and in the PHA for Uroboros Glass[8] for excluding the homegrown produce ingestion pathway that is also applicable to conditions at Owens-Brockway Glass.

The Bullseye Glass PHA concluded that "consumption of homegrown produce harvested around Bullseye Glass was unlikely to harm people's health," and a quantitative assessment of potential exposure from plant ingestion was not performed. The PHA conclusion was based on the following assumptions:

- "Most garden produce does not absorb metals well, such as arsenic."
- "[Use of] common gardening practices such as adding compost, mulch, and other nutrients to the soil reduces the uptake of heavy metals into plants."
- "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."

The same rationale was provided for excluding the homegrown produce exposure pathway in the Uroboros Glass PHA. Owens-Brockway Glass is similar to these glass plants because metals, specifically arsenic, are the primary contributors to risk. Both PHAs indicate that arsenic is not absorbed well by most garden produce. Also, there is no reason to expect gardening practices in one part of Portland to vary significantly from gardening practices in other parts of Portland, so common gardening practices such as adding compost and mulch would be similar and would similarly reduce the concentration of arsenic potentially in plants.

Finally, the modeling effort for Owens-Brockway Glass conducted for the Level 4 risk assessment predicted an additional arsenic concentration of 0.474 mg/kg in surface soil at the nearest residence. Lower concentrations (0.031 mg/kg) were predicted for agricultural uses where tilling and digging were assumed to occur. As a point of comparison, Oregon Department of Environmental Quality compiled a statewide database for naturally occurring metals in soil and calculated background metals concentrations by region. The 95% upper prediction limit (UPL) for arsenic in soil in the Portland Basin is 8.8 mg/kg.[9] Concentrations predicted from the model, which are used for the Level 4 risk assessment, are almost 20 times lower than the regional background concentration in soil, and therefore, background concentrations in soil are unlikely to be measurably affected by the model-

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7 Environmental Health Assessment Program. Oregon Health Authority, Public Health Division. 2021. Public Health Assessment, Initial Public Release, Bullseye Glass Co. (manufacturing site).

8 Environmental Health Assessment Program, Oregon Health Authority, Public Health Division. 2019, Public Health Assessment, Final Release, Uroboros Glass Manufacturing Site. May 31.

9 Oregon Department of Environmental Quality, 2018, Background Levels of Metals in Soils for Cleanups. https://www.oregon.gov/deq/FilterDocs/cu-bkgrmetals.pdf.

predicted emissions from the Owens-Brockway Glass facility. Based on these findings, it is appropriate to exclude the plant uptake/ingestion pathway from the Owens-Brockway Level 4 risk assessment, consistent with its exclusion in recent PHAs for other glass plants in Portland.

However, if the pathway is included, more reasonable assumptions should be used for ingestion rates and percent contribution of homegrown produce to individual diets. The MP factor used for the screening assessment is based on high-end estimates of produce ingestion for four plant categories: root, leafy, protected, and exposed.[10] For a Level 4 risk assessment, a more realistic estimate of produce ingestion should be considered so as not to overestimate cumulative exposure across multiple pathways. The OEHHA[11] guidance, which is the basis for the default screening MP factor for risk assessments other than Level 4, recommends average and high-end ingestion rates for residents from 16 to 70 years old (Table 1).

**Table 1. Mean and high-end produce ingestion rates for adults used in the multi-pathway factor[12]**

| Type of Produce | OEHHA Ingestion Rates (16 to 70 years) (g/kg-day) | | OEHHA Body Weight Adjusted Ingestion Rates (16 to 70 years) (g/day)[1] | |
|---|---|---|---|---|
| | Mean | High-end | Mean | High-end |
| Exposed | 1.8 | 5.6 | 126 | 392 |
| Leafy | 1.1 | 3.4 | 77 | 238 |
| Protected | 1.6 | 5.2 | 112 | 364 |
| Root | 1.5 | 4.2 | 105 | 294 |
| Total | 6.0 | 18.4 | 420 | 1,288 |

**Note:**
[1] Assumes 70-kilogram adult

**Abbreviations:**
g/kg-day — gram per kilogram-day
g/day — gram per day

[10] Office of Environmental Health Hazard Assessment, 2015, Air Toxics Hot Spots Program, Risk Assessment Guidelines, Guidance Manual for Preparation of Health Risk Assessments, February.

[11] Ibid, Table 5.15.

[12] Ibid, Table 5.15

Total fruit and vegetable ingestion of 1,288 g/day of produce for adults is equivalent to almost 3 pounds of produce per day, every day of the year, compared to 1 pound of produce per day based on the mean ingestion rates. So, if this pathway is included, we recommend using mean ingestion rates in this Level 4 risk assessment, so as not to grossly overestimate cumulative exposure with upper-bound estimates, particularly considering that the exposure pathway was considered incomplete in previous PHAs for glass manufacturers in Portland. The proposed mean ingestion rates by age group are presented in Table 2.

**Table 2. Recommended mean produce ingestion rates[13]**

| Produce Type | Third Trimester[1] | 0 to <2 | 2 to <16 | 16 to 70 |
|---|---|---|---|---|
| Exposed | 1.9 | 11.7 | 1.9 | 1.8 |
| Leafy | 0.9 | 3.8 | 0.9 | 1.1 |
| Protected | 1.7 | 5.9 | 1.7 | 1.6 |
| Root | 1.7 | 5.7 | 1.7 | 1.5 |

**Notes:**

[1] Food consumption for the third trimester assumes that the in-utero exposure is the same as the mother's, relative to the body weight of the fetus.

**Abbreviations:**

g/kg-day — gram per kilogram-day

g/day — gram per day

A secondary variable in the produce ingestion pathway is the percentage of homegrown produce ingested relative to total produce ingested, which is 13.7% in the OEHHA guidelines used to develop the MP factor.[14] This factor assumes that daily year-round ingestion of fruits and vegetables from a home garden would be approximately 57 grams (0.13 pound) for OEHHA's mean ingestion rate and 176 grams (0.39 pounds) for OEHHA's high-end ingestion rate. The percentage of homegrown fruits and vegetables in OEHHA's guidance (13.7%) is based on a national survey that includes rural non-metropolitan areas, which have the highest percentages of homegrown produce ingestion of all areas surveyed across the U.S. The survey also found higher rates of homegrown produce consumption in the South and Midwest relative to the West and Northeast. Therefore, the percentage across the entire United States is likely to overestimate the

[13] Ibid, Table 5.15

[14] Ibid.

fraction of homegrown fruits and vegetables consumed by residents near Owens-Brockway Glass.

The Owens-Brockway facility is located in an area of Portland, which is less likely to support a high-yield home garden compared to a rural non-metropolitan area. According to EPA's Exposure Factors Handbook,[15] City Center is defined as cities with populations of 50,000 or more within the metropolitan statistical area (MSA) and legal boundaries of a city, which specifically describes the location of the Owens-Brockway Glass facility, because it is within the MSA of Portland and within the legal boundaries of the city of Portland. Thus, survey data collected in the residential area around Owen-Brockway Glass would be categorized as being from a City Center population. For City Center populations, the fraction of consumed fruits and vegetables that consists of homegrown produce is 2.7%.[16] Also, the fraction of consumed fruits and vegetables that are homegrown, for populations (regardless of area type) in the "West" is 5.95%. Oregon is in the geographic region of "West" in the food consumption survey.[17] Because the West is a broad geographic area, and the Owens-Brockway facility is located in an area that is categorized as City Center using the definitions of the survey, we recommend using the percentage of homegrown produce that is relevant to a City Center (2.7%) for this Level 4 risk assessment.

