Health Consultation

Evaluation of Groundwater Contamination
Boeing Commercial Airlines Fabrication Division
Auburn, King County, Washington State

January 4, 2012

Prepared by

The Washington State Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substance and Disease Registry

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Foreword

The Washington State Department of Health (DOH) has prepared this health consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous wastes. This report was supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act through a cooperative agreement with ATSDR. It was completed in accordance with approved methodologies and procedures that existed at the time the health consultation was initiated. However, it has not been reviewed and cleared by ATSDR. Editorial review was completed by DOH.

The purpose of this health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on specific health issues so that DOH can respond to requests from concerned residents or agencies for health information on hazardous substances. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time of this health consultation, and should not necessarily be relied upon if site conditions or land use changes in the future.

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Glossary

Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Aquifer	An underground formation composed of materials such as sand, soil, or gravel that can store and/or supply groundwater to wells and springs.
Carcinogen	Any substance that causes cancer.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund.
Chronic	Occurring over a long time (more than 1 year) [compare with acute].
Comparison Value (CV)	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dermal Contact	Contact with (touching) the skin (see route of exposure).
Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time). It may be calculated based on how much people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental Protection Agency (EPA)	United States Environmental Protection Agency.

Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).
Groundwater	Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].
Hazardous Substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way (see route of exposure).
Inhalation	The act of breathing. A hazardous substance can enter the body this way (see route of exposure).
Maximum Contaminant Level (MCL)	A drinking water standard established by the federal Safe Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.
Model Toxics Control Act (MTCA)	The hazardous waste cleanup law for Washington State.
Monitoring Wells	Special wells drilled at locations on or off a hazardous waste site so water can be sampled at selected depths and studied to determine the movement of groundwater and the amount, distribution, and types of contaminants present in groundwater.
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
Osceola Mudflow	The Osceola Mudflow originating from Mount Rainier that is a less permeable horizon of silt and clay that acts as a barrier to downward flow of groundwater. It separates the upper aquifer from the deeper aquifer below the Boeing Auburn Plant. The upper aquifer is divided into three zones based on depth: shallow (10–30 feet below ground surface [bgs]), intermediate (40–60 feet bgs), and deep (80–100 feet bgs).

Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.
Plume	A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.
Remedial Investigation (RI)	As directed by federal and state regulations (CERCLA or MTCA), the process of determining the type and amount of hazardous substances, and the extent of their release which has resulted in contamination at a site. The remedial investigation must collect and evaluate sufficient information to select a cleanup action for a contaminated site.
Route of Exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing (inhalation), eating or drinking (ingestion), or contact with the skin (dermal contact).
Volatile Organic Compound (VOC)	Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, methyl chloroform, and trichloroethylene.

Summary

Introduction

Past releases of chlorinated solvents from Boeing's Commercial Airline Fabrication Division Plant in Auburn (Boeing Auburn Plant), King County, Washington have resulted in offsite contaminated plumes in groundwater located in the valley. At the request of the Washington State Department of Ecology (Ecology), this health consultation evaluated the potential human health hazard posed by the contaminants in the groundwater.

The Washington State Department of Health (DOH) prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

Conclusions

Conclusion 1–DOH concludes that chlorinated solvents and related breakdown products found in the groundwater deeper than 40 feet below ground surface (bgs), but above the Osceola Mudflow near the Boeing Auburn Plant, will not harm people's health because people are not drinking or using this contaminated water. As Boeing continues to define the source, edges, and depth of the contaminated water, DOH will continue to verify that people are not exposed.

Basis for decision–The Osceola Mudflow, located dozens of feet below the surface in this area, consists of clay-rich deposits from a large lahar (a volcanic mudflow) originating at Mount Rainier about 5,700 years ago. Water does not easily flow through the Osceola Mudflow, which separates the groundwater above and below it into two separate portions of the aquifer. A review of water quality data from monitoring wells near the Boeing Auburn Plant identified a portion of the upper aquifer that is contaminated with chlorinated solvents including trichloroethylene (TCE), tetrachloroethylene (also known as perchloroethylene or PCE), and related breakdown products.

Groundwater in the upper aquifer appears to be flowing to the north and northwest. Well systems serving 15 or more connections that are closest to the contaminated water are to the east. Drinking water wells draw groundwater from deeper than 40 feet bgs and do not appear to draw from contaminated water. Based on water quality data submitted to DOH, all but one of the well systems in the valley currently have no TCE, PCE, and related breakdown products in them. The Auburn Park Community well has reported decreasing TCE levels in the past few years; this well has never had concentrations that pose a health threat according to federal drinking water standards. Based on the direction of groundwater flow, this well does not appear to be drawing contaminated water from the Boeing Auburn site. Boeing continues to define the source, edges, and depth of the contaminated water to verify that people are not exposed.

According to records submitted to DOH, the approximate locations of wells serving fewer than 15 connections are to the east or much farther north and northwest of the currently identified plume boundary. Owners are not required to monitor for most chemical contaminants, including chlorinated solvents. Preliminary discussions between Boeing's contractor and personnel from the Cities of Auburn, Algona, and Pacific did not identify any other private wells that draw groundwater from within the contaminated plume. However, unknown private wells may exist.

Conclusion 2–DOH cannot currently determine whether chlorinated solvents and related breakdown products from the Boeing Auburn Plant are found in the groundwater below the Osceola Mudflow. The information we need to make this determination is not available. There are no monitoring or drinking water wells that draw from this portion of the aquifer near the Boeing Auburn Plant; however, deeper aquifer contamination in this area is unlikely. DOH will work with Ecology, Boeing, and the City of Auburn to determine if more information is needed to better understand the Osceola Mudflow in this area to confirm that future exposure does not occur.

Basis for decision–The upper aquifer is contaminated near the Boeing Auburn Plant. The deeper aquifer below the Osceola Mudflow has no monitoring wells drilled through it near the Boeing Auburn Plant. Thus, the water quality status of the deeper aquifer in this area is not known, but as water does not flow easily through the Osceola Mudflow, deeper aquifer contamination in this area is unlikely. Should a passage be created between the upper and deeper aquifer by drilling wells through the Osceola Mudflow, TCE-contaminated water may follow these passages down and enter the deeper aquifer. Water quality data from local wells serving 15 or more connections that draw from this deeper aquifer elsewhere in the valley do not exceed public health water quality standards. DOH will work with Ecology, Boeing, and the City of Auburn to determine if more information is needed to better understand the Osceola Mudflow in this area.

Conclusion 3–DOH cannot determine at this time if people are breathing indoor air containing chlorinated solvents that have evaporated from groundwater at the top of the water table and moved into a building through cracks or holes in the foundation. The information we need to determine if exposure is occurring is not available. Historical modeling indicates that harm to people's health from this route is not likely to occur. DOH is working with Boeing and Ecology to gather current information about buildings that lie over the shallow groundwater plume with highest concentrations at the water table.

Basis for decision–Indoor air quality data were not available at the time of this evaluation; therefore, no definitive conclusion can be made regarding exposure. TCE has been identified in the groundwater at the water table (10– 30 feet bgs) near or below buildings; however, better shallow groundwater data is needed to understand the extent and concentration of this contamination and the potential for it to evaporate and move up and into buildings. Historical sampling of soil gas and past vapor intrusion modeling for former or planned buildings over the shallow plume source indicated that no health threat existed at that time. However, more is known about assessing the vapor intrusion pathway today than was known when these buildings were assessed in 2003 through 2006. An updated evaluation of the vapor intrusion pathway is

necessary to evaluate potential health risks at the AMB Property Corporation, YMCA, and Junior Achievement buildings as well as other buildings located over highest contaminated areas of the shallow groundwater plume. Current vapor data collected below Boeing's Building 17-07 (sub-slab vapor sampling) suggest levels of TCE and PCE are elevated below this building. Planned indoor air sampling at this building by Boeing will help determine if people working in this building are being exposed.

Conclusion 4–DOH cannot determine at this time if chlorinated solvents from the Boeing Auburn site in off-property shallow groundwater could harm people's health. Adequate information to make a decision is not available. People touching or breathing in vapors from discharge of shallow contaminated groundwater below the Boeing property is not expected to harm people's health because the measured concentrations are below levels of health concern. DOH is working with Ecology and Boeing to gather the off-property information needed.

Basis for decision–In order to reach a conclusion, DOH needs more information about levels of chlorinated solvents in the shallow groundwater (< 30 feet bgs) off Boeing's property. In addition, more information is needed about the potential for shallow groundwater to discharge to surface water and the levels of chlorinated solvents in surface water.

However, concentrations of TCE in shallow groundwater below the Boeing facility have decreased over time and are considered to be low. If this contaminated water below Boeing's property discharged to surface waters or if future activities led to digging trenches deep enough to reach shallow contaminated groundwater, no harm is expected for people breathing, touching, or incidentally swallowing this water for short amounts of time.

Next Steps

1. Boeing should continue to identify the source and boundaries of the solvents in the impacted groundwater. On-going monitor well sampling and analyses will provide chlorinated solvent concentrations in the contaminated groundwater to determine if they are decreasing.
2. Boeing should complete a private well survey in conjunction with municipalities to identify locations of private wells that may exist within the known area of the plumes and in areas of uncertainty. Exact locations of Group B wells located down gradient of the plume will be identified.
3. Boeing should continue to define the edges and concentrations of chlorinated solvents in the shallow groundwater near the plant. Boeing will assess indoor air quality in Building 17-07 and complete an updated evaluation of the vapor intrusion pathway for the AMB Property Corporation, YMCA, and Junior Achievement buildings. As more off-property water quality data from the contaminated shallow groundwater becomes available, Ecology will facilitate evaluation of the potential for vapors to move from shallow groundwater into overlying buildings as needed.

4. As part of Boeing's planned public notification process, Boeing should inform offsite property owners, municipalities, water utilities, and the local health department that chlorinated solvent concentrations in the deeper aquifer are unknown but unlikely; this notification will include concerns about contaminating the deeper aquifer by boring through the Osceola Mudflow. Ecology should communicate this concern on their "Well Construction Information for Well Drillers" website. DOH will work with Ecology, Boeing, and the City of Auburn to determine if more information is needed to better understand the extent of the Osceola Mudflow in this area.
5. Boeing will continue to assess shallow groundwater concentrations near the site. In addition, more work will be done to better understand groundwater discharge to surface waters.

For More Information

If you have concerns about your drinking water or home near the Boeing Commercial Airlines Fabrication Division Plant in Auburn, please call the toxicologist who prepared this document:

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Purpose and Statement of Issues

The Washington State Department of Health (DOH) conducted this health consultation at the request of the Washington State Department of Ecology (Ecology). The purpose is to determine if community members, living, recreating, and working near Boeing Company's Commercial Airplanes Fabrication Division Plant in Auburn (Boeing Auburn Plant) are currently being exposed or will be exposed in the future, to contaminants in groundwater and whether these potential exposures pose a human health threat. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

The Boeing Auburn Plant produces parts, tools, and assemblies for commercial aircraft. Past releases of solvents from the plant have resulted in two offsite plumes of contaminated groundwater in the upper aquifer, which appear to be comingling away from the source areas. Boeing is currently defining the extent of the contamination (referenced as Plume 1 and Plume 2) as part of ongoing remedial investigations. This health consultation considered two potential exposures: 1) whether people are drinking water contaminated with solvents released from the Boeing Auburn Plant and 2) whether people are breathing indoor air contaminated with solvents which have evaporated from the groundwater then moved as a gas from the soil into a building. Breathing solvent vapors in indoor air is potentially of concern in buildings located over and near areas of shallow-contaminated groundwater or solvent-contaminated soils.

Background

Site Description

The Boeing Auburn Plant, located at 700 15th Street Southwest, Auburn, Washington, is within the city limits of Auburn and Algona. The facility is bounded by 15th Street SW to the north, the General Services Administration (GSA) property to the east, Ellingson Road and the Safeway property to the south in the City of Pacific, and Perimeter Road to the west. The facility includes numerous manufacturing and office buildings, warehouses, support buildings such as a boiler room and wastewater pretreatment plant, roads, and employee parking areas.

Boeing originally purchased the 380 acres from GSA in 1966. In 1974, they purchased additional GSA warehouses, adding to the facility's overall size. In 2003, Boeing sold 104 acres to Safeway. In 2004, they donated 24.5 acres to the YMCA and Junior Achievement. In 2005, they sold 0.71 of an acre consisting of an electrical transfer station to Puget Sound Energy (PSE). In 2005, Boeing also sold 41.9 acres at the north end of the site to AMB Property Corporation (AMB), who later replaced Building 17-05 on this property with a distribution warehouse (Landau Associates 2009a).

The Boeing Auburn Plant makes parts, tools, and assemblies used in the production of Boeing jetliners. Parts, such as spars, wing-skin panels, brackets, and other components are made out of aluminum alloys, titanium, steel, or composite materials. Workers engage in construction, sheet metal work, welding, tooling, maintenance and repair of equipment, process assembly, and other work related to manufacturing parts.

Solvents were used at various locations at the plant. In the former Building 17-05 area, Boeing housed a trichloroethylene (TCE) vapor degreaser and a separate 1,1,1-trichloroethane (TCA) vapor degreaser near the metalbond tank line (Landau Associates 2004 a). TCE and TCA were primarily used to remove grease from fabricated metal parts in the above-grade wash station referred to as the "solvent wash" area or the "body skin manual wash" area. They removed the TCE degreaser in 1979 and used the space for two TCA storage tanks until 1994. The former TCA degreaser operated from 1973 to 1994. The historical data suggested that there was a release of TCE from the former TCE degreaser which resulted in persistent low to moderate groundwater TCE and TCE breakdown product concentrations, which started the Plume 1 (Landau Associates 2004a). It appears that a significant release from the TCA degreaser has not occurred.

Former Building 17-03, which was located just east of the AMB building, also contained a TCE vapor degreaser near the northern end of the former aluminum bond tank line. This degreaser was removed prior to building demolition in late 1992 and investigations in 2004 did not indicate a significant release to either soil or groundwater at this location. Boeing is still determining the use of chlorinated solvents in Buildings 17-07, 17-06, 17-12, and 17-10. TCE and TCA have also been used for degreasing small parts throughout the plant where 1–2 gallons were kept at various locations. Tetrachloroethylene (also known as perchloroethylene or PCE) may have been used in processes at the Boeing Auburn Plant in the past, most likely in small degreasing activities. Vinyl chloride was not used at the site, but is present in the groundwater as a result of breakdown of PCE and TCE.

Land Use and Natural Resources

Most of the land immediately surrounding the Boeing Auburn Plant to the north, east, and south consists of commercial and industrial properties. The interurban trail runs along the western boundary of the facility. Residential areas lie adjacent to the facility in the City of Algona to the west and City of Pacific to the south. Residential areas in the City of Auburn are within a quarter of a mile to the east. North of the commercial areas off Highway 18 lies a large wetland complex on either side of Highway 167. This wetland complex is the location of the 120-acre future Auburn Environmental Park which has saturated soils or flooding during most of the year. The City of Auburn is developing a 1,200-foot elevated boardwalk trail for passive recreation and educational use.

