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EPA Superfund Record of Decision:

East Multnomah County Groundwater Contamination, OU 1
Multnomah County, OR
12/31/1996

DEQ Remedial Action Record of Decision

for the

East Multnomah County Groundwater Contamination Site

Troutdale Sandstone Aquifer

Oregon Department of Environmental Quality

Waste Management & Cleanup Division

December 1996

CONTENTS

TABLES AND ILLUSTRATIONS

1. INTRODUCTION

1.1 Introduction

This document presents the selected remedial action for groundwater contamination within the Troutdale Sandstone Aquifer (TSA) originating from the Cascade Corporation (Cascade) and Boeing of Portland (Boeing) facilities, in Gresham, Oregon. The contaminants of concern are volatile organic chemicals (VOCs) including trichloroethylene (TCE), tetrachloroethylene (PCE), cis-1,2-dichloroethylene (cis-1,2-DCE), and 1,1-dichloroethylene (1,1-DCE). The selected action was selected in accordance with Oregon Revised Statutes 465.200 through 465.380 and Oregon Administrative Rules (OAR) Chapter 340, Division 122, Section 080-110 (340-122-010 to 340-122-110). Also, to the extent practicable, the selected remedial action is consistent with the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and implementing regulations contained in the National Contingency Plan (NCP), 40 CFR Part 300. The East Multnomah County Groundwater Contamination site was proposed for inclusion on the National Priorities List (NPL or "Superfund") in May 1993. A final decision on listing the site on the NPL is pending.

The selected remedial action is based on the administrative record for the site. A copy of the administrative record index is attached as Appendix A. This staff report summarizes the more-detailed information contained in the administrative record, particularly the Remedial Investigation and Feasibility Study reports.

Cascade and Boeing conducted the remedial investigation and feasibility study (RI/FS) under a Consent Order with DEQ. Prior to initiating the joint RI/FS, Cascade and Boeing implemented an interim removal action measure (IRAM) in an effort to control the further spread of groundwater contamination to the north of their facilities. The groundwater IRAM is a component of the selected remedial action.

1.2 Scope and Role of the Remedial Action

The selected remedial action addresses groundwater contamination in the TSA. Contaminant sources in the Troutdale Gravel Aquifer (TGA) are excluded from the TSA remedy decision process and are being addressed by Cascade and Boeing pursuant to separate consent orders with the DEQ and U.S. Environmental Protection Agency (EPA), respectively.

2. SUMMARY OF THE SELECTED REMEDY

The selected remedial action for the Troutdale Sandstone Aquifer (TSA) contaminant plume includes the following components:

- Restoration of the TSA to federal drinking water standards (maximum contaminant levels [MCLs]) through groundwater extraction from wells placed throughout the area of contamination;

- Treatment of extracted groundwater using air-stripping treatment technology;

- Discharge of treated groundwater to Fairview Lake and the Columbia Slough directly or via Multnomah County storm water drainage ways;

- If feasible, reinjection/reinfiltration of treated groundwater into the TSA to improve the effectiveness of the remedy;

- Provisions allowing beneficial reuse of treated groundwater for industrial, agricultural or domestic use;

- Abandonment of six private Sand and Gravel Aquifer (SGA) water supply wells located within the area of the TSA contaminant plume and a provision to replace the abandoned wells with an alternative source of water;

- Institutional controls to restrict groundwater use of the TSA and SGA to prevent exposure to contaminated groundwater and the spread of groundwater contamination during remediation;

- Groundwater monitoring to assess compliance with performance criteria established for the remedy;

- A contingency plan to address emergency operation of the Portland Water Bureau's South Shore Wellfield; and

- Hydraulic containment of those areas of the TSA for which it may be technically impractical to restore to MCL cleanup levels within 20 years.

Section 9 provides a detailed description of the final remedy components.

3. SITE DESCRIPTION

3.1 Site Setting

The East Multnomah County (EMC) project area includes an area bounded by the Columbia River to the North, Fairview Avenue and Campbell Road to the east, NE Halsey Street to the south, and NE 181st Avenue to the west (Figure 3-1). The project area, which is approximately 3.6 square miles, includes most of Sections 19, 20, 28 and 29 in Township 1 North, Range 3 East, Willamette Meridian. Approximately 45 percent of the project area is in Gresham, 35 percent is in Fairview, 15 percent is unincorporated Multnomah County, and 5 percent is in Portland. The "site", for purposes of discussion in this document, refers to all areas in the EMC project area where the Troutdale Sandstone Aquifer (TSA) contains concentrations of halogenated volatile organic compounds at concentrations requiring remediation. The site, which is approximately 300 acres, lies in the central part of the project area.

3.1.1 Land Uses

The EMC project area includes industrial, residential, agricultural and recreational land uses. Prior to 1960, land use was primarily rural and agricultural, and the conversion of agricultural lands to other uses has occurred gradually since then and is still ongoing. As of 1990, approximately 14,476 people reside within these tracts. Specific land uses in the area are as follows:

- A transportation corridor bisecting the project area from the east to west, consisting of Interstate 84 and the Union Pacific Railroad tracks;
- Commercial businesses and heavy and light industry predominate in the southwest and west (south of NE Sandy Boulevard and west of NE 201st Avenue). Major industrial facilities in this area include Boeing south of Sandy Boulevard in the western part of the project area, Cascade located just south of Interstate 84 and west of NE 201st Avenue, Boyd Coffee located north of Cascade and east of Boeing, and Viking Industries, Associated Foods and Swift Adhesive Company all located south of the Boeing Facility and south of Interstate 84;
- Recreational areas in the northeast part of the project area include Blue Lake and Fairview Lake, Blue Lake Park, and marinas on the Columbia River;
- Residential areas are located along the ridge between Blue Lake and Fairview Lakes, south and east of Blue Lake, and east of NE 201st Avenue;

- Agricultural areas are located west of Blue Lake and Fairview Lake, just west of the Boeing Facility, and north of the intersection of NE Sandy Boulevard and NE 205th. The uncultivated fields west of Blue and Fairview Lakes along NE 181st Avenue are currently being converted to commercial uses.

3.1.2 Groundwater and Surface Water Uses

There are three principal groundwater aquifers in the project area that are used for private and municipal drinking water supply and for irrigation. These include the Blue Lake Aquifer (BLA), Troutdale Sandstone Aquifer (TSA) and Sand and Gravel Aquifer (SGA). Fifty-three water supply wells are located within the project area (Figures 3-2a, 3-2b, and 3-2c, and Table 3-1). Fourteen wells are completed in the TSA, one inactive well is completed in both the TSA and the SGA, seventeen wells are completed in the SGA, 10 wells are completed in the BLA, and the construction of the eleven other wells is unknown. The active wells in each aquifer are as follows:

- Nine TSA wells are currently used: six for domestic supply, two for irrigation, and one for municipal supply by the City of Fairview.
- Thirteen SGA wells are currently used: six for domestic supply, three for irrigation, one for municipal supply by the City of Fairview, and three are part of the City of Portland's South Shore Well Field;
- Eight BLA wells are currently used: two for domestic supply, one for irrigation, and five are part of the City of Portland's South Shore Well Field;
- Four of the wells with unknown completion intervals are used for domestic supply, and one is used for irrigation.

Eight wells in the project area are part of the City of Portland's South Shore Well Field, operated by the Portland Water Bureau (PWB). The South Shore Well Field includes the northern part of the project area, and an area extending westward along the Columbia River for about 4.5 miles from the western boundary of the project area (Figure 3-3). The well field currently consists of 22 active production wells with a total designed pumping capacity of 100 million gallons per day (mgd). An additional four wells in the far western part of the well field are currently used for monitoring and are designed for future pumping of an additional 14 mgd. The completion intervals of the production wells are as follows:

- one is completed in the TGA with a current pumping capacity of 2 mgd;
- 5 are completed in the TSA with a current pumping capacity of 10 mgd;
- 10 are completed in the SGA with a current pumping capacity of 34 mgd;
- 5 are completed in the BLA with a current pumping capacity of 45 mgd; and
- one is completed in the Columbia River Sand Aquifer (CRSA) with a current pumping capacity of 4 mgd.