## Exposure via Incidental Ingestion of Soil

Similar to the produce ingestion pathway, the OEHHA guidance used for the MP factor provides an option for 95$^{th}$ percentile and mean incidental ingestion rates. Use of a 95$^{th}$ percentile incidental ingestion rate, along with inhalation, dermal contact, and produce ingestion pathways, will create an unrealistic estimate of upper-bound cumulative exposure. In Table 3, we compared OEHHA ingestion rates with those used in the PHA for Bullseye Glass. The PHA did not include third-trimester soil ingestion exposure based on the mother's exposure, so that comparison is not included. Table 3 presents the mean and 95$^{th}$ percentile incidental ingestion rates from the OEHHA guidance (mg/kg-day) and the incidental ingestion rates used in the PHA (mg/day). To make a comparison, body weights from OEHHA guidance[18] were used to convert the PHA ingestion rates into common units (mg/kg-day). As shown in Table 3, except for the 0- to 2-year-old age

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[15] United States Environmental Protection Agency (U.S. EPA). 2011. Exposure Factors Handbook. Chapter 13. Table 13-68.

[16] EPA also provides the percentage of homegrown fruit and vegetable consumption for suburban areas, which is 5.3%. Suburban is defined as an area that is generally within the boundaries of an MSA but is not within the legal limits of the central city.

[17] The "West" includes Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

[18] Office of Environmental Health Hazard Assessment, 2012, Air Toxics Hot Spots Program, Risk Assessment Guidelines, Technical Support Document for Exposure Assessment and Stochastic Analysis, August. Table 10.1.

bracket, which is a small fraction of total exposure (where the PHA values are lower than the mean), the PHA ingestion rates fall between the mean and 95th percentile values from OEHHA. For this reason, and to be consistent with other glass manufacturing risk assessments, we recommend using the weight-adjusted soil ingestion rates from the PHA for the Level 4 risk assessment. For the third trimester, we recommend using the mean values from the OEHHA guidance. Table 4 summarizes the recommended incidental soil ingestion rates for the Level 4 risk assessment.

**Table 3. Comparison of OEHHA and OHA values for incidental soil ingestion rates**

| Age Group | OEHHA Ingestion Rates [1] (mg/kg-day) | | OEHHA Body Weights [2] (kg) | PHA Ingestion Rate [3] (mg/day) | PHA Ingestion Rate [4] (mg/kg-day) |
|---|---|---|---|---|---|
| | Mean | 95th Percentile | | | |
| 3rd Trimester | 0.7 | 3 | -- | -- | -- |
| 0 to <2 | 20 | 40 | 9.7 | 150 | 15 |
| 2 to <16 | 3 | 10 | 37 | 200 | 5.4 |
| 16 to 70 | 0.6 | 3 | 80 | 109 | 1.4 |

**Notes:**

1. Office of Environmental Health Hazard Assessment, 2015, Air Toxics Hot Spots Program, Risk Assessment Guidelines, Guidance Manual for Preparation of Health Risk Assessments, February. Table 5.14.

2. Office of Environmental Health Hazard Assessment, 2012, Air Toxics Hot Spots Program, Risk Assessment Guidelines, Technical Support Document for Exposure Assessment and Stochastic Analysis, August. Table 10.1.

3. Oregon Health Authority, Public Health Division, 2021, Public Health Assessment Initial and Public Comment Release. Bullseye Glass Company. 3722 SE 21st Avenue, Portland, OR. 97202. Table I-3.

Time-weighted average ingestion rates were calculated for 0 to 2 years (using birth to 1 year and 1 to <2 years).

Time-weighted average ingestion rates were calculated for 16 to 70 years (using 16 to <21 and 21 to 70 years).

4. OHA Ingestion Rate (mg/day) / OEHHA Body Weight (kg) = OHA Ingestion Rate (mg/kg-day)

Green shading indicates values from the Oregon Health Authority (OHA).

Blue shading indicates values from the Office of Environmental Health Hazard Assessment (OEHHA).

**Abbreviations:**

mg — milligrams

kg — kilograms

**Table 4. Recommended incidental soil ingestion rates (mg/kg-day)**

| Produce Type | Third Trimester[1] | 0 to <2 | 2 to <16 | 16 to 70 |
|---|---|---|---|---|
| Incidental Soil Ingestion Rate | 0.7 | 15 | 5.4 | 1.4 |

## Conclusions

For the Level 4 risk assessment, we recommend using the following values:

- Oral RBA of 22%
- OEHHA's mean ingestion rates for produce by age group (Table 2)
- 2.7% of produce consumption is from a home garden
- Weight-adjusted ingestion rates by age group from PHA for ages 0 to 70, and the mean ingestion rate from OEHHA for the third trimester (Table 4).

## ATTACHMENT A

# Resumes

# Deborah Proctor

MANAGING PRINCIPAL SCIENTIST

## CONTACT INFORMATION

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## PROFESSIONAL PROFILE

Ms. Deborah Proctor has more than 25 years of experience in environmental and occupational health risk assessment, specializing in applied toxicology, mode-of-action evaluations for chemical carcinogens, environmental chemistry, human health risk assessment, exposure reconstruction, and quantitative dose-response analysis for the purpose of developing toxicity criteria.

Ms. Proctor has technical expertise for assessing the potential human health risk associated with contaminated air, soil, sediments, groundwater, biota, and consumer products; evaluating failure-to-warn litigation claims pursuant to California Proposition 65, including determination of Safe Harbor Levels; designing risk-based site investigations; assessing the environmental fate and toxicity of metals in the environment; determining the bioavailability of metals in soil and solid media; and risk/hazard communications. Ms. Proctor uses state-of-the-art scientific approaches to evaluate potential hazards and develop health-protective and science-driven remediation goals. She provides technical comments to regulatory agencies on policy and guidance documents, and technical support for public communication. Ms. Proctor has designed studies involving human volunteers and is experienced with the use of Internal Review Boards (IRBs) and the ethical requirements and considerations associated with research involving humans.

Ms. Proctor is a nationally recognized expert regarding the potential health risks associated with occupational and environmental exposure to chromium. She has published extensively in this field and managed research projects that have been used to develop federal and state regulatory health criteria.

Ms. Proctor specializes in environmental risk assessment for metals and inorganic chemicals, and has specific experience modeling exposure to perchlorate in produce, milk, human breast milk, food, and drinking water, and assessing the risk of sensitization and chronic beryllium disease associated with occupational beryllium exposure.

Ms. Proctor's research has been applied to support regulatory decisions and inform health-based criteria. Specific examples include the USEPA Inhalation Reference Concentration for hexavalent chromium using Malsh et al. (1994), the OSHA risk assessment for the 2006 Hexavalent Chromium Rule and revised Permissible Exposure Limit using Luippold et al. (2003); Crump et al. (2003), and Proctor et al. (2003; 2004), USEPA Office of Prevention, Pesticides and Toxic Substances 2008 Reregistration Eligibility Decision (RED) for Chromated Arsenicals using Technical Study Reports FPRL #012506 and FPRL #012406; and the New Jersey Department of Environmental Protection Soil Cleanup Criteria for dermal contact with hexavalent chromium using Fowler et al. (1999). She recently published an adverse outcome pathway (AOP) analysis for rodent forestomach tumors by nongenotoxic initiating events (Proctor et al., 2018).

## ACADEMIC CREDENTIALS

B.S., Environmental Toxicology, University of California, Davis, 1988
Graduate Studies, Epidemiology, University of Pittsburgh, 1996–1998

## PROFESSIONAL AFFILIATIONS

Society for Risk Analysis (member)

Association for Environmental Health Sciences (Scientific Review Board member)

International Society of Exposure Assessment (member)

Society of Toxicology (Councilor, Risk Assessment Specialty Section)

## PUBLICATION AND PRESENTATION AWARDS

**Society of Toxicology (SOT) 2014**
Awarded top 10 Risk Assessment Presentations at the Society of Toxicology conference (Proctor DM, Suh M, Tachovsky JA, Abraham L, Hixon JG, Brorby GP, Campleman SL) by the RASS.