The Boeing Auburn Plant lies between the White and Green Rivers, which flow west and north, respectively, into the broad relatively flat valley. The Osceola Mudflow, located dozens of feet below the surface throughout the valley, consists of clay-rich deposits from a large lahar (a volcanic mudflow) originating at Mount Rainier about 5,700 years ago (Dragovich et al. 1994). According to Washington State Department of Natural Resources, the texture of the Osceola

Mudflow influences groundwater distribution and is an important aquitard with a thickness that commonly exceeds 60 feet in the valley; water appears to be perched above the Osceola Mudflow and locally confined below it (Dragovich et al. 1994). The deeper aquifer below the Osceola Mudflow is generally considered protective of the lower aquifer and measured at least 55 feet thick at one location below the Boeing Auburn plant (Landau Associates 2009a, b). Locally, the upper aquifer has been subdivided into three groundwater zones defined by depth below the surface: the shallow zone (10 to 30 feet below ground surface [bgs]), intermediate zone (40 to 60 feet bgs), and deep zone (80 to 100 feet bgs) (Geomatrix 2003, Landau Associates 2009a, b). Groundwater flow is north to northwest and eventually discharges into the Green River (Geomatrix 2003; Landau Associates 2009a, b; 2010a, b, c; 2011b). Groundwater elevations fluctuate up to five or six feet seasonally in response to seasonal recharge and regional pumping effects (Landau Associates 2009a, b). To the west, Mill Creek runs west to east off of the hill near Highway 18 and then flows north through the valley along Highway 167 eventually entering into the Green River. The flood plain for Mill Creek extends into the valley; short-term fluctuations associated with storm and flooding events may also affect saturation limits and water transport into the shallow portion of the upper aquifer. The aquifers above and below the Osceola Mudflow are used for drinking water throughout the valley. Figure 1 shows the approximate locations and depths of public drinking water wells historically and currently used throughout the valley (DOH 2011). Information on these wells is listed in Appendix A, Table 1. The closest Group A[1] wells to the Boeing Auburn Plant include:

- City of Pacific East, South, and West wells (DOH sources 02, 04, and 06) located adjacent to the southern boundary of the plant. These sources are combined and treated with chlorine for bacterial contamination and sodium dioxide for pH balance before distribution.
- City of Auburn wells 1, 3a, 3b, and 4 (DOH sources 03, 05, 08, and 07) located at different locations to the east.
- Auburn Park Community's well located a half mile to the east. This well serves approximately 91 connections within a mobile home park.
- South Auburn Water Association well about a half a mile to the east. This well serves approximately 47 connections.

The closest Group B[1] well in DOH records, Kuzmer Water Supply, is located near the Auburn Park Community Group A well. This well does not appear to be in use. There is a large wetland complex at least one mile in length on either side of Highway 167, north of Boeing past the commercial/industrial areas and Highway 18. The closest well down gradient of the Boeing Auburn Plant is a Group B well (Barem) located less than a quarter mile north of the wetlands, and less than 1.5 miles from the northern end of the plume (northern plume boundary has not been identified), and 2.4 miles from the Boeing facility (all approximate distances).

[1] Group A wells serve 15 or more connections and Group B wells serve less than 15 connections. Locations of some wells in the DOH database were estimated.

Site History and Environmental Investigations

In 1987, the facility received a *Resource Conservation and Recovery Act (RCRA) permit* (No. 87-1) that specified the requirements for treatment, storage, and handling of hazardous waste and the requirements for corrective action. At RCRA permitted facilities, corrective action is required for all releases of hazardous substances at and from the facility to protect human health and the environment.

Since that permit was issued, Ecology identified 46 Solid Waste Management Units (SWMUs) and 17 Areas of Concern (AOCs) with potential releases of hazardous substances. In 2002, Boeing and Ecology entered into an Agreed Order (01HWTRNR-3345), wherein Boeing agreed to complete a remedial investigation (RI), feasibility study, draft a Cleanup Action Plan, and perform interim actions and clean up as necessary to remediate releases of hazardous substances at the site. With a few exceptions, Boeing reports it has collected sufficient data to characterize potential releases from most of the SWMUs/AOCs identified in the Agreed Order (Landau Associates 2005).

Remedial investigations identified a distinct plume (Plume 1) of volatile organic chemicals (VOCs) in groundwater including TCE, PCE, and their degradation products. Plume 1 was moving northward in the shallow zone of the upper aquifer. Boeing identified the former TCE degreaser located under former Building 17-05 (now the AMB building) as the source of Plume 1. In order to expedite the sale of land to AMB, bioremediation work began on the source area of Plume 1 in 2004. Bioremediation stimulates naturally occurring bacteria to metabolize pollutants in the groundwater. Prior to bioremediation, the highest TCE groundwater concentration was over 1000 µg/L (ppb) located close to the former degreaser. For comparison, the federal primary maximum concentration level (MCL) for public drinking water is 5 µg/L. Three injections of food grade sodium lactate and vegetable oil into the shallow zone of the aquifer were conducted in July 2004, February 2005, and October 2005. This resulted in decreasing the levels of TCE and related VOCs near the source to below the MCL. TCE levels in the shallow zone of the upper aquifer have decreased over time and currently concentrations range from below the detection limit (0.2 µg/L) to 7.8 µg/L in the shallow zone (Landau Associates 2011b). Currently, the highest TCE concentration in Plume 1 lies immediately down gradient of the former source, just north of the AMB Building (Table 1).

To address concerns about people breathing solvents that may have evaporated from the groundwater into the soil gas and then moved into buildings, soil-gas sampling and two vapor intrusion models have been developed. Boeing performed groundwater and soil gas sampling in 2003 during the transfer of the north portion of the Auburn plant to the YMCA (URS 2003). Populations of concern included workers who may spend their lifetime working at the YMCA facility and young children who might attend day-care for the first 6 years of life at the YMCA. During the transfer of the AMB property, Boeing and AMB performed indoor air modeling in 2004 and 2005 to determine potential indoor air exposures. These exposure estimates were used to assess potential health risk to workers present in the former Building 17-05 and newly constructed AMB building (Landau Associates 2004b, GeoEngineers 2005). Results of these studies and current shallow groundwater water quality data are summarized below and detailed in Appendix B.

In 2006, the First Amended Agreed Order contained language for the *State Dangerous Waste Management for Corrective Action permit,* which replaced the original RCRA No. 87-1 permit. Ecology issued this new permit jointly to Boeing and AMB to allow them to move forward together with corrective action. Efforts continued to define the extent of Plume 1 contamination in the intermediate (40–60 feet bgs) and deep zone (80–100 feet bgs). Figures 2 and 3 show contour lines which approximate the concentration of TCE in Plume 1, based on the analysis results of the sampling which took place May–June 2011 in the intermediate and deep zones of the upper aquifer. The shallow zone has only been characterized below or just adjacent to the north of the Boeing facility.

As noted on the maps, there is considerable uncertainty about the horizontal extent of plumes in the three zones. The discovery of increasing concentrations of TCE in offsite wells southwest of Plume 1 made it apparent that a second VOC plume (the western plume or Plume 2) exists from a different source than Plume 1. Figures 2 and 3 also show the contour lines which approximate the concentration of TCE in Plume 2. The most elevated concentration of TCE (14 µg/L) was in groundwater from the intermediate zone at the edge of Boeing's property next to the interurban trail (Landau Associates 2011b) (Table 1). In order to identify the magnitude and extent of Plume 2 at least 19 groundwater monitoring wells have been installed (as of July 2011) and more are planned. This plume is moving off the facility with groundwater flow to the north, and currently measures a minimum of 1.5 miles long in the intermediate zone. Other solvents have been detected in this area as well; however, their concentrations are less than that of TCE and appear to be located well within the TCE plume boundaries.

Boeing performed sub-slab soil gas sampling under Building 17-07 in an effort to determine the source of Plume 2. Concentrations of PCE and TCE in the sub-slab vapor sampling were higher in some samples. Boeing has not yet determined whether the source area for Plume 2 is located below Building 17-07. Additional sub-slab vapor sampling is planned for fall 2011, when groundwater elevations have dropped further below the building.

Demographics

The three communities surrounding the Boeing Auburn plant include the Cities of Auburn, Pacific, and Algona. Collectively these cities have a population around 130,000 people.[2] The socioeconomic status and racial indicators of people in this area are similar to that of people throughout Washington State. The percentile of major ethnic groups present in each city ranges from 65-71% white, 7-12% Hispanic, 8-17% Asian, 2-6% black, and other minor ethnicities.

[2] Statistics according to www.city-data.com as of 2009

Discussion

This health consultation consists of two technical components, the exposure evaluation and health effects evaluation. The exposure evaluation assesses which chemicals are present and to what extent a person may be exposed. The health effects evaluation compares this level of exposure to protective health-based values and determines which chemicals and exposure pathways require an in-depth evaluation. Adverse effects may be carcinogenic or non-carcinogenic in nature depending on which chemicals are present and the extent of exposure. Low-level exposures may not necessarily cause adverse effects.

Exposure Evaluation

The exposure evaluation focuses on understanding the nature and extent of environmental contamination at and around the site. This allows us to determine what contaminants people may be exposed to and at what concentration. The evaluation process starts with the identification of the chemicals of concern, followed by an examination of how people could be exposed.

Chemicals of Potential Concern–Groundwater

This section evaluates environmental contamination data, identifies critical data gaps, and determines the level of chemicals at which people may be exposed. These chemicals may be present in the soil, groundwater, or in indoor air.

The groundwater sampling data from monitoring wells were: 1) measured by stationary laboratory techniques using EPA reference methods (EPA Method 8260 for all VOCs and EPA 8260 SIM for PCE and vinyl chloride), 2) collected and analyzed following EPA-approved and Ecology-approved sampling and analytical methods, and 3) accompanied by Quality Assurance/Quality Control (QA/QC) documentation suggesting that data quality objectives were met. However, samples taken in the shallow zone while boring the intermediate zone monitoring wells (grab samples) may not represent static VOC levels because of the collection method, thus these results should be considered as inconclusive.

For this evaluation, the VOCs of concern at the site include TCE, PCE, and some of their breakdown products: 1,1-dichlorethylene; cis-1,2-dichloroethylene; trans-1,2,-dichloroethylene; and vinyl chloride (Table 1). Other contaminants related to the Boeing activities that are well-specific and not wide-spread were not evaluated.

- *Depth and Spatial Extent of the Plumes*– Low-level VOC contamination has been identified in the three zones in the upper aquifer at and beyond the Boeing property. Figures 2 and 3 show the contours of TCE in the intermediate and deep zones in the valley. The depth and spatial extent of the groundwater plumes, however, have not been completely identified. The range of concentrations found at the site is summarized in Table 1 and a detailed description is located in Appendix B.

Samples taken in the intermediate zone of the upper aquifer show this zone to have the widest lateral extent of contamination (Figure 2). Boeing is also planning to install additional monitoring wells to determine the northern and western down gradient extent of the plumes in all the shallow, intermediate, and the deep zones of the upper aquifer. The shallow and deep zones have a limited number of samples from wells off Boeing's property.

Because VOCs have been detected in the deep zone of the upper aquifer, boring new wells through the protective Osceola Mudflow may result in contaminants moving into the deeper aquifer. Therefore, wells extending into the deeper aquifer have not been installed and no monitoring data has been collected or is planned to be collected from the deeper aquifer below the Osceola Mudflow. Other than the modeling of the Oscoela Mudflow done by the Department of Natural Resources (Dragovich et al. 1994), DOH has not performed or received a systematic review of well logs specific to the contaminated area to verify the consistency or thickness of the Osceola Mudflow. Thus, there is some uncertainty in understanding the extent of protectiveness of the deeper aquifer from contamination.

The northern most detections of TCE in Plume 2 in the intermediate zone are adjacent to the southern edge of the Auburn wetland complex. Further investigations will help determine the extent and exchange of water between the shallow zone of the upper aquifer and surface water in the wetland complex. If TCE is detected in the shallow zone this far north and if water discharge is occurring into the wetland, chlorinated solvents could enter the wetland. These solvents would be subject to evaporation and atmospheric degradation as well as rapid biological degradation within the organic-rich reducing environment typical of wetland sediments.

- *Seasonal Variation*–Boeing has done ground water sampling for VOCs, including non-chlorinated solvents, for many years, with more wells being added each quarter. Boeing's sampling frequency varies from quarterly for the newest wells to semi-annually or annually for wells which show consistent VOC levels over time (Landau Associates 2011a). With the exception of wells installed during or after the summer 2010 drilling program, most wells have four or more quarters of sampling data. With exceptions, an evaluation of concentration over time indicated that impacted wells did not show patterns of seasonal variation (Landau Associates 2011a); however, changes in water flow and depth have been seen to change seasonally. Seasonal effects could have an impact on the concentration of TCE and related VOCs measured at groundwater wells at the site (Ecology, personal communication 2011). Flooding near Mill Creek on the west side of the valley may contribute to water flow into the shallow aquifer near the site and influence contaminant transport.

- *Temporal Extent of the Contamination*–Because of the extended length of Plume 2 in the intermediate zone and unknown width and depth of the VOCs in the three zones of the upper aquifer, it is not clear if the release was historical and has degraded substantially, if there are multiple sources from the Boeing Auburn plant, or if sources outside of Boeing are contributing to the plumes.

- *Measured Concentrations at the Point of Contact*–Figure 1 shows the historical and current Group A and Group B drinking water wells in the valley near the Boeing Auburn Plant along with the current known area where TCE exceeds the MCL in the Boeing plumes as of July 2011. Detailed available information about these public and private wells can be found in Appendix A, Tables 1 and 2 (DOH 2011, Ecology 2011) and a narrative summary can be found in Appendix B. Concentrations of TCE, PCE, and vinyl

chloride measured in the Group A public wells since 1991 (as reported to DOH) are detailed in Appendix A Table 2 and described in Appendix B.

A review of this historical data indicated that chlorinated solvents have been detected above the state reporting limit (0.5 µg/L) in only four Group A wells in the valley: City of Auburn's Wells 2 and 6 (DOH sources 04 and 12) and two small private Group A water systems, Auburn Park Community and South Auburn Water Association. Though detected, none of these wells had concentrations that ever exceeded the federal MCL for chlorinated solvents. The historical chlorinated solvent contamination in Auburn Wells 2 and 6, located at a substantial distance to the northeast away from groundwater flow, was most likely not impacted from the Boeing releases. Furthermore, water from these wells are combined and aerated before distribution; this treatment decreased concentrations below the reporting limit and contamination never reached the consumer.

South Auburn Water Association has not reported TCE concentrations since June 2004. The highest detection of TCE reported in the Auburn Park Community's well was 4.7 µg/L in May 1991, below the MCL (5 µg/L). TCE levels have fluctuated over time in a decreasing trend. The TCE level reported in June 2010 was 1.7 µg/L and below the reporting limit in September 2011. It does not appear that these wells are (or were) impacted by the Boeing plumes as they are not within the direction of groundwater flow. However, additional work is needed to better characterize the boundaries of the plume.

Group B wells do not report monitoring data so their water quality is unknown. The closest Group B well, Kuzmer Water Supply, appears to be located to the east near the Auburn Park Community well, though the exact location is unknown. If used, this well also draws from the intermediate zone of the upper aquifer and likely has water quality data similar to that of Auburn Park Community well. Unknown private wells in the valley may exist.