The City has water permits for expansion of the well field up to a total of 337 mgd. The PWB's capital improvement project for the year 2001 includes the completion of 15 additional production wells in the TGA, TSA and CRSA. The total future design pumping capacity of the well field is estimated to be about 150 mgd. The pumping capacity of the well field has been taken into account in the development of remedial options for the TSA because of the potential influence of pumping on movement of the existing groundwater contamination when the well field is operated currently, and in the future.

The Columbia South Shore Well Field was designed to supplement surface water supplies during times of drought or system emergencies. In the event of a water shortage, the PWB reports that its first priority is to pump groundwater from the well field and blend it with surface water from the Bull Run Reservoir, the city's primary source of water. The City ran the well field for seasonal summer supply purposes in 1985, 1987, 1992 and 1994 and 1996. During the winters of 1986 and 1996, the City ran the well field for short periods because Bull Run water exceeded the federal drinking water standard for turbidity. The highest usage was in 1987 when the well field was operated for approximately 90 days at an average rate of 60 mgd. Future use of the well field is expected to increase as the region grows.

Surface water in the project area is used for irrigation. The agricultural fields east and west of Blue and Fairview lakes are irrigated in part with water withdrawn from the Columbia Slough and Fairview Lake. There are no other known uses of surface water in the project area.

3.2 Physical Setting

The topography of the project area is dominated by a series of historical river terraces which generally slope toward the Columbia River. Elevations range from approximately 200 feet mean sea level (MSL) in the southern part of the project area to approximately 10 to 20 feet MSL on the lower terrace, which is the current floodplain of the Columbia River.

The climate in the project area is west coast marine. The average annual rainfall is about 37 inches, based on records at the Portland airport from 1961 to 1990. Eighty percent of the annual precipitation occurs from October through May. December is the wettest month, with rainfall averaging 6.1 inches. July is the driest month, averaging 0.6 inches of rainfall. The winds are usually northwesterly in the spring and summer, and southeasterly in the fall and winter. The average annual wind speed is about 8 miles per hour (mph) based on data from the Portland airport. Average wind speed ranges from approximately 6.5 mph in early autumn to 10 mph in the winter. Temperatures in the winter generally range from 32° F to 52° F and in the summer range from 54° F to 78° F.

3.2.1 Geologic Setting

The project area is located in the Portland Basin, which is a northwest-southeast-trending, sediment filled structural depression bounded by the Tualatin Mountains to the west and the Cascade Range to the east, north and south. A typical geologic and hydrogeologic column of the project area is shown on Figure 3-4. A large portion of the basin has been filled with Tertiary-age sediments that include the Troutdale Formation and the underlying Sandy River Mudstone (not shown on Figure 3-4). These geologic units are overlain by Quaternary-age terrace, glacio-fluvial, and floodplain alluvial sediments referred to in the project area as Troutdale Gravel, Blue Lake Gravel and Floodplain sand and silt.

The Troutdale Formation consists of a sequence of fine-grained units, separated by thicker sandstone and gravel units. The uppermost fine-grained unit, Siltstone Unit 1 (SU1), contains four distinct subunits of sandstone, siltstone and clayey siltstone. Underlying the SU1 are the Troutdale Sandstone and, below that, the Troutdale Conglomerate. Both of these units have been identified over most of the project area and comprise the portion of the geologic column that is the subject of the East Multnomah County groundwater contamination project. Siltstone Unit 2 (SU2) underlies the Troutdale Conglomerate, and consists of distinct subunits of interbedded siltstone and sandstone. SU2 is present across most of the project area, but is not present in a few localized areas. The lower portion of the Troutdale Formation, beneath the SU2, consists of sandstone and conglomerate. The Sandy River Mudstone is present at some depth below the basal Troutdale Sandstone and Conglomerate, but has not been identified in any of the wells installed for the East Multnomah County project.

The geologic units in the project area have been influenced by structural deformation in the form of folding and potential faulting, with concurrent erosion of the Troutdale Formation. Structural deformation of the Troutdale Formation in the project area has resulted in an upward folding of the Troutdale strata into a dome-like feature, or "structural high". The structural high is centered south of Fairview Lake, in the vicinity of the intersection of Sandy Boulevard and 201st Avenue. Deformed Troutdale Formation strata slope down and away from the center of the structural high, and generally increase in thickness to the west and south. In and near the structural high, the Troutdale Gravel and the SU1 (the upper portion of the Troutdale Formation) have been removed by erosion and possible nondeposition, leaving the Troutdale Sandstone at ground surface covered by only a thin veneer of modern Floodplain silt. The edges of where the Troutdale Gravel and SU1 are not present are referred to as the "truncation" of the Troutdale Gravel and SU1. This truncation, or limit of extent, is represented on site maps by a line (for example, see Figure 5-1).

Near the northeast portion of the project area, between Blue Lake and the south shore of the Columbia River, additional erosion and suspected faulting of the Troutdale Formation has occurred. A deep channel of the Columbia River has incised the Troutdale Formation. The channel has been subsequently filled with gravel referred to as the Blue Lake Gravel. Incision of this channel, and the subsequent filling with gravel, is presumed to have occurred with the erosion of the Troutdale Formation near the structural high.

These geologic features, a structural high, truncation of the Troutdale Gravel and SU1, near-surface presence of the Troutdale Sandstone in the central portion of the project area, and the Blue Lake Gravel-filled channel, play a critical role in groundwater hydraulics and contamination fate and transport and will be discussed further in this section and in Section 5.

3.2.2 Hydrogeologic Setting

The following sections include a description of hydrogeologic units identified in the project area, significant hydrogeologic features, and the presence and movement of groundwater in and between the hydrogeologic units. Hydrogeologic units are defined based upon hydraulic characteristics of the geologic materials, and may be different than geologic units. For the purpose of this discussion, hydrogeologic units include aquifers, water-bearing and permeable material able to transmit water, and confining units, materials of low permeability that retard or restrict groundwater flow through them. In general, the most permeable of the geologic units are grouped into aquifers and the least permeable are grouped into confining units. The relationship between the hydrogeologic units and geologic units previously described can be seen on Figure 3-4 and in a north-south cross-section through the project area (Figure 3-5).

Four aquifers in the project area have a role in the presence and movement of groundwater contamination and are discussed in this report. Three of these aquifers cover most of the project area and are, from shallowest to deepest, the Troutdale Gravel Aquifer (TGA), the Troutdale Sandstone Aquifer (TSA), and the Sand and Gravel Aquifer (SGA). The fourth, Blue Lake Aquifer (BLA), is located in the northeastern portion of the project area. The TGA and the underlying TSA are separated by a confining unit, the CU1. The TSA and the lowermost SGA are separated by a second confining unit, the CU2. As can be seen from Figure 3-4, these hydrogeologic units are in most cases defined differently than the previously described geologic units. For example, the hydrogeologic unit CU1 consists of clayey siltstone, the least permeable of the four subunits of the geologic unit SU1.