**SOT 2013**
Awarded for Three of the Top Ten Risk Assessment Presentations at the Society of Toxicology conference (Kirman et al., Thompson et al., Kopec et al.) by the RASS.

**SOT 2012**
Awarded top nine published papers Advancing the Science of Risk Assessment by the Risk Assessment Specialty Section (Thompson CM, Haws LC, Harris MA, Gatto NM, Proctor DM) by the RASS.

**SOT 2004**
Awarded top five Risk Assessment Presentations at the Society of Toxicology conference (Leung H, Madl A, Proctor D, Hays S, Cohen E) by the RASS, Baltimore MD.

**SOT 2002**
Awarded top five Risk Assessment Presentations at the Society of Toxicology conference (Crump K and Proctor D) by the Risk Assessment Specialty Section (RASS), Nashville, TN.

## MANUSCRIPTS

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## BOOK CHAPTERS

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## CONFERENCE SYMPOSIA SESSION CHAIR

**2018 ASSOCIATION OF ENVIRONMENTAL HEALTH SCIENCES:** Session 5b: The Evolving Risk Assessment Landscape in California.

**2017 AMERICAN INDUSTRIAL HYGIENE ASSOCIATION CONFERENCE**: Challenges in Protecting Worker Health and Achieving Compliance in the World of Low Submicrogram Concentrations: A Case Study of Beryllium.

**2016 SOCIETY OF TOXCIOLOGY:** The Cancer Risk Assessment for Ingested Hexavalent Chromium: Challenges and Controversies

**2015 SOCIETY OF TOXICOLOGY:** Advanced Approaches for Quantitative Risk Assessment Using Human Data with Applications Across Disciplines

**2014 TOXICOLOGY AND RISK ASSESSMENT:** Using New Data and Methods to Improve the Risk Assessment of Environmental Perchlorate Exposure

**2011 SOCIETY OF TOXICOLOGY:** Using Mode of Action Data to Guide Quantitative Cancer Risk Assessment: A Case Study of Hexavalent Chromium in Drinking Water

**2003 SOCIETY OF TOXICOLOGY:** Health Risk Assessment of Hexavalent Chromium in Drinking Water: Carcinogenicity, Research and Regulation.

**1996 ASSOCIATION FOR THE ENVIROMENTAL HEALTH OF SOIL:** Chromium in Soil: Perspectives in Chemistry, Health and Environmental Regulation.

## ABSTRACTS AND PRESENTATIONS

**Suh M**, Verwiel A, Proctor D. Oral and inhalation bioaccessibility of cobalt and nickel in metal alloys: A critical consideration for site-specific human health risk assessments and read across. Poster for Society of Toxicology, Virtual Annual Meeting, 2020, https://eventpilotadmin.com/web/page.php?page=Session&project=SOT20&id=P3190.

**Proctor D**. Use of the latest science in cancer risk assessment for hexavalent chromium: Is it time to step away from the default regulatory approaches? Invited presentation to the International Union of Toxicology (IUTOX) / International Congress of Toxicology (ICT) meeting, Honolulu, HI, June 17, 2019.

Ring CL, Suh M, Casteel S, Dunsmore M, Verwiel A, **Proctor D**. Relative oral bioavailability of cobalt and nickel in residential soil and dust affected by metal grinding operations. Presented at Joint Annual Meeting of International Society of Exposure Science and International Society for Environmental Epidemiology (ISES-ISEE 2018), Ottawa, Canada, August 2018.

Suh M, Wikoff D, Harvey S, Mittal L, Lipworth L, Goodman M, Goodmanson A, Ring C, Rohr A, **Proctor D**. Hexavalent chromium and stomach cancer: A systematic review and meta-analysis. Presented at Joint Annual Meeting of International Society of Exposure Science and International Society for Environmental Epidemiology (ISES-ISEE 2018), Ottawa, Canada, August 2018.

**Proctor, DM.** Hexavalent chromium in drinking water: When is the science sufficient to deviate from defaults? Invited Speaker, Genetic and Environmental Toxicology Association (GETA). Thresholds in Toxicology and Risk Assessment Fall Symposium. Oakland, CA, November 14, 2018.

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Thompson CM, Suh M, **Proctor DM**, Harris MA. Ten factors for considering the mode of action of Cr(VI)-induced intestinal tumors in rodents. Society of Toxicology Annual Meeting, San Antonio, TX, March 11-15.

Thompson CM, Wolf JC, Suh M, **Proctor DM**, HJaws LC, Harris MA. Toxicity and recovery in the duodenum of B6C3F1mice following treatment with intestinal carcinogens; captan, folpet, and hexavalent chromium: Evidence for an adverse outcome pathway. Society of Toxicology Annual Meeting, San Antonio, TX, March 11-15.

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**Proctor DM**, Suh M, Dunsmore D, Verwiel A, Casteel S. Bioaccessibility and relative oral bioavailability of cobalt and nickel from metal alloys in soil and dust. Poster presented at Society of Toxicology Annual Meeting. March 15, 2017. Baltimore, MD.

Kirman CR, **Proctor D**, Suh M, Haws L, Harris M, Thompson C, Hays S. Using physiologically-based pharmacokinetic modeling to address potentially sensitive subpopulations exposure to hexavalent chromium. Poster presented at Society of Toxicology Annual Meeting. March 15, 2017. Baltimore, MD.

Thompson C, Kirman C, Suh M, **Proctor D**, Haws L, Harris M, Hays S. Risk assessment of oral exposure to Cr(VI): Integration of mode of action, pharmacokinetics, and dose-response modeling. Poster presented at Society of Toxicology Annual Meeting. March 14, 2017. Baltimore, MD.

Suh M, Harvey S, Wikoff D, Mittal L, Ring C, Goodmanson A, **Proctor D**. Meta-analysis of hexavalent chromium and stomach cancer. Poster presented at Society of Toxicology Annual Meeting. March 13, 2017. Baltimore, MD.

Verwiel A, **Proctor D**, Tachovsky A. Principal component analysis of metals in soil and dust to distinguish background and anthropogenic sources in an urban area. Association for Environmental Health and Sciences Foundation Annual Meeting. San Diego, CA. March 14, 2016.

Verwiel A, **Proctor DM**. Oral bioaccessibility of nickel and cobalt from metal alloy emissions in soil and dust. Society for Risk Analysis Annual Meeting. Arlington, VA, December 7, 2015.

**Proctor, DM**. Overview of hexavalent chromium mode of action (MOA) and implications for determining safe drinking water concentrations. Naturally occurring compounds of regulatory concern. Groundwater Resources Association Symposium. Garden Grove, CA, November 18, 2015.

Brorby G, Suh M, Bichteler A, **Proctor D**. Use of cluster analysis and homogeneity testing to characterize distributions of exposures among beryllium workers: Tools for developing occupational exposure limits from quantitative risk assessment. 2015 International Society For Exposure Science Annual Meeting. Henderson, NV, October 22, 2015.

Kirman CR, **Proctor DM**, Suh M, Hays S. Reduction of hexavalent chromium by gastric fluids from fed and fasted individuals with applications to toxicokinetic modeling. Presented at the Society of Toxicology's 54th Annual Meeting. San Diego, CA, March 22-26, 2015.

Suh M, Mittal L, Hirsch S, Valdes R, Bartlett C, Rohr A, **Proctor D**. Lung cancer risk in chromate production workers exposed to hexavalent chromium. Presented at the Society of Toxicology's 54th Annual Meeting. San Diego, CA, March 22-26, 2015.