Table 1. Concentrations of selected VOCs from groundwater in monitoring wells and bore hole grab samples from the shallow, intermediate, and deep zones of the upper aquifer, Boeing Commercial Airplane Fabrication Division, Auburn Plant, King County, Washington [*]

Contaminant	Number Detections	Range (µg/L)	Location of Maximum	Health-Based CV (µg/L)	Type of CV	Number Detections > CV
Shallow Zone Monitoring Wells (June 2011)						
Trichloroethene (TCE)	25/57	< 0.2–7.8	AGW125 Plume 1 N of AMB	5 2.4 0.49	EPA MCL MTCA SL_{nc} MTCA SL_c	2 3 16
cis-1,2-Dichloroethene	17/57	< 0.2–3.8	AGW067 Plume 1 N of AMB	70 16	EPA MCL MTCA SL_{nc}	0 0
Tetrachloroethene (PCE)	27/57	< 0.02–0.98	AGW118 S of Plume 1, Bldg 17-06	5	EPA MCL	0
Vinyl chloride	14/57	< 0.02–4.3	AGW152 Plume 2	2	EPA MCL	3

Contaminant	Number Detections	Range (µg/L)	Location of Maximum	Health-Based CV (µg/L)	Type of CV	Number Detections > CV
trans-1,2-Dichloroethene	1/57	< 0.2–0.5	AGW025 Plume 2	100	EPA MCL	0
Shallow Zone Bore Hole Grab Samples (Aug–Nov 2010 and June 2011)						
Trichloroethene (TCE)	7/8	< 0.2–8.6	AGW177 Plume 2	5 2.4 0.49	EPA MCL MTCA SL_{nc} MTCA SL_c	2 5 7
cis-1,2-Dichloroethene	7/8	< 0.2–6.5	AGW179 Between Plume 1&2	70 16	EPA MCL MTCA SL_{nc}	0 0
Vinyl chloride	7/8	< 0.02–6.1	AGW164 Plume 2	5	EPA MCL	2
Tetrachloroethene (PCE)	6/8	< 0.02–0.11	AGW182 W of Plume 2	2	EPA MCL	0
trans-1,2-Dichloroethene	3/8	< 0.2–0.2	AGW182 W of Plume 2	100	EPA MCL	0
Intermediate Zone Monitoring Wells						
Trichloroethene (TCE)	43/49	< 0.2–14	AGW145 Plume 2	5 2.4 0.49	EPA MCL MTCA SL_{nc} MTCA SL_c	12 24 41
cis-1,2-Dichloroethene	35/49	< 0.2–9.3	AGW156 Plume 2	70 16	EPA MCL MTCA SL_{nc}	0 0
Vinyl chloride	22/49	<0.02–9.4	AGW155 Plume 2	5	EPA MCL	1
Tetrachloroethene (PCE)	16/49	<0.02–0.47	AGW057 S of Plume 1 & AMB	2	EPA MCL	0
trans-1,2-Dichloroethene	6/49	<0.2–1.2	AGW145 Plume 2	100	EPA MCL	0
Deep Zone Monitoring Wells						
Trichloroethene (TCE)	15/17	< 0.2–5.1	AGW178 Plume 2	5 2.4 0.49	EPA MCL MTCA SL_{nc} MTCA SL_c	3 8 14
cis-1,2-Dichloroethene	7/17	< 0.2–2.6	AGW167 Plume 2	70 16	EPA MCL MTCA SL_{nc}	0
Vinyl chloride	5/17	<0.02–0.32	AGW167 Plume 2	5	EPA MCL	0
Tetrachloroethene (PCE)	4/17	<0.2–0.11	AGW167 Plume2	2	EPA MCL	0
trans-1,2-Dichloroethene	2/17	<0.02–0.3	AGW146 AGW167 Plume 2	100	EPA MCL	0

* No evidence currently exists indicating that the public drinking water supply draws contaminated water from the Boeing Auburn Plant site.
CV – Health-based comparison value
EPA MCL – U.S. EPA and Washington State primary Maximum Contaminant Level
MTCA SL – Washington State Model Toxics Control Act (MTCA) B and/or C screening levels for non-carcinogenic and carcinogenic effects
VOC - Volatile organic chemical

Chemicals of Potential Concern–Indoor Air and Outdoor Air

Indoor Air–Indoor air concerns involve the same chemicals of potential concern described in the groundwater. Limited soil vapor data exists to characterize the movement of these contaminants from the shallow zone of the upper aquifer into the surrounding soils. The movement of vapors from the shallow groundwater (less than 30 feet bgs) and soil into overlying buildings can result in impacts to indoor air quality.

Currently, the highest concentrations of TCE in the shallow zone of the upper aquifer in the area of Plume 1 occurs north of the AMB distribution center (7.8 µg/L, south of the YMCA). Off Boeing's property to the northwest, grab samples taken while boring intermediate or deep wells had TCE detected in them. The highest concentration in Plume 2 was 8.6 µg/L (Landau Associates 2010b). These are preliminary data and Boeing will continue to install wells near the site to determine the extent of contamination in the shallow groundwater. Uncertainty regarding the source and migration of the VOCs over time at this location confounds the understanding of these results. However, both of these areas of shallow groundwater contamination may affect indoor air in overlying buildings. A summary of soil gas sampling, vapor intrusion modeling, and sub-slab sampling data is in Table 2 and a detailed description of these studies is further detailed in Appendix B. Preliminary grab sampling of shallow groundwater near residences in northeast Algona in September 2011 resulted in low concentrations of TCE (1.2 µg/L) (Landau Associates 2011d, personal communication).

Indoor air risk from hypothetical vapor intrusion modeling was completed before the YMCA and AMB buildings were built. Although the modeling efforts conducted by Boeing in 2004, AMB in 2005, and Ecology in 2006 were a useful tool for estimating the potential groundwater to indoor air pathway at the time, the scientific understanding of the vapor intrusion pathway is more advanced. A discussion of the results from these models is provided in Appendix B. An updated evaluation of the vapor intrusion pathway for the YMCA and AMB buildings should be performed using updated guidance, current building parameters, and the most recent groundwater data.

In 2011, preliminary samples from sub-slab vapor sampling under Building 17-07 on the Boeing property were collected to determine the source of VOCs for Plume 2 (Landau Associates 2011b). A summary of this data is located on Table 2. The highest TCE levels below the building were 1,010 and 168 µg/m^3. PCE was detected slightly more frequently but typically at lower concentrations than TCE, the highest concentrations were 220 and 125 µg/m^3. Indoor air testing has not yet been conducted to determine how much PCE or TCE, if any, is entering indoor air.

Table 2. Concentrations of selected VOCs from soil gas sampling and preliminary sub-slab vapor sampling near the Boeing Commercial Airplane Fabrication Division, Auburn Plant, King County, Washington

Chemical of Concern	Number detections	Range ($\mu g/m^3$)	Number detections	Range ($\mu g/m^3$)
Soil Gas at YMCA property (URS 2003)				
	5 ft bgs		**12 ft bgs**	
Trichloroethene (TCE)	1/5	<4.0–7.8	2/5	< 7.3–90
Tetrachloroethene (PCE)	4/5	< 5–660	3/5	< 4.8–3000
cis-1,2-Dichloroethene	0/5	< 2.9	1/5	< 5.4–14
Sub-slab vapor at Building 17-07 (Landau Associates 2011b)				
Trichloroethene (TCE)	9/27	< 6.9 –1,010	–	–
Tetrachloroethene (PCE)	13/27	< 8.8 –220	–	–
Vinyl chloride	0/27	<4.2	–	–
cis-1,2-dichloroethene	4/27	<6.5 –40.4	–	–
trans-1,2-dichloroethene	20/27	<6.5 –74.7	–	–
1,1-dichloroethane	7/27	<6.6 –185	–	–
1,1-dichloroethene	1/27	<6.5 –7.1	–	–
1,1,2,2-tetrachloroethane	2/27	<11.2–5.0	–	–

Outdoor Air and Air in Confined Spaces–No outdoor air data characterizing the solvent concentrations near the site exist. Solvents have only been identified in water located underground. More information is needed to determine if contaminated groundwater discharges into surface waters. TCE has a high tendency to volatilize from water and efficient transfer of TCE to the atmosphere is possible. The evaporation half-life of TCE in water is on the order of 20 minutes at room temperature (Dilling 1975; Dilling et al 1975). If TCE and other compounds were to end up in surface water, outdoor air conditions in the northwest would likely result in quick evaporation of TCE from the water followed by dilution and dispersion in the air. Breathing outdoor air near slightly contaminated surface waters would likely result in very low to non-existent exposures.

No trench air or outdoor confined space air data currently exists as trenches near the site are not being excavated. The depth to shallow groundwater in Boeing's wells ranges from 7 to 20 feet deep. Digging a ditch or trench could reach groundwater, if it is excavated deep enough. TCE as a gas is heavier than air and will tend to sink into low-lying areas if there is no air movement. Solvent vapors may also be released from the surrounding soils, if present, and enter into the trench. Considering that the highest concentration in the shallow groundwater measured at this time is 8.6 µg/L, this level of contamination is not likely to result in air concentrations of concern, as discussed in the Health Effects section. A preliminary air-partitioning model predicted that groundwater concentrations at or below 65 µg/L would not result in a health risks to excavation workers (Landau Associates 2011d); however, this model has not been validated or evaluated thoroughly by DOH. Though conservative assumptions were used, this model did not use chemical-specific inputs or incorporate input from vapors in surrounding soils.

Exposure Pathways

This section examines how people might become exposed to site contaminants and to characterize the size and susceptibility of the potentially exposed populations.

Exposure Routes–This evaluation considered three routes of exposure: 1) swallowing (ingestion), 2) skin contact (dermal), and 3) breathing in (inhalation) vapors from water that may be contaminated from the site.

- There is no known direct exposure expected from ingestion, dermal contact, or breathing in vapors from drinking or using tap water. Currently there is no evidence indicating that municipal Group A and smaller Group B wells draw from the areas of the upper aquifer that are contaminated with VOCs at levels that exceed the federal MCL (DOH ODW 2011, Landau Associates 2010).

  However, there may be private wells which draw from the contaminated upper aquifer that have not been identified. People using unknown private wells could be exposed by ingestion, contact with water, or breathing volatilized solvents if they draw from the contaminated portion of the upper aquifer.

- Should levels in the shallow zone of the upper aquifer contain elevated levels of volatile organics, like TCE and PCE, vapors could evaporate from water into the soil. If this occurs under or near a building, vapors may accumulate under the building instead of off-gassing into the air. If vapors move into buildings through cracks or openings in the foundation, indoor air quality may be affected. This is a potential route of exposure.

- Should levels in the shallow zone of the upper aquifer be elevated and exposed to open air during digging or trench work, workers could potentially touch the water or breathe volatile organics that have the potential to evaporate from water or soil into outdoor air. This is a potential route of exposure. Likewise, discharge of shallow contaminated water to surface waters, may also result in volatilization which may be respired.

Potentially Exposed Populations–Specific populations that might potentially be exposed to contaminants in the groundwater plumes associated with Boeing activities include the following:

- **Residents**–People in the valley use public drinking water that does not appear to draw from the contaminated portion of the aquifer. However, more work is needed to confirm the extent of the contamination. People may have used or be using water from unknown private wells that draw from the contaminated portion of the upper aquifer. No private wells were identified in the critical well-head survey completed by Boeing (Landau Associates 2010b). Residences located over shallow contaminated groundwater may have solvent vapors moving into their homes depending on individual building features. Depending on results from future shallow groundwater sampling, this is a potential exposure pathway.

- **Construction Workers**–People working in the construction trade might be exposed by coming into contact with chlorinated solvents in shallow groundwater, breathing soil gas, and/or breathing evaporated solvent vapors if working in utility trenches, excavations, etc. located close to the shallow contaminated plumes. These exposures would be for less than 8 hours per day in duration for a short length of time (presumably less than 90 days) as work of this nature is usually job specific. Chronic exposures are not likely to occur. This is a potential exposure pathway.
- **Workers in Buildings**–People working in buildings at Boeing or off-property (i.e., YMCA, Junior Achievement, AMB, or other commercial buildings to the east and north) near the shallow contaminated water may be exposed to vapors moving from the shallow aquifer through the soil and into building spaces. Proximity of the groundwater to the surface allows for a greater potential for evaporation of VOCs from water into soil or directly into the air. Maintenance workers with specialized job duties associated with machinery in the lower levels of buildings may be more exposed. Groundwater levels underneath Boeing Building 17-07 have been reported as too close to the sub floors of this building for vapor sampling in April 2011. Sub-slab vapor sampling has been postponed until lower water levels occur in the fall (Landau Associates 2011b). If water levels are right below the slab, then indoor air testing should be conducted during that time period as well. VOC-containing vapors could be migrating through cracks and other openings in the slab. Depending on results from future indoor air sampling, this is a potential exposure pathway.
- **Children in Daycare in Buildings–**Children in day care at the YMCA and/or Junior Achievement) buildings may be exposed to vapors that have moved into indoor spaces. The amount of time spent in the building can depend on: duration of care per day ranging from 4–10 hours a day; frequency of daycare at the facility ranging from 2 days a week, to 1-week summer camps, to all year long; length of time spent indoors; and time of year. These buildings are relatively new (built around 2005) and assumed to have current standard air circulation and ventilation systems that allows for adequate air exchange. Depending on future indoor air evaluations, this is a potential exposure pathway.
- **Recreational Users of YMCA or Junior Achievement Buildings**–People, especially children, visiting the YMCA or Junior Achievement buildings may be exposed from vapors migrating from the shallow aquifer through the soil and into building spaces during recreational visits. Duration of exposure would be up to two hours per day. As mentioned above, these are relatively new buildings. Depending on future indoor air evaluations, this is a potential exposure pathway.

In summary, the exposure evaluation identified uncertainties regarding the following pathways: 1) the unknown use of water from private wells that potentially draw from the contaminated plumes; 2) the potential for vapor intrusion, especially within buildings above the shallow contaminated groundwater on or off the Boeing facility; and 3) the potential for incidental contact with shallow contaminated groundwater or inhalation of vapors from discharge to surface waters or during short-term construction projects that involve digging into the ground near the site. Thus these three pathways will be screened in the following Health Effects Evaluation section.

Community Exposure Concerns

In the community surrounding the site, concerns have been raised about exposure to contaminated groundwater in their backyard. Specifically, some residents in Algona are concerned that when they dig in their yards (less than two feet), the hole fills with water. Water encountered at shallow depths may be locally perched groundwater meaning it is not directly connected to the main aquifer system that is typically encountered below at least seven feet deep on the Boeing site. Thus, it is unlikely that water within two feet of the surface is directly connected to the contaminated water. Furthermore, most of the buildings in Algona and Auburn above the contaminated portion of the shallow groundwater are commercial or industrial in nature, not residential. More work is needed to better understand discharge from the shallow groundwater into surface waters such as the wetland or ditches.

Health Effects Evaluation

The health effects evaluation consists of two pieces 1) a screening analysis and discussion of community health concerns, and if needed, 2) a more in depth analysis to determine possible public health implications of site-specific exposures.

Screening Analysis

To evaluate the likelihood of possible harmful effects, the screening process determines which chemicals need more in-depth evaluation. For completed and potential exposure pathways, the exposure point concentrations are compared to health-based comparison values. Comparison values are concentrations set well below levels that result in adverse health effects. If a chemical exceeds its comparison value it does not mean an adverse health outcome will result. Instead a more in-depth analysis is required.