Troutdale Gravel Aquifer. The TGA is present throughout most of the Portland basin, except in the central and northeastern portion of the project area where it, along with the underlying CU1, has been truncated (see Figure 5-1). In the project area the TGA is unconfined. Groundwater flows northward in the TGA from the Cascade site toward the truncation, or edge, of the TGA/CU1. Groundwater exits the TGA in the area of the truncation, north of the Cascade site, by three mechanisms: discharge to springs like Shepard Spring, subsurface flow of groundwater over the CU1 truncation (beneath a surficial veneer of Floodplain sand and silt), and vertical leakage downward through CU1. Each of these three mechanisms of flow of groundwater from the TGA serve as recharge to the TSA. These three mechanisms also represent a major pathway for migration of contamination from source areas in the TGA, to the TSA. At the Boeing facility groundwater in the TGA flows northwest, away from the north-south trending line of TGA/CU1 truncation, and discharges into the Columbia Slough.

Confining Unit 1. CU1 is present throughout the project area, wherever the TGA exists (see Figure 5-1). CU1 consists of interbedded siltstone and claystone and is approximately 40 to 50 feet thick at the Cascade and Boeing sites, gradually thinning at the line of truncation. Where the CU1 is thickest, the estimated vertical hydraulic conductivity is very low; in the range of 10^{-6} to 10^{-4} ft/day. In these areas, estimated vertical groundwater velocities are small. Near the TGA/CU1 truncation, vertical groundwater velocities increase as a result of weathering and thinning of CU1, allowing vertical leakage of TGA groundwater downward to the TSA through the CU1.

Troutdale Sandstone Aquifer. The TSA is a regional aquifer that is continuous beneath the project area except where incised by the channel-fill gravel deposit of the BLA. The TSA consists of two subunits: an upper sandstone and a lower conglomerate (see Figure 3-4). The average thickness of the TSA subunits in the project area is approximately 50 feet for the sandstone, and 70 feet for the conglomerate. In the central and northeastern part of the project area, where the TSA is exposed at the ground surface, in the area of the structural high, the TSA is a water-table aquifer. Here, at the structural high, the saturated thickness of the upper sandstone subunit is thin or absent. The saturated thickness in the TSA sandstone increases away from the structural high, to the west, south, and east, to where the TSA is overlain by the TGA/CU1, until eventually the TSA becomes fully saturated and confined.

Regional TSA groundwater flow in the project area is northeast toward groundwater discharge areas along the Columbia Slough and Fairview Lake. Groundwater flow directions in the TSA sandstone and conglomerate are generally similar. When the City's well field is operated, groundwater flow directions in the TSA may change to a northerly to westerly direction, depending on which wells in the well field are pumped. Water levels for the TSA sandstone and conglomerate subunits shown on Figures 3-6 and 3-7, for late November 1994, are representative of water levels during well field non-pumping conditions.

Locally, groundwater flow in the TSA is influenced by a groundwater mound that has developed in the vicinity of the geologic structural high, east of the Boeing facility and north of the Cascade site. The highest TSA water levels in the project area are measured in the groundwater mound (Figure 3-7). Groundwater flows radially away from the mound to the west, south, and east, and eventually coincides with the regional groundwater flow. The groundwater mound has formed because of decreased aquifer transmissivity where saturated portions of the TSA sandstone thin or are absent, and increased recharge to the TSA east and north of the TGA/CU1 truncation where the TSA is exposed at ground surface.

Primary sources of recharge to the TSA in the project area include upgradient regional groundwater flow, direct infiltration of precipitation where the TGA and CU1 are absent, groundwater flow from the SGA in areas where CU2 is more permeable and an upward gradient exists, spring flow and discharge from the TGA at the CU1 erosional truncation, and possibly irrigation.

The hydraulic conductivity of the entire saturated thickness of the TSA is estimated to range from about 30 to 90 feet per day (ft/day) with an average of about 50 ft/day. Aquifer test data and numerical analyses suggest that the TSA sandstone is generally more permeable than the TSA conglomerate. The hydraulic conductivity of the sandstone unit is estimated to range from 38 to 78 ft/day, and the hydraulic conductivity of the conglomerate is estimated to range from 5 to 19 ft/day. In the numerical groundwater model developed for the project area, the TSA sandstone unit is assigned a hydraulic conductivity of 80 ft/day and the conglomerate is assigned a hydraulic conductivity of 10 ft/day. The specific yield of both the sandstone and conglomerate units is estimated to be 0.15. Based on estimated aquifer parameters and measured water level gradients, groundwater velocities in the project area are estimated to range from 93 to 810 feet per year in the TSA sandstone, and from 28 to 930 feet per year in the TSA conglomerate.

Confining Unit 2. The CU2 separates the TSA from the SGA. Where the CU2 is present, it generally consists of a siltstone-sandstone-siltstone sequence and is greater than 30 feet thick. The CU2 is absent in the northeastern part of the study area beneath the BLA channel-fill deposit where a portion of the TSA and the CU2 are eroded away, north of the groundwater mound in the vicinity of Sandy Boulevard and NE 201st Avenue, and in an area east of NE 205th Avenue (Figure 3-8). In some areas where the CU2 is missing, a zone of increased fines is interpreted as a "stratigraphic equivalent".

The vertical hydraulic conductivity of the CU2, and its stratigraphic equivalent, has been investigated in great detail because of the potential for contaminant migration downward through the CU2, from the TSA to the SGA. Where the CU2 has significant thickness, the estimated vertical hydraulic conductivity is very low; in the range of 10^{-6} to 10^{-4} ft/day. In these areas, estimated vertical groundwater velocities are very small, and the potential for contaminant migration from the TSA to the SGA in reasonable time periods is highly improbable except where leaking well casings penetrate both aquifers.

North of the groundwater mound, where the CU2 is missing, about 10 feet of fine-grained CU2-equivalent materials separate the TSA from the SGA. The CU2-equivalent materials have an estimated vertical hydraulic conductivity in the range of $3x10^{-3}$ to $2x10^{-2}$ ft/day. Groundwater travel times from the TSA to the SGA in this area, after 25 days of operation of the SGA wells in the South Shore Well Field, were estimated to be in the range of 30 to 190 days.

Sand and Gravel Aquifer. The SGA is present beneath the entire project area and is 200 to 500 feet thick. In the central and western portions of the project area, the SGA consists of sandstone underlain by conglomerate. In the eastern part of the project area, sandstone is not present in the upper SGA. To the northeast near Blue Lake, the sandstone and conglomerate that are typical of the SGA in most of the project area are not present; instead, the SGA lithology is predominately siltstone and sandstone, with minor conglomerate. The hydraulic conductivity of the SGA is similar to that of the TSA.

Regional groundwater flow in the SGA is east-northeast toward groundwater discharge areas in the northeast part of the project area, near Blue Lake and along the Columbia River. SGA vertical groundwater gradients in most of the project area are upward from the SGA to the TSA, as would be expected in an area of regional groundwater discharge. The exception is in the vicinity of the TSA groundwater mound where the vertical groundwater gradient is downward from the TSA to the SGA. During periods when SGA wells in the South Shore Well Field are operating, SGA horizontal groundwater flow is toward the west-northwest, and normally upward vertical groundwater gradient between the TSA and SGA reverses and becomes downward.

Blue Lake Aquifer The BLA is a highly transmissive aquifer present in the northeastern portion of the project area. The BLA is in direct contact with the underlying TSA and SGA near the southwest shore of Blue Lake, but the hydraulic connection between the aquifers appears to be limited. Hydraulic connection with the Columbia River appears to be good. The transmissivity of the BLA has been estimated to range from 60,000 to 140,000 ft^2/day. Based on an aquifer thickness of 100 to 200 feet, the hydraulic conductivity of the BLA is estimated to range from 100 to 200 ft/day.