**Proctor D**, Suh M, Thompson C, Hixon G. Inhalation Cancer Risk Assessment of Titanium Dioxide. Presented at the Society of Toxicology's 54th Annual Meeting. San Diego, CA, March 22-26, 2015.

Harris MA, Thompson CM, **Proctor DM**, Suh M, Wolf JC, Seiter JM, Chappell MA, Haws LC. Analysis of Duodenal Crypt Health following Exposure to Cr(VI) in Drinking Water. Presented at the Society of Toxicology's 54th Annual Meeting. San Diego, CA, March 22-26, 2015.

Thompson CM, Young RR, Suh M, Dinesdurage H, Elbekai R, Harris, MA, Rohr AC, **Proctor DM**. Hexavalent Chromium Does Not Induce Mutations in the Oral Mucosa of Transgenic Big Blue® Rats following Drinking Water Exposures at a Carcinogenic Dose. Presented at the Society of Toxicology's 54th Annual Meeting. San Diego, CA, March 22-26, 2015.

Crump KS, Suh M, Bichteler A, Brorby GP, Hixon JG, and **Proctor DM**. Chronic Beryllium Disease Risk Assessment for Occupational Beryllium Exposure. Presented at the Society of Toxicology's 53rd Annual Meeting. Phoenix, AZ, March 23-27, 2014.

**Proctor DM**, Suh M, Tachovsky JA, Abraham L, Hixon JG, Brorby GP, Campleman SL. Cumulative Risk Assessment of Urban Air Toxics: A Pilot Study in San Antonio, TX. Presented at the Society of Toxicology's 53rd Annual Meeting. Phoenix, AZ, March 23-27, 2014.

Suh M, Yzenas JJ, **Proctor DM**. Evaluation of Electric Arc Furnace-Processed Steel Slag for Dermal Corrosion, Irritation, and Sensitization. Presented at the Society of Toxicology's 53rd Annual Meeting. Phoenix, AZ, March 23-27, 2014.

Hays SM, Kirman CR, Suh M, **Proctor DM**. Gastric Reduction of Hexavalent Chromium [Cr(VI)] in Fed and Fasted Human Stomach Samples. Presented at the Society of Toxicology's 53rd Annual Meeting. Phoenix, AZ, March 23-27, 2014.

Thompson CM, **Proctor DM**, Suh M, Wolf JC, Haws LC, Seiter JM, Chappell MA, Harris MA. X-ray Fluorescence Microspectroscopic Analysis of Duodenal Mucosae Following Cr(VI) Exposure in Drinking Water. Presented at the Society of Toxicology's 53rd Annual Meeting. Phoenix, AZ, March 23-27, 2014.

Suh M, Thompson CM, Hixon JG, Harris MA, Kirman C, Hays S, Haws L, **Proctor D**. Potential involvement in the development of oral cavity tumors in rats exposed to hexavalent chromium. Presented at the Society of Toxicology's 52st Annual Meeting. San Antonio, TX, March 10-14, 2013.

Kirman C, Thompson C, **Proctor D**, Suh M, Haws L, Harris MA, Hays S. Using PBPK modeling to address diurnal variation and age differences in hexavalent chromium toxicokinetics in humans. Presented at the Society of Toxicology's 52st Annual Meeting. San Antonio, TX March 10-14, 2013.

Thompson C, Kirman C, **Proctor D**, Suh M, Hays S, Haws L, Harris MA. A chronic oral reference dose for hexavalent chromium. Presented at the Society of Toxicology's 52nd Annual Meeting. San Antonio, TX, March 10-14, 2013.

**Proctor D**, Suh M, Thompson, C., Harris, M.A. Mode of action evaluation for hexavalent-induced lung cancer. A chronic oral reference dose for hexavalent chromium. Presented at the Society of Toxicology's 52nd Annual Meeting. San Antonio, TX, March 10-14, 2013.

Brorby G, **Proctor D**, Perry C, Fitzgerald L, Tachovsky A. Probabilistic Risk Assessment of Human Exposure to Iron and Steel Slag. Presented at the Society of Toxicology's 51st Annual Meeting. San Francisco, CA, March 11-15, 2012.

Harris MA, Thompson CM, Wolf JC, Fedorov Y, Hixon JG, **Proctor DM**, Suh M, Haws LC. Assessment of Genotoxic Potential of Cr(VI) in the Intestine via In Vivo Intestinal Micronucleus Assay and In Vitro High Content Analysis in Differentiated and Undifferentiated Caco-2. Presented at the Society of Toxicology's 51st Annual Meeting. San Francisco, CA, March 11-15, 2012.

Hays SM, Kirman C, Aylward L, Suh M, **Proctor D**. Gastric Reduction of Cr(VI) in Mice, Rats and Humans. Presented at the Society of Toxicology's 51st Annual Meeting. San Francisco, CA, March 11-15, 2012.

Hixon JG, **Proctor D**. Use of constrained logistic regression models for the dose-response analysis of beryllium sensitization and chronic beryllium disease with mean exposure. Presented at the Society of Toxicology's 51st Annual Meeting. San Francisco, CA, March 11-15, 2012.

Kirman CR, Hays SM, Aylward LL, Suh M, **Proctor D**. Physiologically-Based Pharmacokinetic Model for Mice, Rats and Humans Orally-Exposed to Chromium. Presented at the Society of Toxicology's 51st Annual Meeting. San Francisco, CA, March 11-15, 2012.

O'Brien TJ, Hao D, Suh M, **Proctor D**, Thompson CM, Harris MA, Parsons BL, Meyers MB. K-ras codon 12 GGT to GAT mutation is not elevated in the duodenum of mice subchronically exposed to hexavalent chromium in drinking water. Presented at the Society of Toxicology's 51st Annual Meeting. San Francisco, CA, March 11-15, 2012.

**Proctor DM**, Thompson CM, Suh M, Haws LC, Harris MA. Mode of Action for Intestinal Carcinogenesis of Ingested Hexavalent Chromium in Mice. Presented at the Society of Toxicology's 51st Annual Meeting. San Francisco, CA. March 11-15, 2012.

Thompson CM, Hixon JG, Kopec AK, Harris MA, **Proctor DM**, Haws LC. Assessment of Genotoxic Potential of Cr(VI) in the Mouse Duodenum via Toxicogenomic Profiling. Presented at the Society of Toxicology's 51st Annual Meeting. San Francisco, CA, March 11-15, 2012.

Haws L, **Proctor D**, Thompson C, Harris M. Research Plan to Fill Data gaps in the Mode of Action for Cancer Risk Assessment of Hexavalent Chromium in Drinking Water. Presented at the Society of Toxicology's 50th Annual Meeting. Washington, DC, March 6-10, 2011.

**Proctor D**, Thompson C, Haws L, Harris M. Use of Mode of Action and Pharmacokinetic Findings to Inform the Cancer Risk Assessment of Ingested Cr(VI): A Case Study. P resented at the Society of Toxicology's 50th Annual Meeting. Washington, DC, March 6-10, 2011.

**Proctor D**, Meek B. Using Mode of Action Data to Guide Quantitative Cancer Risk Assessment: A Case Study of Hexavalent Chromium in Drinking Water. Presented at the Society of Toxicology's 50th Annual Meeting. Washington, DC, March 6-10, 2011.

Thompson C, **Proctor D**, Haws L,Harris M. Mode-of-action for the cancer risk assessment of ingested hexavalent chromium: Identifying and resolving data gaps. Toxicologist. Abstract 1937. Presented at the Society of Toxicology Conference. Salt Lake City, UT, March 2010.

**Proctor D**, Haws L, Tachovsky A, Harris M. Critical Evaluation of the data underlying the USA Today rankings of air quality at schools. Toxicologist. Abstract 1909. Presented at the Society of Toxicology Conference. Salt Lake City, UT, March 2010.