There is no evidence which currently suggests that people are drinking from contaminated portions of the upper aquifer. There is no evidence which currently suggests that people are breathing indoor air or outdoor air contaminated with solvents that have evaporated from the shallow zone of the upper aquifer; however, the potential exists and further study is needed. Until exposure pathways are shown to be complete, a more in-depth analysis of exposure cannot be performed at this time.

Table 1 compares the concentrations of volatile organics in the plume (from the most recent round of sampling) to the federal (U.S. Environmental Protection Agency) drinking water standards for public water supplies and the state regulatory standards for potential cleanup. PCE, TCE, and their breakdown products in groundwater are listed.

Health Effects for Chemicals of Concern

Until exposure pathways are shown to be complete, there are no chemicals of concern. Therefore further examination of chemical-specific toxicity is not reported here. Normally this section would compare site-specific exposure to observed adverse effect levels in scientific studies. The following discussion is general information only and limited to the three compounds found elevated at the site: TCE, vinyl chloride, and PCE.

Trichloroethylene (TCE) is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers. Tetrachloroethylene or perchloroethylene (perc, PCE) is a manufactured chemical used widely for dry cleaning fabrics and for metal degreasing. Boeing reportedly used TCE more than PCE. In the environment, PCE degrades to TCE. TCE degrades into other chlorinated compounds, including vinyl chloride. Vinyl chloride is used elsewhere to make poly vinyl chloride (PVC) found in a variety of plastic products including pipes, wire, cable coatings, and packaging materials. All three of these compounds evaporate easily into the air and have been found in ambient air, surface water, and groundwater throughout the U.S.

For public water systems the U.S. EPA set the primary Maximum Contaminant Level (MCL) at 5 µg/L for TCE and PCE and at 2 µg/L for vinyl chloride. Triggering the MCL would require more rigorous monitoring and additional treatment to reduce the VOCs if levels remained elevated. If long-term exposure were to occur, adverse effects would vary depending on the amount and duration of exposure. The extent of health effects is not clear and scientists continue to research how these chemicals affect us. For further information regarding the health effects of these and other chemicals visit ATSDR's website about contaminant's found at hazardous waste sites at http://www.atsdr.cdc.gov/toxprofiles/index.asp.

In considering short term exposures to outdoor air, ATSDR established an acute inhalation minimum risk level (MRL) of 2 ppm (10,800 µg/m^3) (ATSDR 2003). Adverse effects in people exposed at this level for 14 days or less are not expected to occur. The acute MRL is based on temporary effects to the nervous system. Air concentrations in trenches from volatilized solvents are unlikely to reach this high level, based on low groundwater concentrations and soil gas samples. The recognition odor threshold for TCE is 110 ppm (591,000 µg/m^3), which is slightly higher than the Occupational Safety and Health Administration (OSHA) permissible exposure limit 100 ppm (537,000 µg/m^3) for an 8-hour work day. Thus if a worker smells TCE, the odor generally provides a potential indication of hazardous concentrations. These elevated concentrations will likely not occur considering the relatively low levels of TCE in the shallow groundwater plume. Acute inhalation MRLs for PCE and vinyl chloride are 0.2 ppm (1,360 µg/m^3) and 0.5 ppm (1,280 µg/m^3), respectively (ATSDR 1997, 2006). Both of these compounds are found at much lower concentrations than TC E in the contaminated groundwater and are also not likely to result in high inhalation exposures.

Child Health Considerations

Based on the well protection survey completed by Boeing (Landau Associates 2010b) and low groundwater levels of VOCs below the YMCA (Landau Associates 2011b, URS 2003), DOH does not expect that children are being exposed to contaminants found in the upper aquifer. However, an updated evaluation of the vapor intrusion pathway is needed to confirm this. Steps should be taken to prevent potential future exposures because children can be uniquely vulnerable to the hazardous effects of environmental contaminants, like solvents, when found in indoor air. When compared to adults, pound for pound of body weight, children breathe more air. This can lead to an increased exposure to contaminants. While young children appear to be the most vulnerable, scientists continue to explore vulnerabilities at all growth stages, including adolescence.

Conclusions

1. **DOH concludes that chlorinated solvents and related breakdown products found in the groundwater deeper than 40 feet below ground surface, but above the Osceola Mudflow near the Boeing Auburn Plant, will not harm people's health because people are not drinking or using this contaminated water. As Boeing continues to define the source, edges, and depth of the contaminated water, DOH will continue to verify that people are not being exposed.**

   The Osceola Mudflow, located dozens of feet below the surface in this area, consists of clay-rich deposits from a large lahar (a volcanic mudflow) originating at Mount Rainier about 5,700 years ago. Water does not easily flow through the Osceola Mudflow, which separates the groundwater above and below it into two separate portions of the aquifer. A review of water quality data from monitoring wells near the Boeing Auburn Plant identified a portion of the upper aquifer that is contaminated with chlorinated solvents.

   TCE, vinyl chloride, PCE, and cis-DCE have been identified in the shallow (10 to 30 feet bgs), intermediate (40 to 60 feet bgs), and deep zones (80 to 100 feet bgs) of the upper aquifer below and beyond the Boeing Auburn Plant. The groundwater in the valley is generally moving toward the north at a high flow rate with likely recharge from the White River just south of the Boeing Auburn Plant. Well systems serving 15 or more connections that are closest to the contaminated water are to the east. Drinking water wells drawing groundwater from deeper than 40 feet bgs do not appear to draw from contaminated water. Based on water quality data submitted to DOH, all but one of the well systems in the valley have no TCE, PCE, and related breakdown products in them. The Auburn Park Community well has reported decreasing TCE levels in the past few years; this well has never had concentrations that pose a health threat. Based on the direction of groundwater flow, this well does not appear to be drawing contaminated water from the Boeing Auburn site. According to records submitted to DOH, the approximate locations of wells serving fewer than 15 connections are to the east or much farther north and northwest of the currently identified plume boundary. Owners are not required to monitor for most chemical contaminants, including chlorinated solvents. Preliminary discussions between Boeing's contractor and personnel from the Cities of Auburn, Algona, and Pacific did not identify any other private wells that draw groundwater from within the contaminated plume. However, unknown private wells may exist.

   Boeing identified two separate groundwater plumes. Plume 1 originated from a now-remediated source beneath the former Building 17-05 (currently AMB's distribution center). The plume has undergone bioremediation in the shallow zone of the upper aquifer. Concentrations of VOCs in the shallow zone have decreased over time and most of the plume is now mostly limited to the intermediate zone. The plume is about 0.8 miles in length.

Plume 2 appears to have originated somewhere below Buildings 17-06, 17-07, 17-12, 17-10, or the waste water treatment plant; however, investigations have not yet ruled out the possibility that the source is further up gradient to the southeast. Boeing is conducting sub-slab vapor sampling and installing additional monitoring wells to determine the source. It is possible this is a historical (not ongoing) release. The western, eastern, and northern boundaries of the plume have not been completely identified. Plume 2 is more than 1.8 miles in length south to north and comingles with Plume 1 to the north off the Boeing property.

Public drinking water wells draw water from the upper aquifer outside of the plumes identified to be above the federal MCL. These wells do not appear to be down gradient of the currently defined plume. Based on current data, there is not a public health concern regarding public drinking water related to the Boeing solvent releases.

The north and northwest boundaries down gradient of Plume 2 have not been identified. No public wells exist in the down gradient area of the intermediate zone. The closest well down gradient to the plume is a Group B well, approximately 1.6 miles to the north. No data on VOC concentrations in this well exist. Based on current data, there is not a public health concern, but efforts to identify and monitor the boundary should continue. In addition, other areas of VOC contamination of the aquifer may exist in the valley and may confound the identification of Boeing Auburn plant as the source. DOH supports Ecology's request that Boeing locate and monitor the boundaries of the plumes.

2. **DOH cannot determine whether chlorinated solvents and related break down products from the Boeing Auburn Plant are found in groundwater below the Osceola Mudflow. The information we need to make this determination is not available. There are no monitoring or drinking water wells that draw from this portion of the aquifer near the Boeing Auburn Plant. However, deep groundwater contamination is unlikely. DOH is working with Ecology, Boeing, and the City of Auburn to determine if more information is needed to better understand the extent of the Osceola Mudflow to confirm that future exposure does not occur.**

   The upper aquifer is contaminated near the Boeing Auburn Plant. The deeper aquifer below the Osceola Mudflow has no monitoring wells drilled through it near the Boeing Auburn Plant. Thus the water quality status of the deeper aquifer in this area is not known. Water does not easily flow through the Osceola Mudflow, therefore deeper aquifer contamination is unlikely. Should a passage be created between the upper and deeper aquifer by drilling wells through the Osceola Mudflow, TCE-contaminated water, may follow these passages down and enter the deeper aquifer. Water quality data reported from local wells serving 15 or more connections that draw from this deeper aquifer elsewhere in the valley do not have reported detections of chlorinated solvents. There is some uncertainty about the consistency and extent of the Osceola Mudflow in the area of contamination.

3. **DOH cannot determine at this time if people are breathing indoor air containing chlorinated solvents that have evaporated from groundwater at the top of the water table and moved into a building through cracks or holes in the foundation. The**

information we need to determine if exposure is occurring is not available. Historical modeling indicates that harm to people's health from this route is not likely to occur. DOH is working with Boeing and Ecology to gather current information about buildings that lie over the shallow groundwater plume with highest concentrations at the water table.

Indoor air quality data were not available at the time of this evaluation; therefore, no definitive conclusion can be made regarding exposure. TCE has been identified in the groundwater at the water table (10– 30 feet bgs) near or below buildings; however, better shallow groundwater data is needed to understand the extent and concentration of this contamination and the potential for it to evaporate and move up and into buildings. Historical sampling of soil gas and past vapor intrusion modeling for former or planned buildings over the shallow plume source indicated that no health threat existed at that time. However, more is known about assessing the vapor intrusion pathway today than was known when these buildings were assessed in 2003 through 2006. An updated evaluation of the vapor intrusion pathway is necessary to evaluate potential health risks at the AMB Property Corporation, YMCA, and Junior Achievement buildings as well as other buildings located over the highest contaminated areas of the shallow groundwater plume. Current vapor data collected below Boeing's Building 17-07 (sub-slab vapor sampling) suggest levels of TCE and PCE are elevated below this building. Planned indoor air sampling at this building by Boeing will help determine if people working in this building are being exposed.

4. **DOH cannot determine at this time if chlorinated solvents from the Boeing Auburn site in off-property shallow groundwater could harm people's health. Adequate information to make a decision is not available. People touching or breathing in vapors from discharge of shallow contaminated groundwater below the Boeing property is not expected to harm people's health because the potential concentrations in the air would be below levels of health concern. DOH is working with Ecology and Boeing to gather the off-property information needed.**

   In order to reach a conclusion, DOH needs more information about levels of chlorinated solvents in the shallow groundwater (< 30 feet bgs) off Boeing's property. In addition, more information is needed about the potential for shallow groundwater to discharge to surface water and the levels of chlorinated solvents in surface water. Concentrations of TCE in shallow groundwater below the Boeing facility have decreased over time and are considered to be low. If this contaminated water below Boeing's property discharged to surface waters or if future activities led to digging trenches deep enough to reach shallow contaminated groundwater, no harm is expected for people breathing, touching, or incidentally swallowing this water for short amounts of time.

Recommendations

1. Boeing should continue to identify the source and boundaries of the solvents in the impacted groundwater. On-going well sampling and analyses should be conducted to monitor the chlorinated solvent concentrations in the plumes to determine if they are decreasing.

2. Boeing should complete a private well survey in conjunction with municipalities to identify locations of private wells that may exist within the known area of the plumes and in areas of uncertainty. Exact locations of group B wells located down gradient of the plume will be identified.

3. Boeing should assess indoor air quality in Building 17-07 and complete an updated evaluation of the vapor intrusion pathway for the YMCA and AMB buildings. Ecology will facilitate the evaluation of the vapor intrusion pathway for buildings located over contaminated shallow groundwater off Boeing's property. Depending on these results, further sub-slab and indoor air quality testing may need to be conducted.

4. As a part of Boeing's planned public notification process, Boeing should inform offsite property owners, municipalities, water utilities, and the local health department that impacts of chlorinated solvents to the deeper aquifer below the Osceola Mudflow are unknown. Boeing should include information on the potential risk of cross contamination when drilling into the deeper aquifer. Ecology should communicate this concern on their "Well Construction Information for Drillers" website. DOH will work with Ecology, Boeing, and the City of Auburn to better understand the extent of the Osceola Mudflow in this area.

5. Boeing will continue to assess shallow groundwater concentrations near the site. In addition, more work will be done to better understand shallow water discharge to surface waters.

Public Health Action Plan

1. Ecology is working with the Boeing Company to ensure that DOH recommendations are followed.

    a. Identify the source of Plume 2.

    b. Define the boundaries of the two plumes in the shallow, intermediate, and deep zones of the upper aquifer.

    c. Perform appropriate well monitoring to assess changes in plume concentrations

    d. Assess indoor air quality in Building 17-07.

    e. Better understand the extent of shallow groundwater contamination and potential discharge to surface waters.

    f. Complete an updated evaluation of buildings at the YMCA, AMB, and other properties located over the contaminated shallow groundwater to determine indoor air risk from vapor intrusion.

    g. Compare well logs with those of the City of Auburn to determine if more information is needed to better understand the extent of the Osceola Mudflow.

2. Until monitoring wells have been installed, Boeing will annually review water quality data of public wells near areas of plume boundary uncertainty to the east to verify that chlorinated solvent concentrations are not affected by the contaminated plume.

3. Boeing will identify locations of private wells that may exist within areas of the plumes and in areas of plume boundary uncertainty. Exact locations of Group B wells located down gradient of the plume will be identified.

4. DOH will review water quality data reports and future vapor investigation plans or reports if requested by Ecology or other interested parties.

5. A copy of this health consultation report will be provided to Ecology, King County Public Health, King County Public Library of Auburn and Algona-Pacific, and the Cities of Auburn, Algona, and Pacific and other nearby Group A and B water system management.

6. A copy of this health consultation report will be placed on the DOH site assessment website: http://www.doh.wa.gov/consults

Report Preparation

This Health Consultation for the Boeing Commercial Airline Fabrication Division site in Auburn, Washington was prepared by the Washington Department of Health (DOH) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner (DOH).