3.2.3 Surface Water Features

The major surface water features in the project area are Blue and Fairview Lakes; the Columbia River; the Columbia Slough; Taggart, Shepard and Osbourn springs; and Fairview, Osbourn and Storm Drain creeks (Figure 3-1). The two lakes are located adjacent to each other in the northeastern part of the project area, and are separated by a narrow TSA sandstone ridge. Fairview Lake is approximately 65 acres in size and is very shallow; average depth in the summer is reported to be only 4 feet, and in winter only about 1 foot. The lake is a discharge area for the TSA. Blue Lake is similar in size to Fairview Lake, but it is much deeper. The lake overlies the BLA, and is in contact with the TSA on its southern shore.

The Columbia River, along the northern boundary of the project area, is a regional groundwater discharge area. The Columbia Slough, in the west-central part of the project area, is an engineered waterway controlled by pumps and diversions to provide drainage, flood control and irrigation on the Columbia River floodplain. The Slough originates at Fairview Lake and flows west toward Portland for approximately 30 miles. The TSA discharges to the slough along an estimated 1,500 foot stretch west of Fairview Lake. West of this area, the TGA and floodplain deposits discharge to the slough.

Storm Drain Creek is a tributary of the Columbia Slough. Most of its recharge is from a local storm drain system. The creek also receives discharge from 1) the TSA groundwater extraction and treatment system at well RPW-2, 2) from the TGA groundwater extraction and treatment system at the Boeing Facility, 3) from a 400-foot long trench and treatment system designed to capture TGA groundwater prior to discharge at Shepard Spring north of the Cascade Corporation facility, and 4) from Taggart Spring. Storm Drain Creek is not in direct contact with the TGA. Osbourn Creek and Fairview Creek, in the eastern part of the project area, flow north and northwest, respectively, into Fairview lake. Osbourn Creek is fed by Osbourn Spring, which discharges from the TGA east of NE 205th Avenue and south of Interstate 84.

Other springs in the study area include Taggart and Shepard springs which discharge from the TGA north of the Cascade site and east of the Boeing facility. Discharge at Taggart and Shepard springs is typically less than 30 gpm and 5 gpm, respectively; the highest flows occur in winter and spring, coincident with higher precipitation. Discharge from Taggart spring is diverted to a tight-line storm sewer system that discharges to Storm Drain Creek. Shepard Spring has been dry since December 1995 when an upgradient TGA groundwater extraction trench began operation (see Section 4.5).

Stormwater runoff from NE 201st Avenue south of Interstate 84 and from the Cascade site discharges to the east ditch which is part of the Multnomah County storm sewer system. Other discharges to the east ditch include seepage from the TGA south of the Cascade site, runoff from the Cascade site and effluent from the TGA groundwater extraction and treatment system on the Cascade site. Water in the ditch flows east and northeast to Osbourn Creek.

4. SITE HISTORY

The administrative record index identifies the documents providing the details on the site history summarized below.

4.1 Site Discovery and Preliminary Assessments

Site discovery activities in the project area began in 1986. DEQ and EPA evaluated facilities within the area to identify those that were likely to use the chlorinated VOCs found in groundwater. DEQ completed federal preliminary assessments on the following facilities:

- Boyd Coffee
- Cascade Corporation
- Dirt & Aggregate Interchange
- Dry Cleaning Chemical Storage
- Libby McNeil & Libby
- NW Retreaders
- Norwest Publishing
- Swift Adhesives
- Viking Industries

In addition to the federal preliminary assessments, DEQ conducted state preliminary assessments on the following facilities:

- Multnomah County Parks - Blue Lake
- Opti-Craft

Following the preliminary assessments, additional investigations were performed on the Cascade Corporation, Norwest Publishing, Swift Adhesives and Viking Industries facilities. A summary of these investigations is provided in Section 4.4.

4.2 DEQ Response Actions

Concurrent with site discovery and assessment activities, DEQ undertook other actions in the EMC project area. DEQ response actions related to the groundwater contamination in the project area included monitoring of private supply wells to evaluate the extent of contamination, providing alternate water supplies to residences with contaminated water supplies, management of groundwater use in the area to control the spread of contamination, installation and testing of monitoring wells to further evaluate the extent of contamination, and development of a database and groundwater flow model to evaluate interim groundwater use in the area and develop cleanup alternatives for the contamination.

4.2.1 Groundwater Monitoring

DEQ sampled a number of private water supply wells in 1986 following the discovery of groundwater contamination at the Boeing facility. Resulting data was used to determine the scope of the Boeing monitoring and alternative water supply responsibilities to be conducted under their 1986 Consent Order with EPA and DEQ. In 1988, DEQ performed additional sampling of private supply wells to further investigate the extent of groundwater contamination in the area. In 1989, DEQ began quarterly monitoring of private supply wells located east of the Boeing facility when it was determined that Boeing was not the source of the contamination in this area. The responsibility for monitoring these wells was transferred to Boeing and Cascade in 1993, as part of the joint RI/FS for the TSA.

4.2.2 Alternate Water Supplies and Interim Groundwater Use Management

In 1989, DEQ provided bottled water to several single family residences located on 205th Avenue and north of I-84, which had previously received bottled water from Boeing. Responsibility for providing bottled water was transferred to Cascade in 1990.

DEQ began efforts to manage use of groundwater in the vicinity of the EMC groundwater contamination in 1990. Actions taken by DEQ to reduce the spread of contamination from the pumping of water supply wells included requiring the abandonment of two Rockwood Public Utility District wells in 1990, discontinued use of the Rolling Homes Mobile Terrace well, and development of pumping guidelines to protect the Portland Water Bureau's South Shore Well Field. Since development of the guidelines, the Portland Water Bureau has annually submitted pumping plans to DEQ.

4.2.3 Well Installations

In 1990, DEQ installed 8 wells at the site to determine the extent of groundwater contamination and the potential threats to the Portland well field and other supply wells located between Blue and Fairview Lakes. Another goal was to determine whether contamination in the area east of 201st Avenue was from an unknown upgradient source south of I-84 and east of Cascade. No groundwater contamination was found in that area.

In 1993, DEQ installed three additional wells south of Boeing and west of Cascade to determine whether an upgradient source of contamination existed in this area. No contamination was detected in any of these wells.

4.2.4 Database and Groundwater Flow Model Development

In 1993, DEQ initiated a project to integrate site specific information into a regional conceptual geologic and hydrogeologic model. The project involved evaluation of geologic information from a large number of well logs to refine the geologic model published by the U.S. Geological Survey (USGS), the Portland Water Bureau and others. The geologic interpretations and hydrogeological data, including water levels and aquifer pumping data, were used to develop a groundwater flow model. The model provided a quantitative tool to simulate the affects of pumping of the City of Portland's well field, to predict the future spread of groundwater contamination, and to investigate various cleanup alternatives for the TSA contaminant plume. DEQ completed its model project in June 1993, and provided the model to the City of Portland for their use in well field management, and to Boeing and Cascade for use in development of cleanup alternatives for the TSA.

4.3 EPA Response Actions

EPA has been the lead agency overseeing the investigation and cleanup of the Boeing facility since 1985. These enforcement actions are being conducted pursuant to federal Resource Conservation and Recovery Act (RCRA) authorities.

In coordination with DEQ, EPA evaluated the EMC site for inclusion on the federal National Priorities List (NPL), performed a site investigation of the Libby, McNeil & Libby site (Associated Foods facility) and entered into a memorandum of understanding with DEQ.

4.3.1 Site Inspection & Proposed NPL Listing

In 1991, EPA conducted a NPL listing site inspection at the EMC site. The investigation included performance of a soil gas survey at or in the vicinity of a number of facilities, and sampling of approximately 60 wells for full priority pollutant constituent analyses. Reports on these investigation activities were issued in the fall of 1991.

In May 1993, EPA issued public notice of the proposed listing of the EMC site on the NPL. In 1995, EPA requested the State of Oregon's concurrence to finalize the listing of the site on the NPL. Based on the progress being made on the completion of investigations and implementation of interim cleanup activities by Boeing and Cascade under State oversight, the State requested that EPA defer listing. EPA has taken no further action since then.