Gatto N, Kelsh M, HaMa D, Shu M, **Proctor D**. A meta-analysis of the relationship between occupational exposure to hexavalent chromium and cancers of the gastrointestinal tract. Abstract, Society of Toxicology Annual Meeting. Baltimore, MD, March 2009.

**Proctor D**, HaMai D. Human health risk assessment for environmental applications of steel slag: Differences between material-specific and default approaches. Poster Presentation, Society of Toxicology Annual Meeting. Baltimore, MD, March 2009.

Gujral JS, **Proctor DM**, Su SH, Fedoruk MJ. Water adherence factors for human skin. Poster, International Society for Exposure Analysis and International Society for Environmental Epidemiology. Pasadena, CA, October 13–16, 2008.

Gujral JS, Fowler JF Jr, Su SH, Morgan D, **Proctor DM**. Repeated open application tests for allergic contact dermatitis due to hexavalent chromium [Cr(VI)]: Risk assessment for dermal contact with Cr(VI). 3rd Conference of Occupational and Environmental Exposure of Skin to Chemicals. Golden, CO, June 17–20, 2007.

Hong S, **Proctor D**, Finley B. Assessment of LA sewage spills on Santa Monica Bay beaches. Society of Toxicology 45th Annual Meeting. San Diego, CA, March 2006.

Hong SJ, **Proctor DM**, Finley BL. Exposure to sewage spill-related pathogens at Santa Monica Bay beaches. 4th Society of Environmental Toxicology and Chemistry World Congress and 25th Annual Meeting. Portland, OR, November 2004.

**Proctor D**. Exposure assessment for perchlorate in milk. Abstract 421. Society of Toxicology 45th Annual Meeting. New Orleans, LA, 2005.

**Proctor D**, Hong S. Relevance of rodent forestomach tumors in cancer risk assessment. Abstract 382. Society of Toxicology 45th Annual Meeting. New Orleans, LA, 2005.

**Proctor D**, Cohen E, Leung H, Hays S, Barraj L, Madl A. Exposure assessment for perchlorate in drinking water. Abstract 1754. Society of Toxicology 44th Annual Meeting. Baltimore, MD, 2004.

Madl A, **Proctor D**, Leung H, Goswami E, Hays S, Cohen E. Derivation of an RfD for perchlorate: Identifying a Critical Health Endpoint and Most Sensitive Subpopulation. Abstract 1755. Society of Toxicology 44th Annual Meeting. Baltimore, MD, 2004.

Leung H Madl A, **Proctor D**, Hays S, Cohen E. Scientific rational for the derivation of an RfD for perchlorate. Abstract 1756. Society of Toxicology 44th Annual Meeting. Baltimore, MD, 2004.

**Proctor D**, Ohanian E. Health risk assessment of hexavalent chromium in drinking water: Carcinogenicity, research and regulation. Symposium Chairman. Abstract 277. Society of Toxicology 42nd Annual Meeting, Salt Lake City, UT, 2003.

**Proctor D**, Lau E, Cahill J, Kelsh M. Alternative reference population sensitivity analysis for the morality assessment of a hexavalent chromium exposed worker cohort. Abstract 2008. International Society of Environmental Epidemiology. 2002.

**Proctor D**, Hays S, et al. Rate of hexavalent chromium reduction by human gastric fluid. Abstract 1700. Society of Toxicology, Nashville, TN, 2002.

**Proctor D**, Williams P. Costs and benefits of compliance with alternative remediation standards at hexavalent chromium-contaminated sites. Abstract 1073. Society of Toxicology. Nashville, TN, 2002.

**Proctor D**, Luippold R, et al. Lung cancer mortality among workers exposed to airborne hexavalent chromium. Abstract 773. Society of Toxicology. Nashville, TN, 2002.

Crump C, **Proctor D**, et al. Dose-response assessment for lung cancer mortality of an occupational cohort exposed to airborne hexavalent chromium. Abstract 774. Society of Toxicology. Nashville, TN, 2002. Awarded top five Risk Assessment Presentations at the conference.

**Proctor D**, Kelsh M, Lau E, Exuzides A, Cahill J. Analysis beyond publication: Further evaluation of an occupational study of chromium workers. Abstract 318. Society of Epidemiological Research. 2003.

**Proctor DM**, Su S, Finley BL. Multi-media exposure scenario survey for defining the conceptual site model of a human health risk assessment for a highly urbanized area. Society of Risk Analysis Conference. December 8, 2002.

Shay E, **Proctor D**, Long T. Community response and health risk assessment of a PCB release from a natural gas pipeline rupture. Association for the Environmental Health of Soils. San Diego, CA, March 2000.

**Proctor DM**. Use of bench top laboratory studies to quantify potential health risks due to mercury vapors: A case study. Society for Risk Analysis. 1998.

**Proctor DM**, et al. Methods for refining health-based remediation goals for PAHs in soil. Association for the Environmental Health of Soil. March 12, 1998.

**Proctor DM**, et al. Prevalence of chromium allergy in the United States and it implications for setting soil cleanup levels: A cost-benefit case study. Society of Risk Analysis. December 1997.

**Proctor D**, Nethercott J, Fredrick M, Finley B, Paustenbach D. Assessing the potential for elicitation of allergic contact dermatitis in Cr(VI)-sensitized subjects following prolonged contact with Cr(VI) in solution. Society of Toxicology, March 12, 1997.

Scott P, **Proctor D**, Paustenbach D. Evaluating the 10% elicitation threshold for Cr(VI) in terms of mass per surface area using benchmark dose methods. Society of Toxicology. March 12, 1997.

**Proctor DM**. Strategies for approaching liability using risk based corrective action (RBCA). Industrial Site Recycling Conference (ISRC). Pittsburgh, PA, April 8, 1997.

**Proctor D**, Shay E, Scott P. Health-based soil action levels for trivalent and hexavalent chromium: A comparison to state and federal standards. Association for the Environmental Health of Soils (AEHS), Newport Beach, CA. March 13, 1996.

**Proctor D**, Fehling KA, Scott PK. Use of health risk assessment to facilitate redevelopment of a former steel production site. Society for Risk Analysis Annual Conference and Exposition. December 7, 1995.

**Proctor DM**, Scott PK, Finley BL. Approach for determining generic health based soil action levels for trivalent and hexavalent chromium at residential and industrial sites. Abstract F4.16. Society for Risk Analysis Annual Conference and Exposition. December 6, 1994.

**Proctor DM**, Malsch PA, Gargas ML. Considerations for determining appropriate reference doses for soluble and insoluble trivalent chromium compounds. Abstract P1.26. Society for Risk Analysis Annual Conference and Exposition. December 5, 1994.

**Proctor DM**. Chromium speciation and risk assessment issues. Ohio Chapter Society for Risk Analysis. June 29, 1994.

Malsch PA, **Proctor DM**, Finley BL. 1994. Estimation of chromium inhalation RfC by the benchmark dose method. Society of Toxicology 33rd Annual Meeting. March 1994.

Gargas ML, Finley BL, Norton RL, **Proctor DM**, Paustenbach DJ. Biomonitoring of chromium (Cr) exposure by urinary excretion: Bioavailability and sampling design. Society of Toxicology 33rd Annual Meeting. March 1994.

**Proctor DM**, Finley BL. A methodology for setting soil cleanup goals based on protection of allergic contact dermatitis. Society for Risk Analysis Annual Meeting. December 5–8, 1993.

**Proctor DM**, Finley BL. Using real human sweat to extract chromium from chromite ore processing residue: Implications for setting standards based on allergic contact dermatitis. Society for Risk Analysis Annual Meeting. December 5–8, 1993.