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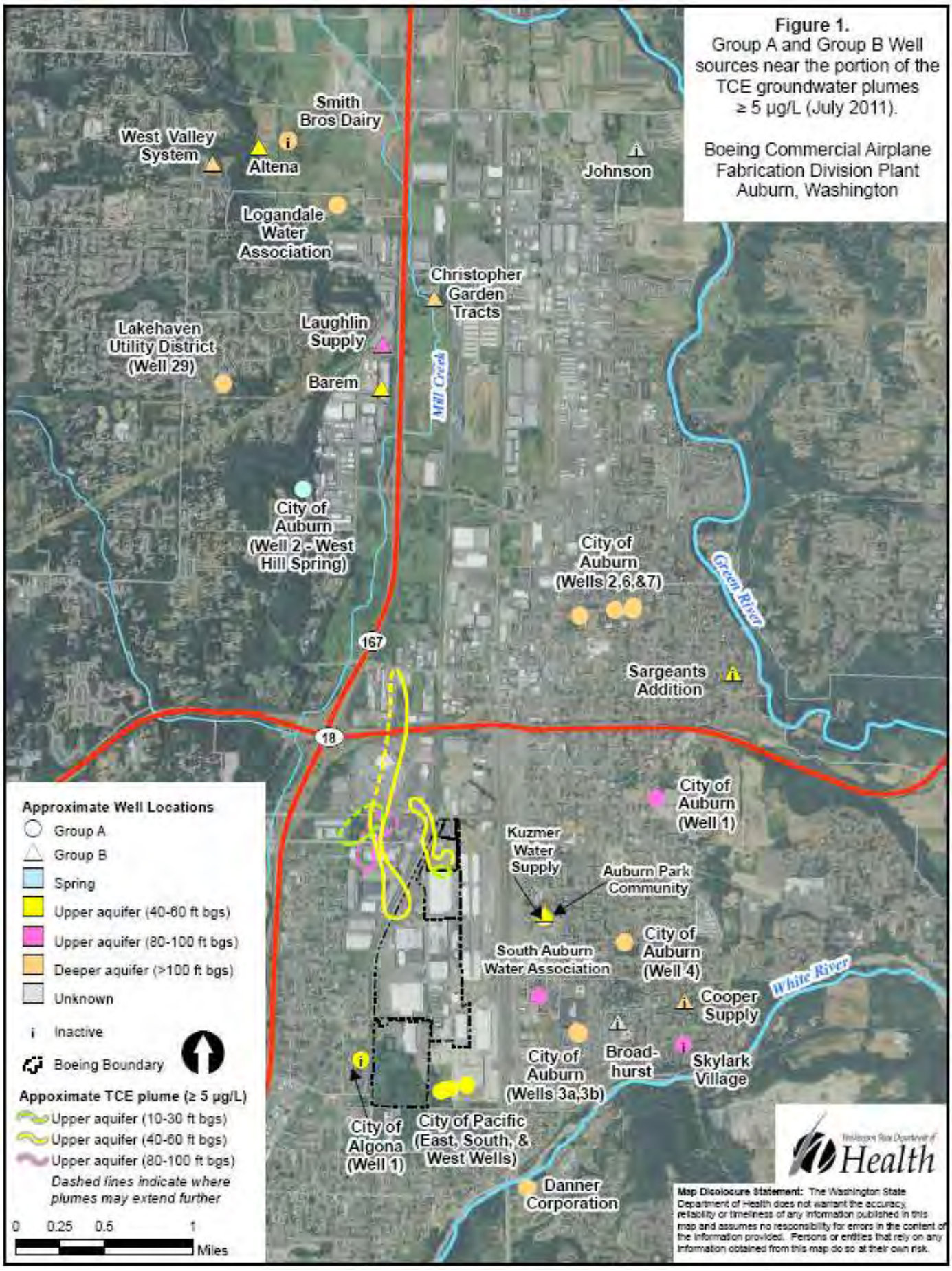
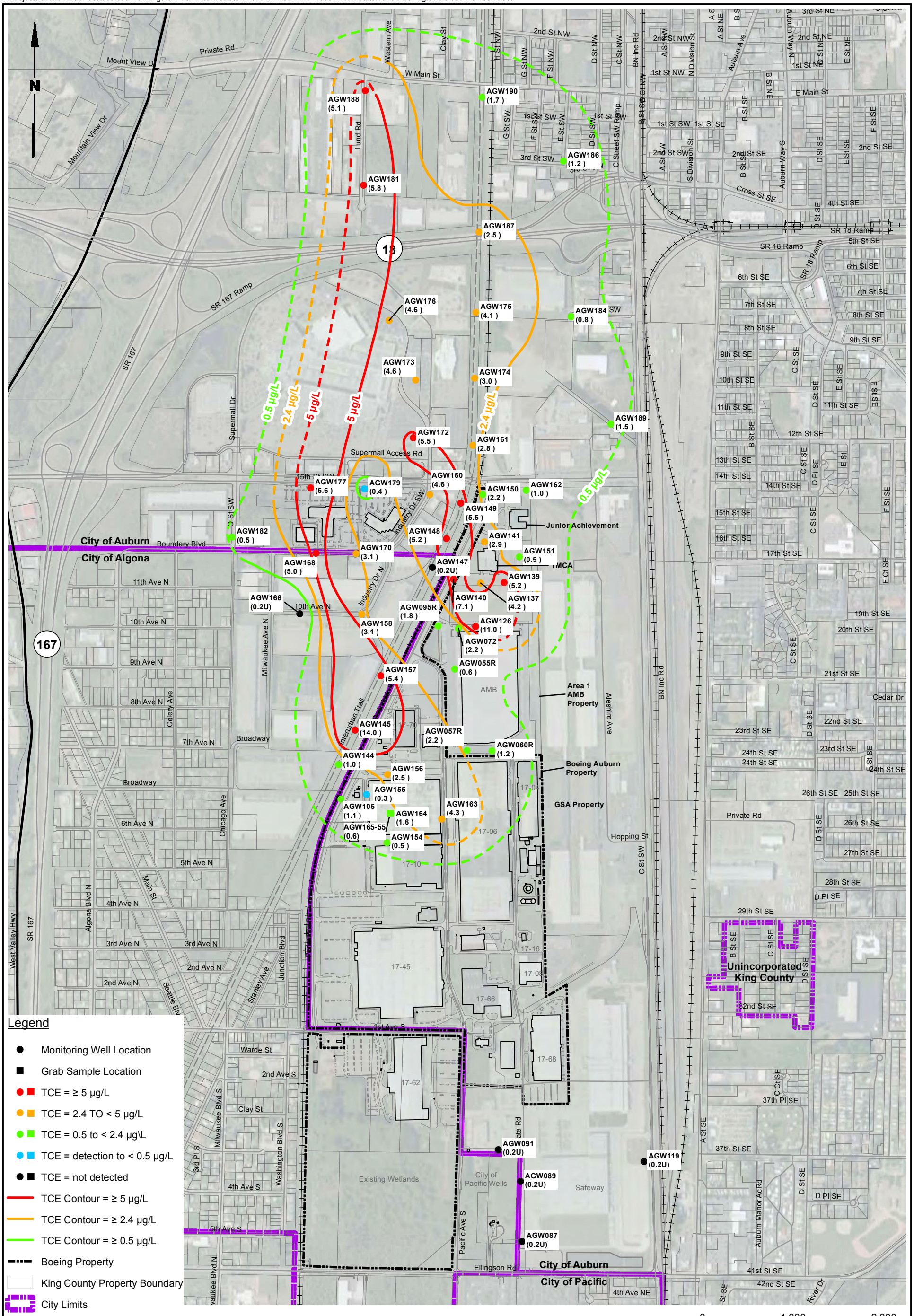


Figure 1.
Group A and Group B Well sources near the portion of the TCE groundwater plumes ≥ 5 µg/L (July 2011).
Boeing Commercial Airplane Fabrication Division Plant Auburn, Washington
Smith Bros Dairy
West Valley System
Altena
Johnson
Logandale Water Association
Christopher Garden Tracts
Lakehaven Utility District (Well 29)
Laughlin Supply
Barem
Mill Creek
City of Auburn (Well 2 - West Hill Spring)
City of Auburn (Wells 2,6,&7)
Green River
167
Sargeants Addition
18
City of Auburn (Well 1)
Kuzmer Water Supply
Auburn Park Community
South Auburn Water Association
City of Auburn (Well 4)
White River
Cooper Supply
Broad-hurst
Skylark Village
City of Auburn (Wells 3a,3b)
City of Algona (Well 1)
City of Pacific (East, South, & West Wells)
Danner Corporation
Approximate Well Locations
Group A
Group B
Spring
Upper aquifer (40-60 ft bgs)
Upper aquifer (80-100 ft bgs)
Deeper aquifer (>100 ft bgs)
Unknown
Inactive
Boeing Boundary
Appoximate TCE plume (≥ 5 µg/L)
Upper aquifer (10-30 ft bgs)
Upper aquifer (40-60 ft bgs)
Upper aquifer (80-100 ft bgs)
Dashed lines indicate where plumes may extend further
0 0.25 0.5 1
Miles
Washington State Department of Health
Map Disclosure Statement: The Washington State Department of Health does not warrant the accuracy, reliability or timeliness of any information published in this map and assumes no responsibility for errors in the content of the information provided. Persons or entities that rely on any information obtained from this map do so at their own risk.

Y:\Projects\025164\MapDocs\080.083\DOH\Figure 2 TCE Intermediate.mxd 12/12/2011 NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet



Legend

- Monitoring Well Location
- Grab Sample Location
- TCE = ≥ 5 µg/L
- TCE = 2.4 TO < 5 µg/L
- TCE = 0.5 to < 2.4 µg\L
- TCE = detection to < 0.5 µg/L
- TCE = not detected
- TCE Contour = ≥ 5 µg/L
- TCE Contour = ≥ 2.4 µg/L
- TCE Contour = ≥ 0.5 µg/L
- Boeing Property
- King County Property Boundary
- City Limits

Notes

1. Dashed TCE Contour lines indicate where plume boundaries are uncertain.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Base map source: Geometrix 2003; Aerial Photo Source: I3_Imagery_Prime_World_2D; Parcel Data Source: King County GIS 2010

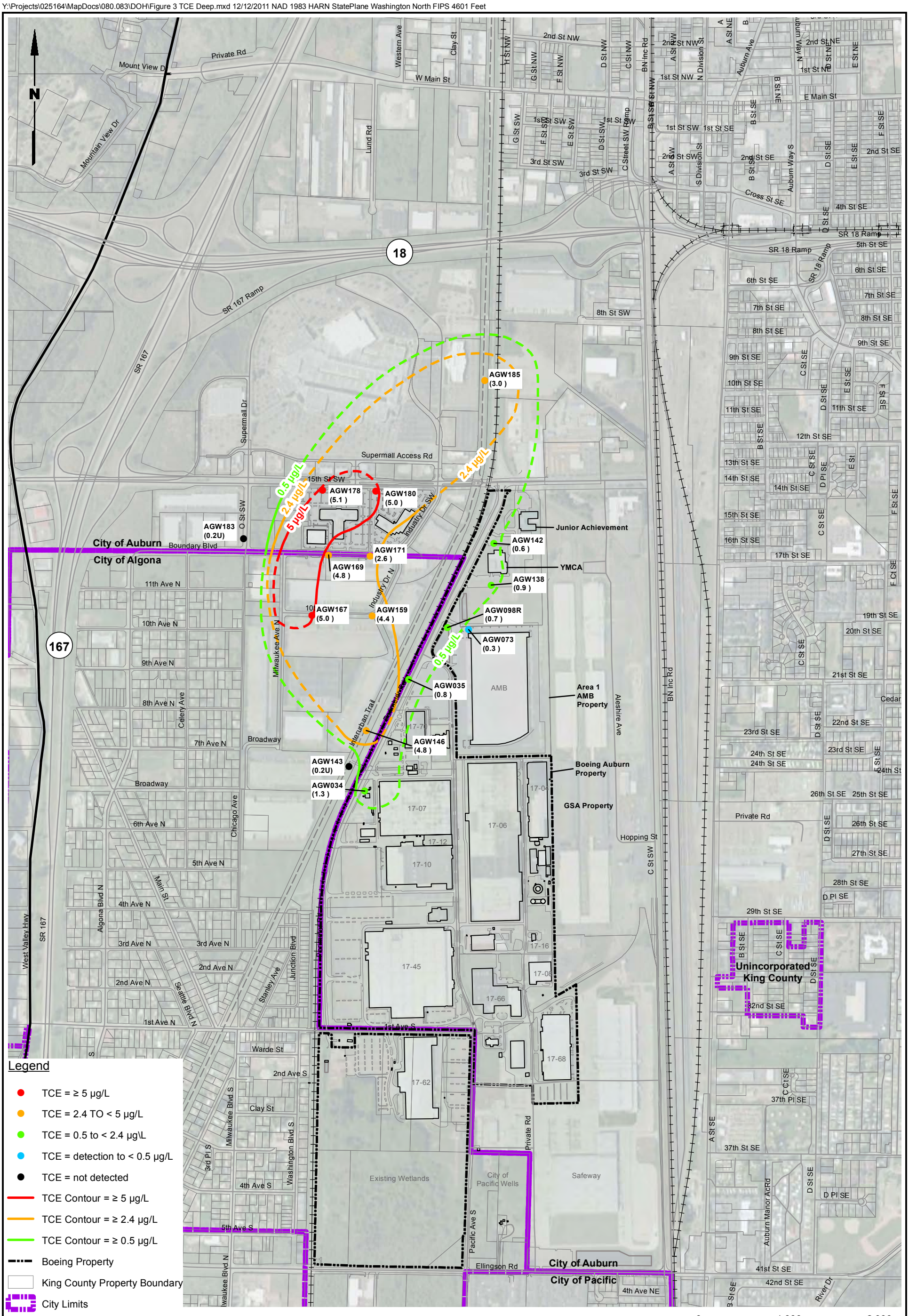
LANDAU ASSOCIATES

Boeing Commercial Airlines
Fabrication Division
Auburn, Washington

Intermediate (40-60 ft BGS) Monitoring Well and Grab Sample Results for Trichloroethene June 2011

Figure 2

Y:\Projects\025164\MapDocs\080.083\DOH\Figure 3 TCE Deep.mxd 12/12/2011 NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet



Notes

1. Dashed TCE Contour lines indicate where plume boundaries are uncertain.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Base map source: Geometrix 2003; Aerial Photo Source: I3_Imagery_Prime_World_2D; Parcel Data Source: King County GIS 2010

LANDAU ASSOCIATES

Boeing Commercial Airlines
Fabrication Division
Auburn, Washington

Deep (80-100 ft BGS) Monitoring Well Results for Trichloroethene June 2011

Figure 3

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Appendix A – Well Information and Water Quality Data for Public Water Supplies near the Boeing Auburn Plant

Appendix A. Information on wells located near the Boeing Commerical Airline Fabrication Plant, Auburn, King County, Washington [a,b]
Table 1.