4.3.2 Associated Foods Site Investigation

In 1992, EPA performed a preliminary assessment and site investigation of the former Libby, McNeil & Libby site owned by Associated Foods. This investigation was prompted by allegations from a former employee that solvent wastes had been disposed at the site. No VOCs were detected in soil samples and no further action was taken.

4.3.3 Memorandum of Agreement with DEQ

In August 1994, DEQ and EPA entered into a memorandum of agreement (MOA) for the EMC site. The MOA formalized the respective roles and responsibilities of DEQ and EPA on the coordination of future investigation and cleanup at the EMC site. The MOA designated DEQ as the lead agency for the investigation and cleanup of Swift Adhesives, Cascade Corporation and the TSA area-wide groundwater contamination under State authorities. EPA retained lead for the Boeing facility under RCRA authorities.

4.4 Enforcement Activities

This section summarizes the enforcement activities taken in response to the discovery of groundwater contamination in the EMC project area in 1986.

4.4.1 Boeing

In 1986, Boeing entered into an Administrative Order on Consent with EPA and DEQ to address groundwater contamination detected at the facility. This order required Boeing to characterize the nature and extent of contamination at the facility, to provide alternate water supplies for contaminated groundwater supply wells, and to conduct monitoring of off-site supply wells. In 1989, Boeing's responsibility for providing alternate water supplies and monitoring was revised to eliminate areas east and south of the Boeing facility that apparently were not contaminated by the Boeing facility.

In 1993, Boeing entered into a second Order with EPA for completion of the facility investigation and the development and implementation of final corrective measures for soil and TGA groundwater contamination at the facility. EPA, with DEQ's concurrence, will be selecting a final cleanup for the Boeing facility later this year.

4.4.2 Cascade

In 1988, Cascade entered into a Consent Order with DEQ for a preliminary remedial investigation. A second Order was issued in 1989 for completion of a remedial investigation and feasibility study. Cascade has completed these activities. Public comment on DEQ's selected final remedy for the Cascade facility is proceeding concurrently with the TSA remedy selection process.

4.4.3 Swift Adhesives

In 1989, Reichhold Chemicals, Inc., owner of Swift Adhesives, entered into a Consent Order with DEQ for completion of a site investigation. In 1990, an amendment to the Consent Order was issued requiring completion of a RI/FS for VOC contamination discovered in a shallow TGA "perched" aquifer. In May 1994, DEQ selected a cleanup remedy and issued a record of decision for the site based on the results of the RI/FS. Reichhold Chemicals, Inc. is currently implementing the final remedy which includes groundwater extraction and treatment from a shallow perched aquifer.

4.4.4 Viking Industries

In 1989, Viking Industries entered into a Consent Order with DEQ requiring completion of a site investigation related to historical solvent disposal practices and a RI/FS for a release of diesel from an underground storage tank at the facility. The investigations were completed in 1991. No evidence of soil or groundwater contamination related to historical solvent disposal was discovered. The cleanup of the diesel contamination is being overseen by DEQ.

4.4.5 Boeing/Cascade

In July 1993, DEQ entered into a Consent Order with Boeing and Cascade requiring them to perform a removal action to control the northerly migration of the TSA contaminant plume. In 1994, an amendment to the Order (1994 Consent Order) was issued for completion of a comprehensive RI/FS for the TSA contaminant plume.

4.5 Interim Removal Action Measures

This section summarizes the interim removal actions (IRAMs) performed by Boeing and Cascade to control sources of contamination in the TGA at their respective facilities and prevent further migration of the area-wide TSA contaminant plume to the north.

4.5.1 TGA Source Control

Boeing and Cascade have implemented measures at their respective facilities to control the spread of groundwater contamination within the TGA, and control the migration of contamination from the TGA to the TSA.

Boeing Facility. IRAMs implemented at and near the Boeing facility to address TGA source areas include installation and operation of a groundwater extraction and treatment system, soil vapor extraction, abandonment of several supply wells, and soil excavation and disposal.

The groundwater extraction and treatment system is designed to control groundwater movement in the TGA under the Boeing facility and to capture and remove VOCs from this groundwater. The system, which began operation on March 1989, currently consists of 13 groundwater extraction wells and an air stripping tower. Between March 1989 and January 1996, the system extracted and treated approximately 740 million gallons of TGA groundwater containing approximately 3,100 pounds of VOCs.

Boeing implemented a soil vapor extraction (SVE) system to remove VOCs from soil above the saturated zone of the TGA beneath the Boeing facility. Two SVE wells (VE-3 and VE-4) are currently operating and two additional wells are planned to be operational by July 1996. The SVE system removed approximately 300 pounds of VOCs from soil between September 1995 and January 1996.

Other measures implemented by Boeing include the abandonment of former Boeing supply well A-2(d) and Rockwood Water District wells RW-1 and RW-2, abandonment of two domestic supply wells, and excavation and disposal of VOC-contaminated soil during building expansion in 1992.

Groundwater monitoring data suggests that Boeing's IRAMs are currently controlling migration of contamination within the TGA.

Cascade Facility. Cascade has implemented two IRAMs on its plant site to address TGA source areas and an offsite IRAM to cut off the discharge of contaminated TGA groundwater to the TSA north of the facility. These removal actions include installation and operation of a groundwater extraction and treatment system at the north property boundary (the onsite IRAM), decommissioning a former industrial supply well, removal of contaminated soil from several areas, and installation and operation of an offsite groundwater interceptor trench and treatment system (the offsite IRAM).

The onsite IRAM consists of five extraction wells located along the northern property boundary and an air stripping tower. Through December 1995, the onsite IRAM has removed and treated more than 27 million gallons of TGA groundwater containing approximately 380 pounds of VOCs.

The offsite IRAM, located approximately 600 ft north of the Cascade site, is a 400-ft long trench with the bottom keyed into CU1 designed to capture the off-site groundwater VOC plume causing contamination to the underlying TSA. The TGA control trench extraction and treatment system was brought on line in October 1995, and has operated continuously since December 1995. Preliminary monitoring data indicate the off-site IRAM system is functioning as designed.

Cascade has completed other IRAMs at its facility. A TSA industrial water supply well was abandoned because of a leaky well casing allowed contaminated TGA groundwater to flow to the lower TSA. Contaminated soil has been removed from several parts of the site, including the removal of approximately 160 yd^3 of soil from a drainage ditch along the northern property boundary.

4.5.2 TSA Interim Removal Measures

Boeing and Cascade implemented an IRAM to control the northerly migration of the TSA contaminant plume pursuant to the joint 1993 Consent Order (see section 4.4.5). Three extraction wells were installed in the TSA (identified as RPW-1ds, RPW-1dg and RPW-2). The RPW-1 wells are located west of Fairview Lake, and RPW-2 is located about 1000 feet southwest of Fairview Lake. RPW-2 has been operated since August 1994. Groundwater is treated by an air stripping system and discharged to the Columbia Slough. The RPW-1 wells are currently not pumped because they are beyond the extent of the TSA contaminant plume. The RPW-1 wells are not a component of the selected remedy, but will be maintained for monitoring and possible contingency operation in the event of an emergency requiring long-term operation of the entire PWB well field.