**Proctor DM**, Scott PK, Fehling KA. Comparison of exposure estimates obtained using conservative state-mandated methodology, refined point estimate approach, and Monte Carlo analyses. Society for Risk Analysis Annual Meeting. December 5–8, 1993.

**Proctor DM**, Ulrich GA, Agnew WW. 1993. Application of human health risk assessment in oil and gas production. No 26362. Society of Petroleum Engineers International Annual Technical Conference and Exhibition. October 3–6, 1993.

**Proctor DM**, Finley BL, Paustenbach DJ. 1993. An alternative to the USEPA's proposed inhalation reference concentration for hexavalent and trivalent chromium. Abstracts of the 32nd Annual Meeting Society of Toxicology 13(1):416.

**Proctor DM**, Trowbridge KR. An analysis of risk driven site investigation and remediation. Abstract 9970. Society of Environmental Toxicology and Chemistry 13th Annual Meeting. October 8–12, 1992.

## TECHNICAL STUDY REPORTS

**Proctor DM**, Gujral J, Su S, Fowler Jr. JF. Repeated open application test for allergic contact dermatitis due to hexavalent chromium [Cr(VI)] as CopperShield®: Risk assessment for dermal contact with Cr(VI). FPRL #012506. Environmental Protection Agency. Washington, DC, July 2006.

**Proctor DM**, Gujral J, Su S, Fowler Jr. JF. Repeated open application test for allergic contact dermatitis due to hexavalent chromium [Cr(VI)] as potassium dichromate: Risk assessment for dermal contact with Cr(VI). FPRL #012406. Environmental Protection Agency Washington, DC, September 2006.

# Ann Holbrow Verwiel, M.P.P.

SENIOR MANAGING SCIENTIST

## CONTACT INFORMATION

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## PROFESSIONAL PROFILE

Ms. Verwiel is a Managing Scientist with ToxStrategies, Inc., and is based in northern California. She has more than 20 years of experience in environmental consulting in the areas of human health risk assessment, site assessment, and environmental regulation. Over her career, she has focused on integrating risk assessment into an overall risk management approach to problem definition, investigation, and mitigation. She has successfully applied this approach in negotiations with regulatory agencies and public groups to develop cost-effective investigations, assessments, and mitigation strategies. She has published and presented papers on a wide variety of topics, including probabilistic risk assessment (Monte Carlo analysis), environmental fate and transport of contaminants, and environmental auditing.

Ms. Verwiel has managed and conducted numerous human health risk assessments that addressed a wide variety of chemicals in soil, soil vapor, air, and groundwater. Petroleum, aerospace, mining, and MGP sites are among some of the most common sites for which she has performed these risk assessments. She has evaluated the chemical signatures, transport mechanisms and ultimate fate, and likely current and future human exposures as key first steps in the health risk evaluation. At sites where volatile organic compounds (VOCs) are present, she has addressed the potential for a vapor intrusion exposure pathway through modeling and measurement, and worked to develop investigation strategies and perform assessments of exposure to indoor and ambient air that included evaluating air emission sources, modeling, soil vapor measurements, and indoor/ambient air measurements.

Ms. Verwiel has a detailed understanding of a broad cross section of environmental regulations, which she has applied to regulatory impact analyses, environmental compliance, and training programs. She has evaluated potential impacts of new regulations on operating facilities and new developments, assessed compliance at operating facilities with a wide variety of environmental regulations, and developed training materials to help regulatory agencies make their requirements clear and to help regulated entities comply. She has conducted air toxic analysis to meet the requirements of Proposition 65, AB2588 Toxic "Hot Spots" Act, and the California Environmental Quality Act (CEQA).

Ms. Verwiel also has communicated risk to formal public groups, such as Restoration Advisory Boards, as well as the general public. She has worked with regulatory public participation specialists, public affairs officers, and others to develop written summaries and presentation materials that convey complex technical issues to the public. She has provided litigation support for several projects involving disputes between owners and operators, alleged air emissions exposures, and California Proposition 65 litigation.

## EDUCATION AND DEGREES EARNED

1996 Master of Public Policy, Georgetown University, Washington, DC

1987 B.S., Chemistry, University of California, Irvine

## CERTIFICATIONS

OSHA 40-hour training (updated annually since 1987)

OSHA Supervisor training

## PROFESSIONAL AFFILIATIONS

American Chemical Society (ACS; member)

Society of Environmental Toxicology and Chemistry (SETAC; member)

Society of Risk Analysis (SRA; member)

## SELECTED PROJECT EXPERIENCE

### *Multi-Media Environmental Human Health Risk Assessments*

Managed the risk assessment planning process for the soil operating unit of a former airport, aircraft maintenance facility, and military manufacturing site. Worked with EPA to attain concurrence on a scoping document for the risk assessment that addressed the major questions regarding the approach to the risk assessment. This allowed the risk assessment to proceed quickly and streamlined EPA's review.

Managed a site-wide HHRA for an active chemical manufacturing facility subject to RCRA under EPA oversight. Chemicals at the site included VOCs, semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, dioxin/furans, and inorganics. Key factors included an upgradient contribution of VOCs from an adjacent Superfund site, shallow groundwater (~5 feet below ground surface), redevelopment of a portion of the former site as a regional park, off-site residences 350 feet from the site boundary, a nearby creek, and a variety of source areas.

Managed human health risk assessment activities at a confidential Superfund mining site. Over the last 10 years, participated in the project management team that developed work plans, performed site characterization activities, evaluated nature and extent of affected areas, and developed a baseline human health risk assessment work plan. Unique features of this project included:

- Developed a site conceptual model that incorporated unique receptors, including a Native American tribal member and forager
- Evaluated incremental sampling methods for mine-waste piles

- Conducted bioaccessibility testing for key metals
- Prepared a work plan and collected data to develop site-specific plant uptake factors
- Collected site-specific background data sets for multiple media and calculated statistically based benchmarks for comparison to site data.

Developed cleanup goals for future redevelopment of a former Department of Energy facility that was being decommissioned. ToxStrategies was hired by the developer to assist in evaluating the implications of hundreds of due diligence samples collected in support of the property transaction. Developed site-specific cleanup goals for more than 50 chemicals in soil, soil gas, and/or groundwater and evaluated these data with respect to the cleanup goals. The cleanup goals were also used by the developer to estimate remediation costs and strategies. The project team worked with regulators—including Missouri's Department of Natural Resources and Department of Health and Senior Services—to achieve regulatory concurrence on the cleanup goals and enable the project to move forward.

Managed a human health and ecological risk assessment for an operating lumber mill for on-site impacts in operational areas and off-site impacts in a slough. Developed a baseline human health risk assessment (HHRA) and cleanup levels for upland soil and performed the scoping ecological and off-site human health risk assessment to evaluate ecological and human health risks associated with chemicals present in the slough, both of which received regulatory approval. Developed a sediment management strategy to document that conditions in the slough remained protective of aquatic organisms.

Developed a risk assessment approach for the investigation of former ponds believed to have been affected by mine drainage from a nearby mine. Developed a risk-based investigation and risk assessment work plan to evaluate the residual material and the effort necessary to mitigate the impacts at the site.

Project Manager responsible for evaluating environmental issues associated with an approximately 1100-acre ranch where wastewater from a nearby pulp and paper mill was used to irrigate specific agricultural fields.

Supported various parts of the California Environmental Quality Act (CEQA) process related to future use of the site as a gravel mine, including preparing public information sheets on dioxins.

Performed an HHRA in support of a Remedial Action Workplan (RAW) for two parcels that were formerly part of a larger manufactured gas plant where PAHs and benzene were key chemicals of potential concern (COPCs) in soil, groundwater, and/or indoor air. The HHRA was approved by the California Department of Toxic Substances Control (DTSC), and the RAW was implemented.