DOH PWS ID	Group Type	System name	System Type	System Status	PWS Population served	PWS Total Connections	Source Name	DOH Source No.	Source Type	Source Use	GPM	Source Depth (ft bgs)	Screen Interval (ft bgs)	Water Level	Elevation	Location Determ-ination [c]	VOCs Ever Reported (Yes/No)	Direction from plumes	Notes (treatment before use, distribution, activity, other contaminants, etc.)
Currently Active Systems																			
01450	A	City of Algona [d]	Comm	Active	2590	1022	Well 1	01	W	P	NA	45				Estimated	No	SE	Decomissioned (removed in 1997)
03344	A	Auburn Park Community LLC	Comm	Active	189	91	Well 1	01	W	P	60	52				GPS	**Yes**	E	No treatment; mobile home park
03350	A	City of Auburn [d]	Comm	Active	**50962**	21941	Well 1	03	W	S	1400	133				GPS	No	E	Rarely used (no use since 1996 except briefly in 2010); no treatment
							Well 2	04	WW	P	1600	293	239-282	NA	64	GPS	**Yes**	NE	in WF, very deep
							Well 6	12	WW	P	1800	290 390	245-290 320-380	7 -	70 -	GPS	**Yes**	NE	in WF, very deep
							Well 7	11	WW	P	3500	303	235-295	11.5	NA	GPS	No	NE	in WF, very deep
							Wells 2,6 &7	14	WF	P	6900					Estimated	No	NE	Disinfection and corrosion control by air stripping (decreases VOC concentration prior to distribution)
							Well 3A	05	W	S	1500	365	285-360	112	39.1	GPS	No	SE	No use since 1998
							Well 3B	08	W	S	1500	375	307-369	39	NA	GPS	No	SE	No use since 1996
							Well 4	07	W	P	2600	356				GPS	No	E	Disinfection
							Spring 2 West Hill	02	SP	P	600	-				GPS	No	NW	Disinfection; on hill, spring
65300	A	City of Pacific [d]	Comm	Active	5770	2406	South Well	06	WW	P	1700	53	32-47	2.69	85	Estimated	No	S	in WF
							West Well	04	WW	P	925	56	46-56	6	79	GPS	No	S	in WF
							East Well	02	WW	P	825	47				GPS	No	S	in WF
							E, S & W Wells	07	WF	P	1700	47				Estimated	No	S	Disinfection and corrosion control by pH adjustment
06806	A	Danner Corporation	NTNC	Active	35	1	Well 1	01	W	P	30	260				GPS	No	SE	No treatment; south of White River
41997	A	Lakehaven Utility District [d]	Comm	Active	112000	29288	Well 29	35	W	S	250	650				GPS	No	NW	Rarely used; disinfection, filtration, and Fe/ Mn removal; on hill, very deep
47700	A	Logandale Water Association	Comm	Active	42	21	Well 1	01	W	P	45	182	172-182	NA	NA	GPS	No	N	No treatment
81400	A	South Auburn Water Association	Comm	Active	159	47	Well 1	01	W	P	110	92				GPS	**Yes**	SE	No treatment; home owners association, no storage (continuous pumping)
							Well 2	02	W	E	120	NA				Estimated	**Yes**[e]	SE	Rarely used; no treatment;
01962	B	Altena	Owner	Active	5	2	Well 1	01	W	P	25	60				GPS	NA	NW	No treatment
04200	B	Barem	Owner	Active	8	3	Well 1	01	W	P	NA	40				Estimated	NA	N	No treatment
12925	B	Christopher Garden Tracts	Owner	Active	10	4	Well 1	01	W	P	560	215		NA	NA	Estimated	NA	N	Disinfection
43280	B	Kuzmer Water Supply	Owner	Active	13	5	Well 1	01	W	P	100	61				Estimated	NA	SE	No treatment
46200	B	Laughlin Supply	Owner	Active	5	2	Well 1	01	W	P	NA	73				Estimated	NA	N	No treatment
AC655	B	West Valley Water System	Owner	Preactive	15	1	Well 1	01	W	P	20	193				Estimated	NA	NW	New well, not activated yet

DOH PWS ID	Group Type	System name	System Type	System Status	PWS Population served	PWS Total Connections	Source Name	DOH Source No.	Source Type	Source Use	GPM	Source Depth (ft bgs)	Screen Interval (ft bgs)	Water Level	Elevation	Location Determ-ination [c]	VOCs Ever Reported (Yes/No)	Direction from plumes	Notes (treatment before use, distribution, activity, other contaminants, etc.)
Historically Active Systems																			
03342	A	Skylark Village	Comm	Inactive	350	256	Well 1	01	W	P	250	98				Estimated	NA	SE	Inactive since 1988, no treatment, mobile home park
80450	A	Smith Bros Dairy	TNC	Inactive	10	5	Well 1	01	W	P	35	103				Estimated	NA	NW	Inactive since 1996, no treatment
							Well 2	02	W	P	NA	150				Estimated	NA	NW	Inactive since 1996, no treatment
							Well 1 (West)	03	W	P	50	263	248-263	NA	NA	Estimated	NA	NW	Inactive since 1997, disinfection
							Well 2 (East)	04	W	P	100	226	211-226	27	50	Estimated	NA	NW	Inactive since 1997, disinfection
							Well 3 (North)	05	W	P	100	73				Estimated	NA	NW	Inactive since 1997, disinfection
25751	B	Broadhurst	Owner	Inactive	5	6	Well 1	01	W	P	NA	NA				Estimated	NA	SE	Inactive since 2000, no treatment
14820	B	Cooper Supply	Owner	Inactive	20	6	Well 1	01	W	P	NA	550				Estimated	NA	SE	Inactive since 1982, no treatment
32201	B	Johnson	Owner	Inactive	5	2	Well 1	01	W	P	NA	NA				Estimated	NA	NE	Inactive since 2000, no treatment
76350	B	Sargeants Addition	Owner	Inactive	5	2	Well 1	01	W	P	20	40				GPS	NA	E	Inactive since 2006, no treatment

Source: DOH Office of Drinking Water Sentry database (2011), Ecology well logs (2011)

a - No evidence currently exists indicating that these wells draw from the portion of the aquifer containing selected VOCs from the Boeing Auburn Facility

b - State Reporting Level (SRL) for selected VOCs for drinking water compliance data is 0.5 ug/L

c - Location of wells were either determined by GPS or estimated within a quarter quarter section, section, or manually.

d - Only wells near Boeing facility listed, other wells may be associated with a public water supply

e - Well not monitored (rarely used) but assumed to have same levels as South Auburn Water Association Well 1 (draws from same location in aquifer)

DOH - Washington State Department of Health
BTEX - benzene, toluene, ethyltoluene, xylene
Comm - community well
E - well used only in emergency
ft bgs - feet below ground surface
Group A - more than 15 connections
Group B - less than 15 connections, serving less than 24 people; monitoring not required
NA - not available or unknown
NTNC - non-transient non-community such as industrial setting
P - permanent use
PWS ID - public water supply identification
S - seasonal use depending on demand
SP - spring source
TNC - transient non-community
VOC - volatile organic compounds (including trichloroethylene, perchloroethylene, cis-1,2-dichloroethylene, or vinyl chloride excluding trihalomethanes and BTEX)
W - well
WF - well field (water from different wells combined and treated together)
WW - well of a well field

Appendix A. Selected volatile organic chemicals (µg/L or ppb) in Group A wells near Boeing
Table 2. Commercial Airlines Fabrication Division, Auburn, King County, Washington [a,b,c]

System Well (DOH Source)	Auburn Well 2 (DOH 04)			Auburn Well 6 (DOH 12)			Auburn Well 7 (DOH 11)			Auburn Wellfield (Wells 2,6,&7)		
Date	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**
17-Dec-10												
08-Nov-10												
22-Oct-10												
21-Jul-10										**<0.5**	**<0.5**	**<0.5**
01-Jun-10												
26-Apr-10												
14-Aug-09												
13-Aug-09												
01-Jul-09										**<0.5**	**<0.5**	**<0.5**
02-Jun-09												
08-Jul-08										**<0.5**	**<0.5**	**<0.5**
03-Jun-08												
02-Oct-07												
29-Aug-07	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**			
07-Aug-07												
19-Jun-07												
27-Dec-06												
06-Dec-06												
25-Oct-06												
03-Oct-06												
20-Jun-06										**<0.5**	**<0.5**	**<0.5**
25-Apr-06												
18-Jul-05												
29-Jun-05				1	**<0.5**	1.1						
28-Jun-05												
07-Jun-05												
12-Apr-05	**<0.5**	**<0.5**	**<0.5**									
11-Apr-05				1.2	**<0.5**	1.3						
04-Jan-05	**<0.5**	0.9	**<0.5**									
05-Oct-04												
20-Sep-04				1.5	**<0.5**	1.6						
30-Aug-04	**<0.5**	**<0.5**	**<0.5**									
23-Aug-04												
06-Jul-04												
30-Jun-04												
27-Apr-04												
04-Dec-03	1.2	**<0.5**	0.7									
28-Aug-03												
10-Jun-03				**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**			
19-Mar-03												
12-Mar-03												
06-Dec-02				**<0.5**	**<0.5**	**<0.5**						
05-Dec-02				**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**			
03-Sep-02												
28-Jun-02				0.9	**<0.5**	**<0.5**						
27-Jun-02				0.9	**<0.5**	**<0.5**						
04-Jun-02												
17-Apr-02	1.8	**<0.5**	1.9	0.7	**<0.5**	1						
05-Mar-02												

System Well (DOH Source)	Auburn Well 2 (DOH 04)			Auburn Well 6 (DOH 12)			Auburn Well 7 (DOH 11)			Auburn Wellfield (Wells 2,6,&7)		
Date	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE
11-Dec-01				0.9	<0.5	0.9						
04-Dec-01												
18-Sep-01												
21-Aug-01				1.6	<0.5	1.6						
08-Aug-01												
16-Jul-01												
05-Jun-01												
18-Apr-01												
16-Apr-01	1.6	0.6	1.6	1.9	0.6	2	<0.5	<0.5	<0.5			
20-Mar-01							<0.5	<0.5	<0.5			
02-Feb-01				0.8	<0.5	0.8						
29-Jan-01				1	<0.5	0.9	<0.5	<0.5	<0.5			
29-Dec-00	0.9	<0.5	0.9									
05-Dec-00												
18-Oct-00				1.8	0.8	1.7						
09-Oct-00				2	0.9	2						
05-Sep-00												
08-Aug-00												
07-Aug-00												
06-Jun-00												
28-Mar-00												
03-Mar-00												
28-Dec-99												
15-Nov-99												
04-Nov-99	1.8	0.7	1.8									
30-Sep-99												
08-Apr-99				2.5	0.6	2.5						
21-Dec-98												
07-Dec-98												
28-Oct-98												
06-Jul-98												
07-Jan-98												
15-Oct-97	1.5	0.5	1.6									
15-Sep-97	1.7	0.5	1.8									
15-Mar-97							<0.5	<0.5	<0.5			
16-Dec-96												
25-Sep-96	1	<0.5	1									
03-Sep-96												
12-Jul-96												
20-Sep-95	1.9	0.9	2.1									
12-Jun-95	2	0.7	2.2									
14-Mar-95	1.3	0.6	1.4									
12-Dec-94	1.5	<0.5	1.8									
19-Sep-94	1	<0.5	1.7									
21-Jun-94	1.6	<0.5	1.7									
08-Mar-94	2	0.9	2.5									
29-Dec-93												
14-Dec-93	2.4	1	2.6									
06-Oct-93												
28-Sep-93												
20-Sep-93	1.8	0.76	2.2									
08-Jun-93	1.8	0.8	1.9									
02-Jun-93												
09-Mar-93	1.5	0.7	1.7									

System Well (DOH Source)	Auburn Well 2 (DOH 04)			Auburn Well 6 (DOH 12)			Auburn Well 7 (DOH 11)			Auburn Wellfield (Wells 2,6,&7)		
Date	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**
27-Dec-92												
16-Dec-92	2.1	0.8	2.2									
17-Nov-92												
16-Sep-92												
09-Sep-92	3	1.1	3.2									
20-Aug-92												
20-Jul-92												
01-Jul-92												
24-Jun-92	2.6	1	2.6									
15-Jun-92												
23-Mar-92	1.8	0.7	1.9									
06-Mar-92												
30-Dec-91												
15-Jul-91	2.7	1.1	2.3									
09-May-91												
04-Feb-91	1.1	0.5	0.8									
16-Oct-90	1.6	0.9	1.1									
11-Jun-90	**<0.5**	**<0.5**	**<0.5**									
14-Feb-90	1.3	0.6	0.9									
20-Dec-89	1.3	0.7	0.8									
18-Oct-89	1.4	0.6	0.9									
30-May-89												
05-Apr-89												
05-Dec-88												
14-Jun-88												
21-Mar-88	**<0.5**	**<0.5**	**<0.5**									

Appendix A.
Table 2.

System Well (DOH Source)	Auburn Park Community LLC			South Auburn Water Association			Lakehaven Well 29 (DOH 35)			Logandale		
Date	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE
17-Dec-10				<0.5	<0.5	<0.5						
08-Nov-10												
22-Oct-10												
21-Jul-10												
01-Jun-10	1.7	<0.5	<0.5									
26-Apr-10										<0.5	<0.5	<0.5
14-Aug-09							<0.5	<0.5	<0.5			
13-Aug-09												
01-Jul-09												
02-Jun-09	0.9	<0.5	<0.5									
08-Jul-08												
03-Jun-08	1.1	<0.5	<0.5									
02-Oct-07	2	<0.5	<0.5									
29-Aug-07												
07-Aug-07												
19-Jun-07				<0.5	<0.5	<0.5						
27-Dec-06												
06-Dec-06												
25-Oct-06												
03-Oct-06	3	<0.5	<0.5									
20-Jun-06												
25-Apr-06										<0.5	<0.5	<0.5
18-Jul-05												
29-Jun-05												
28-Jun-05				<0.5	<0.5	<0.5						
07-Jun-05	2.1	<0.5	<0.5									
12-Apr-05												
11-Apr-05												
04-Jan-05	2.4	<0.5	<0.5									
05-Oct-04	2.5	<0.5	<0.5									
20-Sep-04												
30-Aug-04												
23-Aug-04												
06-Jul-04	3.1	<0.5	<0.5									
30-Jun-04				<0.5	<0.5	<0.5						
27-Apr-04	3.9	<0.5	<0.5									
04-Dec-03												
28-Aug-03	2.5	<0.5	<0.5									
10-Jun-03												
19-Mar-03												
12-Mar-03												
06-Dec-02												
05-Dec-02												
03-Sep-02	3	<0.5	<0.5									
28-Jun-02												
27-Jun-02										<0.5	<0.5	<0.5
04-Jun-02	4.2	<0.5	<0.5									
17-Apr-02												
05-Mar-02	1.8	<0.5	<0.5									

System Well (DOH Source)	Auburn Park Community LLC			South Auburn Water Association			Lakehaven Well 29 (DOH 35)			Logandale		
Date	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE
11-Dec-01												
04-Dec-01	1.9	<0.5	<0.5									
18-Sep-01	3.1	<0.5	<0.5									
21-Aug-01												
08-Aug-01												
16-Jul-01												
05-Jun-01	2	<0.5	<0.5									
18-Apr-01												
16-Apr-01												
20-Mar-01	1.9	<0.5	<0.5									
02-Feb-01												
29-Jan-01												
29-Dec-00												
05-Dec-00	2	<0.5	<0.5									
18-Oct-00												
09-Oct-00												
05-Sep-00	2.7	<0.5	<0.5									
08-Aug-00				0.7	<0.5	<0.5						
07-Aug-00												
06-Jun-00	3.9	<0.5	<0.5									
28-Mar-00	3.6	<0.5	<0.5									
03-Mar-00												
28-Dec-99	3.7	<0.5	<0.5									
15-Nov-99				0.7	<0.5	<0.5						
04-Nov-99												
30-Sep-99	3.5	<0.5	<0.5									
08-Apr-99												
21-Dec-98												
07-Dec-98										<0.5	<0.5	<0.5
28-Oct-98												
06-Jul-98				0.8	<0.5	<0.5						
07-Jan-98												
15-Oct-97												
15-Sep-97												
15-Mar-97												
16-Dec-96												
25-Sep-96												
03-Sep-96	3.1	<0.5	<0.5									
12-Jul-96							<0.5	<0.5	<0.5			
20-Sep-95												
12-Jun-95												
14-Mar-95												
12-Dec-94												
19-Sep-94												
21-Jun-94												
08-Mar-94												
29-Dec-93				1.4	<0.5	<0.5						
14-Dec-93												
06-Oct-93												
28-Sep-93												
20-Sep-93												
08-Jun-93												
02-Jun-93										<0.5	<0.5	<0.5
09-Mar-93												

System Well (DOH Source)	Auburn Park Community LLC			South Auburn Water Association			Lakehaven Well 29 (DOH 35)			Logandale		
Date	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE
27-Dec-92												
16-Dec-92												
17-Nov-92												
16-Sep-92												
09-Sep-92												
20-Aug-92				2.6	**<0.5**	**<0.5**						
20-Jul-92												
01-Jul-92												
24-Jun-92												
15-Jun-92												
23-Mar-92												
06-Mar-92				2.5	**<0.5**	**<0.5**						
30-Dec-91				2.6	**<0.5**	**<0.5**						
15-Jul-91												
09-May-91	4.7	**<0.5**	**<0.5**									
04-Feb-91												
16-Oct-90												
11-Jun-90												
14-Feb-90												
20-Dec-89												
18-Oct-89												
30-May-89												
05-Apr-89												
05-Dec-88												
14-Jun-88												
21-Mar-88												

Appendix A.
Table 2.