5. INVESTIGATION SUMMARY

5.1 Contaminants and Sources

The TSA is contaminated with several halogenated volatile organic compounds (VOCs). Compounds that have been consistently detected in TSA groundwater in the project area include trichloroethene (TCE), tetrachloroethene (PCE), and 1,2-dichloroethene (1,2-DCE). Two other compounds, 1,1,1-trichloroethane (1,1,1-TCA) and 1,1-dichloroethene (1,1-DCE) also have been detected in the TSA at low concentrations. The VOCs considered chemicals of potential concern (COPCs) that have been detected at concentrations above federal drinking water standard maximum contaminant levels (MCLs) include TCE, PCE, cis-1,2-DCE, and 1,1-DCE. The maximum concentrations of these COPCs detected in the TSA in a sampling round conducted in August 1994 were: 160 µg/L for TCE, 8 µg/L for PCE, 29 µg/L for cis-1,2-DCE, and 2 µg/L for 1,1-DCE. TCE is the most widespread of the VOCs detected in the TSA, and is also the VOC detected at the highest concentrations.

VOCs have also been detected in the SGA beneath the area where the TSA is contaminated. The VOCs detected in the SGA include TCE, cis-1,2-DCE and PCE, but concentrations are significantly lower than those in the TSA. TCE is the only contaminant detected above the MCL. A summary of TSA and SGA groundwater contaminant concentrations is listed on Table 5-1. The maximum TCE concentration detected in the SGA in late 1995 was 16 µg/L.

The primary source of contamination to the TSA is the discharge of contaminated groundwater from the TGA. The areal extent of total VOC contamination in the TGA as of summer 1994 is shown on Figure 5-1. Potential migration pathways from the TGA to the TSA include infiltration from springs, seeps, and vertical leakage downward through the CU1 near the TGA/CU1 truncation north of Cascade, and leakage along well casings of former water supply wells at the Boeing and Cascade facilities. The areas of highest TCE concentrations in the TSA, shown on Figures 5-2 and 5-3, correlate to locations of potential pathways from the TGA to the TSA and subsequent migration from these areas. TGA source control measures implemented by Boeing and Cascade, which have included intercepting the contaminated groundwater flow that formerly discharged at springs and seeps and abandonment of wells with leaking casings, have eliminated or are expected to eliminate or control transport of VOCs to the TSA.

The source of VOC contamination in the SGA is most likely leakage along well casings completed through CU2. Four water supply wells have had confirmed detections of VOCs, and these wells were all constructed without a seal through CU2 and have been, or are currently, used.

5.2 Extent of Contamination

Contamination in the TSA generally extends over an area of about 300 acres in the central part of the project area from south of Interstate 84 near the Cascade site, northward just beyond the Columbia Slough. The extent of contamination in the TSA Sandstone and Conglomerate subunits, as defined by the presence of TCE in groundwater, is shown on Figures 5-2 and 5-3, respectively. The highest TCE concentration in both the TSA Sandstone and Conglomerate, reported in August 1994, occurred in and west of the groundwater mound area. The maximum TCE concentrations were 140 µg/L at MW-18(ds) in the TSA Sandstone and 160 µg/L at well BOP-13(dg) in the TSA Conglomerate. The historical source of contamination to these locations is interpreted to be discharge of contaminated groundwater from TGA near the TGA/CU1 truncation and TSA recharge in the groundwater mound area. Outside of the mound area the maximum observed TCE concentration was 90 µg/L in the TSA Sandstone on the Boeing facility near the location of a former supply well. The areal extent of TSA Sandstone and Conglomerate groundwater contaminated above the TCE MCL of 5 µg/L is illustrated by the 5 µg/L contour on Figures 5-2 and 5-3. Approximately 3 billion gallons of water in the TSA contain concentrations of TCE in excess of the MCL (based on an aquifer porosity of 0.25). The total mass of TCE in this volume is estimated to be about 1900 pounds.

The distributions of PCE and total 1,2-DCE in the TSA Sandstone and Conglomerate are less extensive than the TCE distribution, and concentrations are much lower. PCE concentrations exceed the MCL (5 µg/L) at a few wells within the groundwater mound area. 1,2-DCE concentrations do not currently exceed the MCL (70 µg/L) within the project area. In August 1994, detections of 1,1-DCE were only reported at three wells; none of these detections exceed the MCL of 7 µg/L. Maximum concentrations of PCE and 1,2-DCE in the TSA Sandstone generally occur within and downgradient of the groundwater mound area. The maximum concentration of 1,1-DCE occurs in the TSA Sandstone beneath the Boeing facility.

For the COPCs, contaminant distributions are slightly more widespread and at higher concentrations in the TSA Sandstone than in the TSA Conglomerate, except in the groundwater mound area where the TSA sandstone is not saturated or the saturated thickness is minimal. In the mound area, concentrations in the upper part of the conglomerate are similar to, or exceed, concentrations in the sandstone. The VOC concentrations in the TSA are very low compared to their aqueous solubility, indicating that there is no direct source of contamination within the TSA (e.g. pure solvents within the soil matrix).

The leading edge of the VOC plume has been defined by wells with no TCE detections. The TCE plume, as shown on Figures 5-2 and 5-3, encompasses the plumes for the other COPCs and, therefore, is considered to be the primary representative of contaminant distributions within the TSA. Uncertainty currently exists as to the northeast extent of the TSA VOC plume between MW-23(ds) and DEQ-4(s) and the VOC concentrations at the base of the TSA at MW-23(ds) (see Figure 3-2a). Additional investigations are being implemented to address these uncertainties.

The available water quality data for the SGA indicates that there is most likely not a continuous plume of groundwater contamination in that aquifer. Confirmed detections (two or more consecutive detections since 1991) have been reported in four water supply wells beneath the TSA plume, where natural hydraulic gradients are downward from the TSA to the SGA. In

November 1995, TCE was only detected at three of these wells at concentrations ranging from 1.4 to 16 µg/L (Figure 5-4). VOCs have been detected at four other SGA wells located north and northwest of the TSA plume, but these detection have been at low concentrations and have not been confirmed in consecutive samples from these wells.

The only surface water body that receives discharge from the TSA or SGA, in the project area where VOCs have been detected, is the Columbia Slough just downstream of Fairview Lake. The Columbia Slough was sampled at two stations east of the erosional truncation of CU1, in the area where groundwater from the TSA discharges to the slough. At the downstream station, TCE has been detected intermittently at low concentrations, up to 2.3 µg/L, over the monitoring period. In addition to the Columbia Slough, water samples were also collected from Fairview Lake and Osbourn Creek. No VOCs were detected from these sampling events. Surface-water sampling data for the Columbia Slough are summarized on Table 5-2.

5.3 Contaminant Fate and Transport

The VOCs in the TSA result from migration of dissolved VOCs from the TGA to the TSA via discharge of contaminated groundwater from the TGA to the TSA, and leakage along unsealed water supply well casings. Within the TSA, the primary VOC transport process is advective transport with the groundwater (refer to Section 3.2.2 and Figures 3-6 and 3-7). VOCs have migrated radially from the TSA mound to the east and west and eventually farther downgradient move in the direction of regional TSA groundwater flow, to the north/northeast toward Fairview Lake. Contaminants have been transported a shorter distance to the northeast of the groundwater mound because of the decreased sandstone saturated thickness in that direction (Figure 5-2), the lower transmissivity of the conglomerate, and because most of the TGA recharge to the TSA occurs on the south side of the mound where groundwater flows to the south. VOCs in the TSA originating from a leaky well casing at the Boeing facility have migrated toward the northeast. The VOC plume in the TSA currently extends to the western corner of Fairview Lake and the Columbia Slough which is a groundwater discharge area for the TSA. The eastern portion of the VOC contaminant plume is migrating toward discharge areas south of the eastern end of Fairview Lake. Other less significant contaminant transport and fate processes include sorption and biotic and abiotic transformations. Sorption processes are estimated to be relatively low due to the low organic and silt/clay content in the TSA, and biotic and abiotic transformations apparently occur very slowly.