Performed an HHRA and developed risk-based remediation goals for future residential or commercial/industrial land use at a former manufacturing site with metals in soil and VOCs in soil vapor, which were approved by DTSC.

Managed a multi-disciplinary project to provide consulting services for the operators of a former fuel storage terminal (the terminal) in the Port of Los Angeles. Performed the HHRA, obtained regulatory concurrence, developed remediation goals, negotiated with the regulatory agency, and provided support to the client's negotiations with the landowner.

Used a risk-based approach to evaluate off-site risk resulting from a groundwater plume that had migrated from a bulk petroleum storage facility beneath an adjacent residential neighborhood. Worked with members of the public in a formal Restoration Advisory Board (RAB) to refine the existing HHRA Work Plan, perform the risk assessment, and achieve regulatory concurrence.

Managed a multi-phase investigation of petroleum hydrocarbons in soil at a residential development that was discovered after redevelopment. Worked with the City, developer, and numerous regulatory agencies to prioritize investigation needs, conduct a comprehensive investigation, and perform a screening risk assessment. Work was completed in an expedited time frame, and the development was able to move forward.

Managed preparation of an HHRA Work Plan for a jet-fuel plume at a major U.S. airport that focused on current and potential future receptors. Negotiated acceptance of the work plan with property owner, and completed the risk assessment.

Lead risk assessor for a residential development planned adjacent to a former agricultural chemical manufacturing facility (the site) where groundwater had been affected by agricultural chemicals and VOCs. Completed the risk assessment, which was approved by the regulators, within strict time constraints required to obtain approval of development financing by lending agencies.

Lead risk assessor for site characterization activities and subsequent remediation measures related to VOCs in soil gas, VOCs, and hexavalent and total chromium in soil and groundwater at a former metal-plating facility pursuant to a Cleanup and Abatement Order with the Los Angeles Regional Water Quality Control Board (RWQCB).

Managed the health risk assessment components of the evaluation of waste piles at a former mine site. Performed a background comparison and a risk assessment to evaluate site conditions.

### *Vapor Intrusion Risk Assessments*

Evaluated vapor intrusion of TCE at two industrial buildings adjacent to a shallow soil vapor source. The buildings were monitored over a period of two years, and results demonstrated minimal impacts, with indoor air concentrations below health-based screening levels.

Evaluated potential vapor intrusion of TCE and six other VOCs at 100+ homes in the vicinity of a shallow groundwater plume. Developed an indoor air sampling protocol, health-based screening levels, and letters reporting results to residents. Continued monitoring at fewer than 10 homes after the extent of TCE in groundwater was assessed.

Provided third-party review for a vapor intrusion assessment at a future residential development. Worked with land owner to design a development plan that minimizes potential impacts to new homes.

Lead risk assessor for a vapor intrusion HHRA at a former manufacturing facility redeveloped as a business park in southern California. VOCs, primarily trichloroethylene (TCE), were detected in subsurface soil, groundwater, and soil vapor. Developed an indoor air sampling program, calculated site-specific screening levels, and evaluated off-site migration using soil vapor measurements under regulatory oversight.

Lead risk assessor for a vapor intrusion evaluation at an operating hazardous waste treatment facility with chlorinated solvents present in soil and groundwater both on and off site. Evaluated potential human health risks at nearby residences for on-site workers.

Conducted an indoor air evaluation using multiple lines of evidence to evaluate conditions at a surgical hospital prior to a property transaction. Soil gas, sub-slab soil gas, and indoor air samples were collected simultaneously to provide information for decision making within the time frame of the property transaction.

Conducted an indoor air evaluation at a public building to address potential vapor intrusion issues related to a tetrachloroethene (PCE) plume from a former dry cleaning operation at the site.

Lead risk assessor responsible for evaluating potential human health risks associated with free product on the groundwater table approximately 200 feet below ground surface at a former refinery, and for assessing potential impacts to off-site residents.

Lead risk assessor for an HHRA for a former (UST) site where potential indoor air impacts were the key issue following soil remediation because of residual concentrations of petroleum constituents and 1,2-dichloroethane in groundwater at the site and off-site.

### *California Proposition 65 Evaluations*

Evaluated concentrations of chemical ingredients in lubricant products such as gear oils, greases, and other oils and lubricants, that would require a warning label pursuant to California's Safe Drinking Water and Toxic Enforcement Act of 1986 (commonly referred to as Proposition 65). Developed exposure scenarios relevant to each product group, such as chemical-specific dermal absorption factors, potential incidental ingestion, product-specific density, and product-specific exposure frequencies. Using these exposure parameters, estimated potential exposures to the listed chemicals in the product, to assess whether Proposition 65 notifications were required.

Provided support to legal counsel and their client in the evaluation of potential off-site exposure to diesel exhaust from ski resort operations.

Performed a Proposition 65 evaluation for a metal forge operation in southern California; results demonstrated that notification was not required for off-site residents.

Evaluated potential exposures to lead in a dietary supplement and in a skin product, based on daily use suggested by the product label. Recommended additional analysis to assess bioavailability to more accurately assess exposure,

Sixty-day notices were sent by plaintiffs' attorneys to numerous industrial facilities in California based on the simple listing of a Proposition 65 chemical in their emission inventory reported to local air districts and made publicly available. Assisted several clients by conducting simple evaluations of their emissions, which showed that, under conservative assumptions, specific regulatory levels for the Proposition 65-listed chemicals had not been exceeded.

Evaluated requirement to notify off-site persons potentially exposed to emissions from an industrial facility in southern California. Developed specific regulatory levels when such levels had not been published by the state.

Provided technical support in negotiations with the California Attorney General's office on behalf of a manufacturing facility that was issued a 60-day notice based on erroneous interpretations of a public air toxics risk assessment report.

Developed a Proposition 65 emission calculator for diesel exhaust from construction activities for a client that conducts numerous construction projects every year, to assess whether notification may be required,

Evaluated building materials, furniture, and chemical products at a large child-care facility, to identify Proposition 65-listed chemicals and assess whether Proposition 65 notification may be required.

Estimated potential exposure to cadmium and lead in a food product, including evaluating laboratory data and researching typical consumption patterns.

### *Air Toxics Health Risk Assessments*

Managed a California AB2588 health risk assessment (AB2588 HRA) for a metal forge operation in southern California.  Demonstrated that potential exposures were below significance levels.

Managed a California AB2588 health risk assessment (AB2588 HRA) for emissions from a metal-finishing facility in the South Coast Air Quality Management District (SCAQMD). Work included generating emission estimates, characterizing source operations, conducting air dispersion modeling, and completing risk evaluation and comparisons to local monitoring data. All work was performed on an expedited schedule to meet agency enforcement deadlines.

Managed evaluation of source material testing for metals (including hexavalent chromium) at various emission sources at a cement manufacturing plant in northern California.

Performed a California AB2588 HRA for a manufacturing facility in northern California, and obtained regulatory approval from the Bay Area Air Quality Management District (BAAQMD) with minimal comments.

Prepared a California AB2588 HRA for a film-processing facility with emissions of PCE and other solvents used in film developing and cleaning processes.

Evaluated chemical emissions from multiple air emission sources at an urban medical center, in support of an Environmental Impact Report (EIR) under CEQA.

Evaluated chemical emissions from multiple emission sources at the University of California – Riverside campus, to support preparation of an EIR for the long-range development plan for the university.

Project manager responsible for evaluating potential worker exposure to vehicle emissions in a proposed subterranean parking garage used for large volumes of material transport. Findings were used to revise the building design to mitigate potential exposures of the workers in the garage.

Led a study to evaluate emissions from neighboring industrial sources prior to construction of a child-care facility at a food production facility, for the convenience of their employees.