System Well (DOH Source)	Pacific East Well (DOH 02)			Pacific West Well (DOH 04)			Pacific South Well (DOH 06)			Pacific Wellfield (East, West, South		
Date	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**
17-Dec-10												
08-Nov-10										**<0.5**	**<0.5**	**<0.5**
22-Oct-10												
21-Jul-10												
01-Jun-10												
26-Apr-10												
14-Aug-09												
13-Aug-09												
01-Jul-09												
02-Jun-09												
08-Jul-08												
03-Jun-08												
02-Oct-07												
29-Aug-07												
07-Aug-07										**<0.5**	**<0.5**	**<0.5**
19-Jun-07												
27-Dec-06												
06-Dec-06												
25-Oct-06												
03-Oct-06												
20-Jun-06												
25-Apr-06												
18-Jul-05												
29-Jun-05												
28-Jun-05												
07-Jun-05												
12-Apr-05												
11-Apr-05												
04-Jan-05												
05-Oct-04												
20-Sep-04												
30-Aug-04												
23-Aug-04	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**						
06-Jul-04												
30-Jun-04												
27-Apr-04												
04-Dec-03												
28-Aug-03												
10-Jun-03												
19-Mar-03							**<0.5**	**<0.5**	**<0.5**			
12-Mar-03												
06-Dec-02												
05-Dec-02												
03-Sep-02												
28-Jun-02												
27-Jun-02												
04-Jun-02												
17-Apr-02												
05-Mar-02												

System Well (DOH Source)	Pacific East Well (DOH 02)			Pacific West Well (DOH 04)			Pacific South Well (DOH 06)			Pacific Wellfield (East, West, South		
Date	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE
11-Dec-01												
04-Dec-01												
18-Sep-01												
21-Aug-01												
08-Aug-01	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**						
16-Jul-01												
05-Jun-01												
18-Apr-01												
16-Apr-01												
20-Mar-01												
02-Feb-01												
29-Jan-01												
29-Dec-00												
05-Dec-00												
18-Oct-00												
09-Oct-00												
05-Sep-00												
08-Aug-00												
07-Aug-00												
06-Jun-00												
28-Mar-00												
03-Mar-00												
28-Dec-99												
15-Nov-99												
04-Nov-99												
30-Sep-99												
08-Apr-99												
21-Dec-98	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**						
07-Dec-98												
28-Oct-98												
06-Jul-98												
07-Jan-98	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**						
15-Oct-97												
15-Sep-97												
15-Mar-97												
16-Dec-96	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**						
25-Sep-96												
03-Sep-96												
12-Jul-96												
20-Sep-95												
12-Jun-95												
14-Mar-95												
12-Dec-94												
19-Sep-94												
21-Jun-94												
08-Mar-94												
29-Dec-93												
14-Dec-93												
06-Oct-93												
28-Sep-93												
20-Sep-93												
08-Jun-93												
02-Jun-93												
09-Mar-93												

System Well (DOH Source)	Pacific East Well (DOH 02)			Pacific West Well (DOH 04)			Pacific South Well (DOH 06)			Pacific Wellfield (East, West, South		
Date	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE
27-Dec-92												
16-Dec-92												
17-Nov-92												
16-Sep-92												
09-Sep-92												
20-Aug-92												
20-Jul-92												
01-Jul-92				**<0.5**	**<0.5**	**<0.5**						
24-Jun-92												
15-Jun-92	**<0.5**	**<0.5**	**<0.5**									
23-Mar-92												
06-Mar-92												
30-Dec-91												
15-Jul-91												
09-May-91												
04-Feb-91												
16-Oct-90												
11-Jun-90												
14-Feb-90												
20-Dec-89												
18-Oct-89												
30-May-89												
05-Apr-89												
05-Dec-88	**<0.5**	**<0.5**	**<0.5**									
14-Jun-88												
21-Mar-88												

Appendix A.
Table 2.

System Well (DOH Source)	Algona Well 1 (DOH 01)			Danner Corporation			Auburn Well 1 (DOH 03)			Auburn West Hill Spring (DOH 02)		
Date	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**
17-Dec-10												
08-Nov-10												
22-Oct-10				**<0.5**	**<0.5**	**<0.5**						
21-Jul-10										**<0.5**	**<0.5**	**<0.5**
01-Jun-10												
26-Apr-10												
14-Aug-09												
13-Aug-09							**<0.5**	**<0.5**	**<0.5**			
01-Jul-09												
02-Jun-09												
08-Jul-08												
03-Jun-08												
02-Oct-07												
29-Aug-07										**<0.5**	**<0.5**	**<0.5**
07-Aug-07												
19-Jun-07												
27-Dec-06												
06-Dec-06										**<0.5**	**<0.5**	**<0.5**
25-Oct-06				**<0.5**	**<0.5**	**<0.5**						
03-Oct-06												
20-Jun-06												
25-Apr-06												
18-Jul-05												
29-Jun-05												
28-Jun-05												
07-Jun-05												
12-Apr-05												
11-Apr-05												
04-Jan-05												
05-Oct-04												
20-Sep-04												
30-Aug-04												
23-Aug-04												
06-Jul-04												
30-Jun-04												
27-Apr-04												
04-Dec-03												
28-Aug-03												
10-Jun-03										**<0.5**	**<0.5**	**<0.5**
19-Mar-03												
12-Mar-03				**<0.5**	**<0.5**	**<0.5**						
06-Dec-02												
05-Dec-02										**<0.5**	**<0.5**	**<0.5**
03-Sep-02												
28-Jun-02												
27-Jun-02												
04-Jun-02												
17-Apr-02												
05-Mar-02												

System Well (DOH Source)	Algona Well 1 (DOH 01)			Danner Corporation			Auburn Well 1 (DOH 03)			Auburn West HIll Spring (DOH 02)		
Date	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE	TCE	cisDCE	PCE
11-Dec-01												
04-Dec-01												
18-Sep-01												
21-Aug-01												
08-Aug-01												
16-Jul-01												
05-Jun-01												
18-Apr-01							**<0.5**	**<0.5**	**<0.5**			
16-Apr-01										**<0.5**	**<0.5**	**<0.5**
20-Mar-01												
02-Feb-01												
29-Jan-01												
29-Dec-00												
05-Dec-00												
18-Oct-00												
09-Oct-00												
05-Sep-00												
08-Aug-00												
07-Aug-00										**<0.5**	**<0.5**	**<0.5**
06-Jun-00												
28-Mar-00												
03-Mar-00				**<0.5**	**<0.5**	**<0.5**						
28-Dec-99												
15-Nov-99												
04-Nov-99												
30-Sep-99												
08-Apr-99												
21-Dec-98												
07-Dec-98												
28-Oct-98				**<0.5**	**<0.5**	**<0.5**						
06-Jul-98												
07-Jan-98												
15-Oct-97												
15-Sep-97												
15-Mar-97												
16-Dec-96												
25-Sep-96							**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**
03-Sep-96												
12-Jul-96												
20-Sep-95												
12-Jun-95												
14-Mar-95												
12-Dec-94												
19-Sep-94							**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**
21-Jun-94												
08-Mar-94												
29-Dec-93												
14-Dec-93												
06-Oct-93										**<0.5**	**<0.5**	**<0.5**
28-Sep-93	**<0.5**	**<0.5**	**<0.5**									
20-Sep-93							**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**
08-Jun-93												
02-Jun-93												
09-Mar-93												

System Well (DOH Source)	Algona Well 1 (DOH 01)			Danner Corporation			Auburn Well 1 (DOH 03)			Auburn West HIll Spring (DOH 02)		
Date	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**
27-Dec-92												
16-Dec-92												
17-Nov-92												
16-Sep-92												
09-Sep-92												
20-Aug-92												
20-Jul-92	**<0.5**	**<0.5**	**<0.5**									
01-Jul-92												
24-Jun-92												
15-Jun-92												
23-Mar-92							**<0.5**	**<0.5**	**<0.5**			
06-Mar-92												
30-Dec-91												
15-Jul-91												
09-May-91												
04-Feb-91												
16-Oct-90												
11-Jun-90												
14-Feb-90												
20-Dec-89												
18-Oct-89												
30-May-89							**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**
05-Apr-89	**<0.5**	**<0.5**	**<0.5**									
05-Dec-88												
14-Jun-88												
21-Mar-88							**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**

Appendix A.
Table 2.

System Well (DOH Source)	Auburn Well 3a (DOH 05)			Auburn Well 3b (DOH 08)			Auburn Well 4 (DOH 07)			Auburn Well 5b (DOH 13)		
Date	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**
17-Dec-10												
08-Nov-10												
22-Oct-10												
21-Jul-10												
01-Jun-10												
26-Apr-10												
14-Aug-09												
13-Aug-09												
01-Jul-09												
02-Jun-09												
08-Jul-08												
03-Jun-08												
02-Oct-07												
29-Aug-07							**<0.5**	**<0.5**	**<0.5**			
07-Aug-07												
19-Jun-07												
27-Dec-06										**<0.5**	0.6	**<0.5**
06-Dec-06												
25-Oct-06												
03-Oct-06												
20-Jun-06												
25-Apr-06												
18-Jul-05										**<0.5**	**<0.5**	**<0.5**
29-Jun-05												
28-Jun-05												
07-Jun-05												
12-Apr-05												
11-Apr-05												
04-Jan-05												
05-Oct-04												
20-Sep-04												
30-Aug-04												
23-Aug-04												
06-Jul-04												
30-Jun-04												
27-Apr-04												
04-Dec-03							**<0.5**	**<0.5**	**<0.5**			
28-Aug-03												
10-Jun-03												
19-Mar-03												
12-Mar-03												
06-Dec-02												
05-Dec-02							**<0.5**	**<0.5**	**<0.5**			
03-Sep-02												
28-Jun-02												
27-Jun-02												
04-Jun-02												
17-Apr-02												
05-Mar-02												

System Well (DOH Source)	Auburn Well 3a (DOH 05)			Auburn Well 3b (DOH 08)			Auburn Well 4 (DOH 07)			Auburn Well 5b (DOH 13)		
Date	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**
11-Dec-01												
04-Dec-01												
18-Sep-01												
21-Aug-01												
08-Aug-01												
16-Jul-01	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**						
05-Jun-01												
18-Apr-01												
16-Apr-01							**<0.5**	**<0.5**	**<0.5**			
20-Mar-01												
02-Feb-01												
29-Jan-01												
29-Dec-00												
05-Dec-00												
18-Oct-00												
09-Oct-00												
05-Sep-00				**<0.5**	**<0.5**	**<0.5**						
08-Aug-00												
07-Aug-00	**<0.5**	**<0.5**	**<0.5**				**<0.5**	**<0.5**	**<0.5**			
06-Jun-00												
28-Mar-00												
03-Mar-00												
28-Dec-99												
15-Nov-99												
04-Nov-99												
30-Sep-99												
08-Apr-99												
21-Dec-98												
07-Dec-98												
28-Oct-98												
06-Jul-98												
07-Jan-98												
15-Oct-97												
15-Sep-97												
15-Mar-97												
16-Dec-96												
25-Sep-96	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**			
03-Sep-96												
12-Jul-96												
20-Sep-95												
12-Jun-95												
14-Mar-95												
12-Dec-94												
19-Sep-94	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**						
21-Jun-94												
08-Mar-94												
29-Dec-93												
14-Dec-93												
06-Oct-93	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**						
28-Sep-93												
20-Sep-93							**<0.5**	**<0.5**	**<0.5**			
08-Jun-93												
02-Jun-93												
09-Mar-93												

System Well (DOH Source)	Auburn Well 3a (DOH 05)			Auburn Well 3b (DOH 08)			Auburn Well 4 (DOH 07)			Auburn Well 5b (DOH 13)		
Date	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**	**TCE**	**cisDCE**	**PCE**
27-Dec-92	**<0.5**	**<0.5**	**<0.5**									
16-Dec-92												
17-Nov-92				**<0.5**	**<0.5**	**<0.5**						
16-Sep-92	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**						
09-Sep-92												
20-Aug-92												
20-Jul-92												
01-Jul-92												
24-Jun-92												
15-Jun-92												
23-Mar-92							**<0.5**	**<0.5**	**<0.5**			
06-Mar-92												
30-Dec-91												
15-Jul-91												
09-May-91												
04-Feb-91												
16-Oct-90												
11-Jun-90												
14-Feb-90												
20-Dec-89												
18-Oct-89												
30-May-89	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**			
05-Apr-89												
05-Dec-88												
14-Jun-88	**<0.5**	**<0.5**	**<0.5**									
21-Mar-88							**<0.5**	**<0.5**	**<0.5**			

Source: DOH 2011, Ecology 2011

a - No evidence currently exists indicating that these wells draw from the portion of the aquifer containing selected VOCs from the Boeing Auburn Facility

b - Water was collected from Group A wells and sampled by local Public Water Systems. Results submitted to WA state Department of Health's Office of Drinking Water (only quality assured data included)

c - No samples exceed the federal MCL

	No sample collected
<0.5	Water sample does not exceed SRL of 0.5 µg/L.
4.7	Cells highlighted yellow have detected samples > 0.5 µg/L.
	Well inactive, decomissioned, no longer used or used rarely
	Well in well field
	Well field

DOH - Washington State Department of Health

TCE - Trichloroethylene (MCL 5 µg/L)

cisDCE - cis-1,2-Dichloroethylene (MCL 70 µg/L)

PCE - Tetrachloroethylene (MCL 5 µg/L)

MCL - U.S. EPA Maximum Contaminant Level for drinking water systems

SRL - State Reporting Limit (0.5 µg/L)

Appendix B – Detailed Summary of Groundwater, Soil-Gas, and Sub-slab Vapor Sampling and Vapor Intrusion Modeling for Areas near the Boeing Auburn Plant

This Appendix of the Boeing Auburn Health Consultation contains detailed descriptions of groundwater sampling results and sampling or modeling efforts completed to understand potential health concerns in indoor air.