Pumping from the City of Portland's South Shore well field has the potential to affect the direction and rate of groundwater flow in the TSA. A numerical groundwater transport model was used to investigate potential plume migration under four different wellfield use scenarios and the absence of remediation:

- Reasonable Current Average (RCA) Scenario. Pumping of the existing BLA production wells at estimated maximum capacity of 50 mgd, for 90 days per year, for 20 years.
- Reasonable Current Maximum (RCM) Scenario. Pumping of existing TSA, BLA, SGA, CRSA and TGA production wells at estimated maximum capacity of 99 mgd, for 151 days per year, for 20 years.

- Reasonable Future Maximum (RFM) Scenario. Pumping of existing and proposed production wells at estimated total maximum capacity of 150 mgd, for 151 days per year, for 20 years.

- Emergency-Use Scenario. Continuous pumping of existing production wells at estimated maximum capacity of 99 mgd, for 3 years.

The results of the modeling analyses indicate that, in the absence of remediation, the TCE plume would expand significantly beyond its current configuration. Under the RCA scenario, most of the plume eventually discharges to the surface water bodies, but the plume also expands to encompass the BLA production wells. Under the RCM and RFM scenarios the VOC plume expands to the west and is not substantially captured by the surface water bodies. The TCE plume in the TSA is calculated to extend to the BLA and TSA production wells under these scenarios. Under the emergency use scenario, the TCE plume is primarily northwesterly and is less extensive than predicted under the RCM or RFM scenarios. The plume front is not predicted to extend to either the BLA or TSA production wells within the simulated 3-year period.

5.4 Endangerment Assessment

An endangerment assessment was performed as part of the RI, in accordance with OAR 340-122-080 and USEPA guidance to evaluate the potential risks to human health and the environment and the need for remedial action, or no action, at the site. The endangerment assessment included a human health evaluation and an ecological evaluation. Each evaluation included an evaluation of the chemicals of concern, a toxicity assessment, an exposure assessment, risk characterization, and an uncertainty assessment.

5.4.1 Human Health Evaluation

TCE, PCE, cis-1,2-DCE, and 1,1-DCE were identified as COPCs based on chemical toxicity, and detection frequency in groundwater and surface water. TCE and cis-1,2,-DCE were identified as COPCs in TSA and SGA groundwater and in surface water in the Columbia Slough. PCE was identified as a COPC in both TSA and SGA groundwater, and 1,1-DCE was identified as a COPC in TSA groundwater.

Residential, occupational, and recreational exposure scenarios were evaluated based on land use and zoning information. For each of these scenarios, the following potential current exposure pathways were quantitatively evaluated for potential impacts from the TSA VOC plume:

- Residential ingestion, dermal contact, and inhalation of chemicals volatilizing from TSA water during household use;

- Residential ingestion, dermal contact, and inhalation of chemicals volatilizing from SGA water during household use;

- Residential ingestion of food crops that have been irrigated with water from the TSA, the SGA, or the Columbia Slough;

- Residential and occupational inhalation of chemicals volatilizing from TSA water through soil into a residence and workplace environment, respectively;

- Recreational dermal contact with surface water in the Columbia Slough.

For each of these exposure pathways, central tendency exposure (CTE) and reasonable maximum exposure (RME) conditions were used to evaluate potential impacts to human health. CTE and RME intake assumptions from EPA guidance, professional judgment, and data collected from the TSA, the SGA, and the Columbia Slough were used to estimate chronic daily intakes (CDIs) and lifetime daily intakes (LDIs).

Potential non-carcinogenic effects were evaluated by comparing the CDIs with non-carcinogenic indicators of safe daily intakes (i.e., EPA-established reference doses). The reference dose is the estimate of a daily exposure for humans that is unlikely to produce an appreciable risk or deleterious effect. The ratio of the calculated intake of a chemical to its reference dose is called the hazard quotient. The sum of the hazard quotients for each COPC at the site is a hazard index. A hazard index greater than one suggests that deleterious effects may occur to exposed individuals.

The increased probability of developing cancer (excess cancer risk) from exposure to TSA-related compounds was estimated with EPA-established carcinogenic slope factors and the calculated LDIs. Total excess cancer risk is determined by dividing the intake of each COPC by its slope factor and summing all of the ratios. The risk is expressed as a probability, such as 1 in 1,000,000 or 1×10^{-6}.

The non-cancer hazard index for all exposure pathways for both the CTE and RME assumptions were less than one. The excess lifetime cancer risk under the CTE assumptions exceeded 10^{-6} for the residential use of TSA groundwater exposure scenario, and under the RME assumptions exceed 10^{-6} for both the residential use of TSA groundwater and use of SGA groundwater from supply wells with leaking well casings. The excess lifetime cancer risk estimated for the residential use of TSA groundwater is 4.8×10^{-6} under the CTE assumptions and 4.0×10^{-5} under the RME assumptions. Most of the excess lifetime cancer risk is from inhalation of TCE during showering. The estimated excess lifetime cancer risk for the residential use of SGA groundwater under the RME assumptions is 3.4×10^{-6}, with most of the risk associated with the inhalation of TCE vapors from the water. A summary of the estimated risks is provided in Table 5-3.

A numerical groundwater model was used to evaluate transport of the TSA VOC plume and to estimate exposures for hypothetical future exposure pathways under the four aquifer-use scenarios described in Section 5.3. Under the RCA scenario, TCE concentrations at the BLA wells are predicted to be less than the MCL, due to dilution from Columbia River recharge of the BLA. Private supply wells PMX-345 and PMX-189 (see Figure 3-2a) were predicted to be impacted. Under the RCM and RFM scenarios, PWB wells 5 and 15 may become impacted. Limited contamination of the SGA was also predicted under the RCA and RCM scenarios. The spread of contamination was predicted to be greater under the RCM and RFM pumping scenarios than under the 3 year continuous emergency use scenario.

5.4.2 Ecological Evaluation

Potential impacts to ecological receptors from discharge of TSA groundwater into surface water bodies were also evaluated. Cis-1,2-DCE and TCE in Columbia Slough water were identified as the COPCs for ecological receptors. No COPCs were identified for the other surface water bodies evaluated. No TSA-related chemicals were detected in sediments of the Columbia Slough. The COPCs were used to estimate potential adverse ecological effects associated with ingesting water from the slough.

The marsh wren and the common muskrat were selected as the indicator species for assessing ecological impacts, on the basis of size and higher food and water intake rates relative to body weight. The muskrat was also selected because it can ingest bottom-dwelling plants in the slough while foraging. Two sensitive-critical species (i.e., the painted turtle and western pond turtle) were identified in the project area, but were observed only at Fairview Lake, a surface water body that had no detectable levels of VOCs.

Two methods were used to evaluate potential impacts to ecological receptors using parameters and assumptions for the indicator species. First, COPC concentrations in surface water were compared with published water quality criteria intended to protect freshwater life. Second, the potential risks to the health of individual members of a wildlife species expected to have high exposure were estimated, by comparing CDIs with toxicity reference values. The results of the ecological assessment indicate the ecological receptors are not expected to be impacted by the COPCs in the Columbia Slough.

6. REMEDIAL ACTION OBJECTIVES AND CLEANUP LEVELS

This section summarizes the remedial action objectives and cleanup goals developed for the site to protect human health and welfare, and the environment.

6.1 Remedial Action Objectives

Remedial action objectives (RAOs) are site-specific goals for protection of human health and the environment. The RAOs for the EMC site were established in the consent order for the TSA RI/FS. In the consent order, RAO-a specified restoration of the TSA to background conditions. The technical feasibility of restoring the TSA to MCLs and to background was evaluated in detail in the FS. Restoration to background conditions in a reasonable time frame was determined to be infeasible. Restoration to background, defined as 0.05 µg/L TCE concentration, was estimated to take from 2.5 to 4 times longer than restoration to MCLs. For the most effective alternative presented in the FS, a time frame of 45 to 80 years was predicted to achieve background. A time frame of this magnitude was not considered reasonable.