Project manager responsible for evaluating potential health effects associated with emissions from an oil drilling operation in a highly urban area of Los Angeles.

Prepared an HHRA for remedial action activities, including dust generation and diesel exhaust, in support of a permit application for a remedial action at a former burn dump and shooting range. Managed development and implementation of an air monitoring plan to document concentrations of particulates and lead for comparison to acceptable levels established in the monitoring plan.

### *Regulatory Review and Guidance*

Co-author of a chapter on risk analysis as part of a California government agency hazardous waste manual.

Risk assessment representative on a technical advisory group (TAG) that produced a guidance document for calculating, applying, and updating site-specific preliminary remediation goals for a large university research facility operated by the Department of Energy.

Developed compliance handbooks for workers and owners of facilities using coatings in the SCAQMD.

### *Site Characterization*

Managed characterization of metals in soil and dust related to emissions from a metal forge operation. Assessed the bioaccessibility of key metals to evaluate potential bioavailability relative to metal forms used for toxicity testing.

Managed the fast-track evaluation of the potential for radionuclides to be present above background levels at the site of sludge deposits from a laundering facility that handled uniforms for Lawrence Livermore National Laboratory. Reported results to the County Public Utilities Commission and testified at the City Planning Department meeting prior to certification of the EIR.

Developed a detailed work plan for the first phase of a multimedia chemical and radionuclide sampling program and served as project manager for the second phase of investigation at a former aerospace manufacturing and rocket testing facility. More than 1,500 soil, water, and vegetation samples were analyzed for chemicals and radionuclides throughout two phases of the project. Work plan and field work approval were provided by EPA, several state regulatory agencies, and a Public Working Group.

Managed subcontractors conducting groundwater monitoring, and provided third-party review for quarterly monitoring reports prepared for tank-farm sites.

## PUBLICATIONS

Suh M, Casteel S, Dunsmore M, Ring C, **Verwiel A**, Proctor DM. 2019. Bioaccessibility and relative oral bioavailability of cobalt and nickel in residential soil and dust affected by metal grinding operations. Sci Tot Environ 660:677–689.

**Holbrow AM**, Keller A, Dagdigian JV, Amantea C. 1994. Identifying potential liabilities associated with business transactions. J Environ Law May/June.

Copeland TL, **Holbrow AM**, Connor D, Paustenbach DJ. 1994. Use of Monte Carlo techniques to understand the conservatism in California's approach to assessing air toxic contaminants. J Airand Waste Manag Assoc 44(12):1399–1413.

## ABSTRACTS AND PRESENTATIONS

**Verwiel A**, Proctor D. 2020. Risk management for VOCs in indoor air and building evacuation decisions. Poster for International Society of Exposure Science Virtual Annual Meeting, September 2020.

**Verwiel A**, Proctor D, Suh M. Glyphosate risk assessment to assess Proposition 65 requirements for pesticide applicators and construction workers: Risk communication case study. Poster for Society of Toxicology, Virtual Annual Meeting, 2020. https://eventpilotadmin.com/web/page.php?page=IntHtml&project=SOT20&id=2097.

Johnson D, Thompson C, **Verwiel A**, Brorby B. Derivation of California Proposition 65 safe harbor levels for nine chemicals. Poster for Society of Toxicology, Virtual Annual Meeting, 2020. https://eventpilotadmin.com/web/page.php?page=IntHtml&project=SOT20&id=2633.

Suh M, **Verwiel A**, Proctor D. Oral and inhalation bioaccessibility of cobalt and nickel in metal alloys: A critical consideration for site-specific human health risk assessments and read across. Poster for Society of Toxicology, Virtual Annual Meeting, 2020, https://eventpilotadmin.com/web/page.php?page=Session&project=SOT20&id=P3190.

Ring CL, Suh M, Casteel S, Dunsmore M, **Verwiel A**, Proctor D. Relative oral bioavailability of cobalt and nickel in residential soil and dust affected by metal grinding operations. Presented at Joint Annual Meeting of International Society of Exposure Science and International Society for Environmental Epidemiology (ISES-ISEE 2018), Ottawa, Canada, August 2018.

Proctor DM, Suh M, Dunsmore D, **Verwiel A**, Casteel S. Bioaccessibility and relative oral bioavailability of cobalt and nickel from metal alloys in soil and dust. Poster presented at Society of Toxicology Annual Meeting. March 15, 2017. Baltimore, MD.

**Holbrow Verwiel A**. Development of a long-term monitoring solution for dioxins/furans in sediment. Poster Presentation at Dioxin 2010: 30th International Symposium on Halogen Persistent Organic Pollutants, San Antonio, TX. September 12-17, 2010.

Croteau D, Bernhardt T, **Holbrow A**, Conti E, and Ellery B. Site characterization using a dioxin screening method: Former sawmill, California, United States of America. Proceedings of the Dioxin 2008: 28th International Symposium on Halogenated Persistent Organic Pollutants, Birmingham, England. Aug 17-22, 2008. Also published in Organohalogen Compounds, v. 70. 2008.

Connor K, Kelly C, Cheung R, and **Holbrow A**. Risk-based screening values for vapor intrusion pathway and flux chamber data. Society for Risk Analysis 2005 Annual Meeting, Orlando, FL. December 6, 2005.

Rush HC, **Holbrow A**, Embree J, and Szerdy FS. Empirical and modeled attenuation factors and the contribution of preferential pathways to indoor air quality. Vapor Intrusion Attenuation Workshop, 14th Annual West Coast Conference on Soils Sediment and Water, U.S. EPA, San Diego, CA. 2004.

**Holbrow AM**, Brorby GP and Zemo DA. Reality check? Soil vapor data applied to an evaluation of chemical migration from groundwater to air. 10th West Coast Conference of the Association for the Environmental Health of Soils, San Diego, CA. March 20–23, 2000.

**Holbrow AM**, Nazmi N, Smith JS and Brorby GP. Implementing a risk assessment work plan developed by stakeholder consensus. Presented at the Society for Risk Analysis Conference, Atlanta, GA. December 1999.

Spencer AL, **Holbrow AM** and Graf T. The 'free product' dilemma: Is free-product removal required to achieve site closure? International Petroleum Institute Conference, Albuquerque, NM. Oct. 20–23, 1998.

Marquis SA, Copeland TL and **Holbrow AM**. A site-specific health-based approach for determining groundwater cleanup concentrations - Part I: Advective transport modeling. Presented at Hazmacon '93, San Jose, CA. April 1993.

Copeland TL, **Holbrow AM** and Marquis SA. A site-specific health-based approach for determining groundwater cleanup concentrations - Part II: Vapor emission modeling and risk characterization. Presented at Hazmacon '93, San Jose, CA. April 1993.

**Holbrow AM**, Copeland TL and Sullivan MJ. Data characterization methods for contaminated soil and the effects on exposure estimates calculated using a Monte Carlo simulation. Presented at Society for Risk Analysis, San Diego, CA. December 1992.

McCullough ML, Dagdigian JV and **Holbrow AM**. Developing air compliance plans. Presented at the Eighth Annual EA Environmental Compliance Conference, San Diego, CA. August 1992.

Connor K, **Holbrow AM** and Copeland TL, and Paustenbach D. Use of quantitative uncertainty analysis in air toxics risk assessment. Presented at the 85th Annual Meeting of the Air and Waste Management Association, Kansas City, MO. June 21–26, 1992.

Connor K, **Holbrow AM** and Copeland TL. Monte Carlo analysis applied to multipathway risk assessment of chlorinated dibenzo-p-dioxins and dibenzofurans. Poster presentation at the Society of Toxicology 1992 Annual Meetings, Seattle.

### *Continuing Education*

1989 UC Irvine, Hazardous Waste Certification Program