Groundwater

For this evaluation, the volatile organic chemicals (VOCs) of concern in groundwater at the site include trichloroethylene (TCE), tetrachloroethylene (perchlorethylene or PCE), and some of their breakdown products: 1,1-dichlorethylene, cis-1,2-dichloroethylene, trans-1,2-dichloro-ethylene, and vinyl chloride. The data collected by Boeing's remedial investigations are summarized in Table 1 and Figures 2 and 3 of the main report. The following discussion highlights of the groundwater water quality data and contaminated plumes mostly limited to the most recent rounds of sampling (Landau Associates 2011b,d). Figures cited in the text refer to the figures of the main report.

Depth and Spatial Extent of the Plumes

Low-level VOC contamination has been identified in the three depth zones in the upper aquifer at and beyond the Boeing property. The depth and spatial extent of the groundwater plumes, however, have not been completely identified.

Shallow Zone (10–30 feet below ground surface [bgs])

The TCE levels found in the shallow zone of the upper aquifer (data not shown) at the southern portion of the facility are low (less than 1 µg/L) to non-detectable. In the shallow zone of Plume 1, bioremediation decreased levels in the source area for the plume. Currently, the highest concentration (7.8 µg/L) remains just north of the AMB Property Corporation's building at the boundary with the YMCA (Landau Associates 2011c). The shallow wells on the YMCA and Junior Achievement properties have one well with TCE detected (1 µg/L), the rest were non-detect. In the shallow zone of Plume 2, most wells outside of those under Building 17-07 and 17-10 showed low levels (less than 1µg/L to non-detect). Off of Boeing's property, shallow grab samples of the recently bored northern intermediate wells have higher TCE concentrations, up to 8.6 µg/L. A preliminary grab sample in September 2011 of shallow zone groundwater near residences on 10th Avenue North in Algona measured that TCE concentration at 1.2 µg/L (Landau Associates 2011c, personal communication). Water quality data from new shallow wells off-property is needed to better understand potential exposures either through contact with shallow groundwater discharged to surface water or through vapor intrusion into buildings.

Intermediate Zone (40–60 feet bgs)

The plume boundaries in the intermediate zone have not been defined (Figure 2). Boeing is planning to install additional monitoring wells to determine the northern and western down gradient extent of the plumes in the intermediate zone of the upper aquifer. TCE associated with Plume 2 appears to combine with TCE from Plume 1 as they move north (Landau Associates 2011c). TCE concentrations decrease as the Plume 1 moves north, but TCE has been detected as far north as West Main Street (1.7 µg/L). Low-level TCE concentrations surround Plume 1 in the intermediate zone to the east, west, and south. Currently in Area 2, TCE concentrations of up to 5.1 µg/L have been detected at the northern-most intermediate well (near West Main Street). The highest concentration in the Area 2 intermediate plume (14.0 µg/L) appears to center around the interurban trail adjacent to the waste-water processing plant on the Boeing facility (Landau Associates 2011c). It is not clear if the source is located in this general vicinity or some distance up gradient (i.e. southeast) from this location. New monitoring well data sampled in September 2011 from the intermediate zone near residences on 10th Avenue North had no TCE found at the detection limit of 0.2 µg/L (Landau Associates 2011c, personal communication). With very few exceptions, most of the other monitoring wells off Boeing's property in the intermediate zone had stable concentrations ±0.5 µg/L. However, three wells between the two plumes in the intermediate zone showed a drop in concentration of up to 4.3 µg/L since the June sampling. Ongoing monitoring will delineate if this is seasonal variation or a consistent drop in concentration.

Deep Zone (80–100 feet bgs)

Boeing is also planning to install additional monitoring wells to determine the northern and western down gradient extent of the plumes in the deep zone of the upper aquifer. The eastern boundary of the plume in the deep zone has not been identified and TCE levels may increase moving east near the AMB building as they do in the shallow and intermediate zones. As seen on Figure 3, there are fewer wells in the deep zone of the upper aquifer, and elevated TCE concentrations appear to be limited to the western Area 2 plume. The highest TCE concentrations, June 2011 data, in the deep wells (4.4–5.1 µg/L) occurred between the interurban trail up to the most northern well in the deep zone at 15th Street SW (Landau Associates 2011c). As with the intermediate well, the new deep zone well sampled in September 2011 near residences on 10th Avenue North had no TCE found at the detection limit, 0.2 µg/L (Landau Associates 2011c, personal communication). Other well data appeared to remain consistent (± 0.5 µg/L).

Because VOCs have been detected in the deep zone of the upper aquifer, boring new wells through the Osceola mudflow may result in contaminants moving into the deeper aquifer. Therefore, wells to the deeper aquifer have not been installed and no monitoring data has been collected or is planned to be collected from the deeper aquifer below the Osceola mudflow.

Seasonal Variation

Boeing has done ground water sampling for VOCs, including non-chlorinated solvents, for many years, with more wells being added each quarter. Bioremediation during 2004–2005 reduced the high concentrations of VOCs in the shallow zone near the source of Plume 1

contamination over time. Boeing's sampling frequency varies from quarterly for the newest wells to semi-annually or annually for wells which show consistent VOC levels over time (Landau Associates 2011a). With the exception of wells installed during or after the summer 2010 drilling program, most wells have four or more quarters of sampling data. The water quality data does not appear to have seasonal variation (Landau Associates 2011a); however, changes in water flow and depth have been reported. Ecology believes that seasonal effects could have an impact on the concentrations of TCE and related VOCs being measured at monitoring wells near the site (Ecology personal communication, 2011). The differences between the June and September 2011 water quality data in the intermediate zone as described above indicates that this is a possibility.

Temporal Extent of the Contamination

Because of the length of the Area 2 plume and unknown width and depth of the VOCs in the three zones of the upper aquifer, it is not clear if the release was historical and has degraded substantially, if there are multiple sources from the Boeing Auburn plant, or if sources outside of Boeing are contributing to the plumes.

Measured Concentrations at the Point of Contact

Figure 1 shows the historical and current Group A and Group B wells in the valley near the Boeing Auburn Plant along with the current known area were TCE exceeds the maximum contaminant level (MCL) in the Boeing plumes. A summary of publically available information about these public and private wells can be found in Appendix A, Table 1 (DOH 2011, Ecology 2011). Group A wells are required to monitor for VOCs every three years. If VOCs are above the state reporting limit (0.5 µg/L), annual monitoring is required until levels decrease below the reporting limit.

Group A Wells

Concentrations of TCE, PCE, and vinyl chloride measured in the Group A public wells since 1991 (as reported to DOH) are summarized in Appendix A. A review of the data indicated that chlorinated solvents have been detected above the state reporting limit (0.5 µg/L) in only four wells in the valley: City of Auburn Well 4 (DOH source 04), City of Auburn well 6 (DOH Source 12), Group A well of Auburn Park Community LLC, and Group A well of South Auburn Water Association. Though detected, none of these wells had concentrations that ever exceeded the federal MCL for chlorinated solvents. These well data are summarized below along with information from Boeing's wellhead protection analysis (Landau Associates 2010b). While it does not appear that these wells are (or were) impacted by the Boeing plumes based on what is currently understood about groundwater flow below the site, additional work (i.e., better plume definition) is needed to better characterize this.

City of Auburn Wells 2 and 6 (DOH sources 04 and 12)–These two Auburn wells had reported detections of TCE and PCE at similar concentrations until August of 2007, when they dropped below the state reporting limit (0.5 µg/L). Since monitoring began, in these wells have never had TCE or PCE levels reported above the federal MCL. These wells are located about a mile east-northeast of the plume areas that exceeds the MCL (5 µg/L) for TCE. The source of the

TCE and PCE in these wells is unknown. However, the signature of TCE and PCE at similar concentrations is different than that observed in the Boeing plumes where PCE levels are approximately an order of magnitude lower than TCE. This suggests that the VOCs may be from a different source. These wells draw from the deeper aquifer, below the Osceola mudflow; it is unknown if contamination from the Boeing site has moved into the deeper aquifer. These wells are in a well field and their water is combined, disinfected, and treated for corrosion by air stripping which decreases the VOC concentrations prior to distribution. No detections have been reported in the treated water. These wells lie laterally to the northward gradient of groundwater flow. Though these specific wells were not included in the wellhead protection analysis by Boeing, they did evaluate specific requirements or ordinances associated with Group A water supplies within a mile of the facility (Landau Associates 2010b, 2009a). Boeing concluded that the 10-year time of travel zone for the wells within a mile of the facility as estimated by the City of Auburn did not extend onto the facility (data not seen).

Auburn Park Community LLC Well–The highest detection of TCE reported in the Auburn Park Community's well was 4.7 µg/L in May 1991. PCE, cis-1,2-dichloroethylene, and vinyl chloride levels have not ever been above the state reporting limit. TCE levels fluctuated over time in a decreasing trend. The TCE level reported in June 2010 was 1.7 µg/L. Levels of TCE from this well have never been reported above the federal MCL. This well appears to draw water from the intermediate zone of the upper aquifer and is located east of the Boeing facility. The well lies lateral to the northward gradient of groundwater flow. No wellhead protection information for this system exists (Landau Associates 2010b).

South Auburn Water Association Well–The Association's highest detection of TCE was 2.6 µg/L in December 1991. PCE, cis-1,2-dichloroethylene, and vinyl chloride levels have not ever been above the state reporting limit. These levels have consistently decreased. TCE levels have been below the state reporting limit (0.5 µg/L) since June 2004 (last measured in December 2010). Levels of TCE from this well have not been reported above the federal MCL. This well appears to draw from the deeper zone of the upper aquifer and is located southeast of the western Area 2 plume. The well lies lateral to the northward gradient of groundwater flow. No wellhead protection information for this system exists (Landau Associates 2010b).

Group B Wells

In the wellhead protection analysis, the City of Algona indicated that there are at least two private wells within the city limit (Algona 2010 cited by Landau Associates 2010b). The location of these private wells or other private wells in Pacific and Auburn is not known. Group B wells do not report monitoring data so their water quality is unknown. The closest Group B well, Kuzmer Water Supply, appears to be on an adjacent property of the Auburn Park Community well, though the exact location is unknown. If used, this well appears to draw from the intermediate zone of the upper aquifer and likely has similar water quality data to the Auburn Park Community well. The Group B wells, Barem, Laughlin Supply, and Christopher Garden Tract wells are the closest wells directly north (approximately 1.6, 1.8, and 2.0 miles, respectively) of the known extent of the Area 2 western plume that exceeds the MCL. Between the plume and these Group B wells lies a wetland complex that may receive groundwater discharge from the aquifer, resulting in volatilization of contaminants. The furthest intermediate

well north is artesian in nature, indicating that some upward groundwater flow may be occurring in the aquifer. Further characterization of the plume is needed to identify the fate of the contaminants in the plume.

Sampling Efforts for Potential Indoor Air Impacts

The following studies were completed to assess potential impacts to buildings, which may occur through vapor intrusion. A summary of these data is listed in Table 2 of the main text of the report.

Soil Gas Study near the YMCA (URS 2003)

In 2003, prior to the bioremediation of Area 1, Boeing performed a soil gas study on the land slated to become the YMCA (URS 2003). Soil gas samples were obtained in Summa canisters from five borings at 5 and 12 feet bgs and measured by EPA Method TO-15. Table 2 summarizes the soil gas samples taken at that time. PCE levels ranged up to 660 $\mu g/m^3$ at the 5 foot depth and 3000 $\mu g/m^3$ at the 12 foot depth. TCE levels ranged up to 7.8 $\mu g/m^3$ at the 5 foot depth and 90 $\mu g/m^3$ at the 12 foot depth. The Johnson and Ettinger model was used to assess potential risk to users (including children) of the YMCA at that time (Johnson and Ettinger 1991). The model used the highest values measured from the location closest to where the building was to be built. Boeing reported that the highest risk from carcinogenic effects using the soil gas measurements led to a combined risk of 6×10^{-9} for carcinogenic effects from exposure to PCE and TCE. While this may have been the most reasonable approach at the time, DOH has not reviewed this work to confirm the findings because the soil gas results obtained in 2003, when no building existed, may not reflect conditions as they exist today – i.e. an actual building constructed over a plume with similar TCE but lower PCE concentrations. Recent studies in the vapor intrusion field show that soil gas levels measured below buildings tend to be higher than those measured beyond the building footprint (U.S. EPA 2009).

Vapor Intrusion Modeling

Although the modeling conducted by Boeing in 2004, AMB in 2005, and Ecology in 2006 was a useful tool for estimating the potential groundwater to indoor air pathway at the time, there are uncertainties associated with such an approach. An evaluation of the vapor intrusion pathway in the YMCA and AMB buildings, including slab vulnerabilities to vapor intrusion, would be needed to make a current determination about the vapor intrusion pathway.

Former Building 17-05 (Landau Associates 2004b)

In 2004, Boeing completed an indoor air evaluation in former Building 17-05 to determine potential human health risks associated with breathing indoor air impacted by VOCs in the underlying shallow groundwater (Landau Associates 2004b). They conducted vapor intrusion modeling using the Johnson and Ettinger Model version 3.0 (U.S. EPA 2003, Johnson and Ettinger 1991) specific to workers in conditions of Building 17-05 at that time.

The model used the 95 percent upper confidence limit (UCL) of the arithmetic mean of the Plume 1 shallow groundwater samples (n=21). For TCE, vinyl chloride, and PCE these values were 38.2, 1.6, and 0.396 µg/L respectively. Risk estimates for carcinogenic effects from these chemicals were 8.2×10^{-7}, 2.2×10^{-8}, and 6.5×10^{-10}. Cumulative health risk for all compounds was 8.4×10^{-7}.

AMB Corporation Distribution Center Prior to Construction (GeoEngineers 2005)

In 2005, AMB Corporation predicted potential exposures inside the AMB building before it was built (GeoEngineers 2005). Groundwater VOC levels near the AMB property from May 2005 (Landau Associates 2005) were used to conduct vapor intrusion modeling using the Johnson and Ettinger Model version 3.1 (U.S. EPA 2004, Johnson and Ettinger 1991) to calculate groundwater concentrations that are considered protective of indoor air. Maximum concentrations of TCE and vinyl chloride in groundwater exceeded the estimated groundwater risk-based concentrations for the conservative hypothetical residential scenario, but not the worker scenario. Using this model, levels of shallow groundwater that would trigger indoor air sampling to assess worker protection were 41, 130, and 480 µg/L (at 10 feet bgs) for TCE, vinyl chloride and PCE, respectively.

Modeling for Regulatory Action (Ecology 2006)

In the Amended Agreed Order (Attachment 11), Ecology determined that any shallow groundwater measurements of 30 µg/L TCE or 99 µg/L vinyl chloride (representing 1×10^{-6} health risk in the Johnson and Ettinger model) or greater would warrant further investigation for vapor intrusion in the AMB Distribution Center building (Ecology 2006). Concentrations of TCE and vinyl chloride below the building remain well below these levels, and investigations have therefore not been undertaken.

Sub-slab Vapor Sampling Under for Building 17-07 (Landau Associates 2011c)

In 2011, preliminary samples from sub-slab vapor sampling under Building 17-07 on the Boeing property were collected to determine the source of VOCs for the western Area 2 plume (Landau Associates 2011c). A summary of this data is located on Table 2. The highest TCE levels below the building were 1,010 and 168 µg/m^3. PCE was detected slightly more frequently but typically at lower concentrations than TCE, the highest concentrations were 220 and 125 µg/m^3. No indoor air testing has been conducted to date to determine how much PCE or TCE , if any, is entering indoor air.

[References listed in the main report]