The analyses conducted during the RI and FS process indicate that restoration of the TSA to protective levels (MCLs) is feasible. The relatively low dissolved VOC concentrations in TSA groundwater and the aquifer characteristics (e.g., low organic content and moderate permeability) indicate there is a reasonable potential for restoration of the TSA using groundwater extraction and treatment technologies. RAO-a, as revised by DEQ, and the remaining RAOs for protection of human health, welfare, and the environment specified in the consent order are summarized below.

a) Restore the TSA to protective concentrations in a reasonable time, if feasible. If not feasible, minimize the extent of the TSA containing VOCs above MCLs, or 1×10^{-6} excess cancer risk levels, whichever is more stringent, and provide long-term containment of areas where concentrations are above MCLs;

b) Prevent ingestion of TSA groundwater that contains TCE, PCE, cis-1,2-DCE and 1,1-DCE at concentrations above their respective MCLs;

c) Protect environmental receptors by preventing surface water discharge of TSA groundwater with VOC concentrations that exceed surface water ambient water-quality criteria;

d) Prevent the further spread of contamination in the TSA to the extent practicable;

e) Protect groundwater quality in the SGA and the BLA; and

f) Allow existing uses of groundwater resources in eastern Multnomah County, or if not feasible, minimize the type and length of groundwater use restrictions.

6.2 Cleanup Goals

The cleanup goals for the four COPCs in groundwater (TCE, PCE, cis-1,2-DCE and 1,1-DCE) are the federal drinking water MCLs promulgated under the Safe Drinking Water Act (SDWA). MCLs are the maximum concentrations of contaminants allowed in water used for drinking. Oregon has adopted the federal regulations as state water regulations (OAR Chapter 333 Division 61). The current MCLs for the COPCs and corresponding risk levels are listed on Table 6-1. The risk levels were estimated using EPA residential exposure assumptions for ingestion of, dermal contact with, and inhalation of vapors from chemicals in groundwater, during normal household use.

The excess cancer risks corresponding to the MCLs for 1,1-DCE and PCE exceed 1×10^{-6}. The groundwater contaminant plumes for these chemicals are encompassed by the TCE plume. The maximum concentrations of PCE is slightly above the MCL, and 1,1-DCE is below the MCL.. Cleanup of the TSA to the TCE MCL, therefore, will reduce the concentration of the other chemicals well below their respective MCLs. To illustrate, remediation of the highest TCE concentration (160 ppb) to the MCL (5 ppb) represents a 32-fold reduction in concentration. If this 32-fold factor is similarly applied to the maximum TSA plume concentrations for PCE (7.9 ppb) and 1,1-DCE (2.2 ppb), it is anticipated that the concentrations will be proportionally reduced to 0.25 ppb and 0.07 ppb, respectively. These concentrations correspond to estimated cancer risk levels of 3×10^{-7} for PCE and 1×10^{-6} for 1,1-DCE (based on residential exposure).

The cleanup goals for the COPCs in surface water are the ambient water-quality criteria developed under the federal Clean Water Act, as administered by the state of Oregon. These criteria are:

- TCE — 45,000 µg/L for acute exposure, 21,000 µg/L for chronic exposure;
- PCE — 5,280 µg/L acute, 840 µg/L chronic; and
- cis-1,2-DCE and 1,1-DCE — 11,600 µg/L total DCE for acute and criterion for chronic exposure.

The maximum concentrations of these COPCs in TSA groundwater are well below their respective water quality criteria. Therefore, future groundwater discharges to surface water will not cause exceedances of these criteria.

6.3 Applicable or Relevant and Appropriate Requirements

While not a remedy selection criterion or State law requirement, remedy implementation will comply with "applicable or relevant and appropriate requirements" (ARARs) to help meet RAOs and provide consistency with the federal NCP. The ARARs identified for the TSA cleanup are described below.

6.3.1 Resource Conservation and Recovery Act (RCRA)

DEQ's Hazardous Waste Management rules, Oregon Administrative Rules (OAR), 340-100-001*et.seq.*, generally adopt the federal RCRA regulations. These regulations are applicable to cleanups involving "hazardous wastes" as defined in RCRA. Hazardous wastes must meet the applicable regulations under OAR 340-122-100, 101, 102, 104, 105, and 106, as well as Sections 260, 261, 262, 265 and 268 of RCRA, unless specific requirements are exempted by the Director of DEQ under Oregon Revised Statutes (ORS) 465.315, or are determined to be procedural requirements only. Oregon regulations in OAR Chapter 340 establish state requirements that are in addition to federal requirements, including annual reporting and fees for hazardous waste generation.

The VOCs in the TSA contaminant plume may be hazardous constituents from historical releases of spent solvents and sludge, from former vapor degreaser operations, or cutting oils used in parts machining at the Cascade and Boeing facilities. However, dissolved VOCs in the TSA groundwater are from multiple sources from the Boeing and Cascade facilities and a definitive determination cannot be made as to the source of the VOCs. Therefore, soil drill cuttings, excavated soil, or groundwater extracted during the TSA remedy would not be a hazardous waste, unless contaminant concentrations exceed toxicity characteristic regulatory levels specified in 40 CFR Part 261.24. Maximum reported TCE, PCE and DCE concentrations in the TSA are below these regulatory levels.

Drill cuttings from installation of TSA extraction wells in source areas on the Boeing facility, where highly contaminated soils may exist, will also need to be characterized to determine if they are a hazardous waste. Wastes determined to be hazardous under RCRA would need to be disposed in accordance with Sections 265 and 268 of RCRA.

Drill cuttings from wells installed in other portions of the TSA contaminant plume would not contain sufficient concentrations of hazardous constituents to exceed risk based concentrations in soil, based on knowledge of groundwater contaminant concentrations and chemical partition coefficients, and the results of previous drill cutting characterizations. Wastes determined to be non-hazardous pursuant to Section 261, must be managed in accordance Oregon rules for solid waste in OAR 340-93 through 97.

6.3.2 Clean Air Act

Oregon Air Pollution Control Laws (OAR 340-20 and 28) regulate operation of stationary air pollution sources. These regulations are applicable to groundwater air-stripping treatment systems. DEQ has determined that VOC emissions from a packed tower air-stripping systems located at least 100 meters upwind from residential populations would not exceed significant emission rates under OAR 340-20-225. Treatment of VOC emissions from the air stripping units will, therefore, not be required provided the system is located at least 100 meters from residential populations.

6.3.3 Drinking Water Quality Act

The Oregon Drinking Water Act (ORS 448.115 through 990) authorizes adoption of federal regulations for drinking water promulgated under the Safe Drinking Water Act (SDWA)

(40 CFR 141.11-141.16). The Oregon rules for public water systems (OAR 333-61) implement this statute, and are applicable to any cleanup which involves beneficial reuse of treated groundwater as a source of public water supply. The maximum contaminant levels (MCLs) presented in Table 6-1 are applicable standards for beneficial reuse of treated groundwater.

6.3.4 Clean Water Act

Oregon Water Pollution Laws regulate the discharge of pollutants to surface waters of the State and are applicable to the discharge of treated groundwater. Rules applicable to the TSA cleanup include OAR 340-41 which specify surface water quality standards, and regulations pertaining to National Pollutant Discharge Elimination System (NPDES) and Water Pollution Control Facility (WPCF) permit requirements under OAR 340-45.

6.3.5 Water Resource Department Regulations

Oregon Water Resource Department regulations under OAR Chapter 690 may be applicable to one or more of the remedial alternatives. Regulations that may be applicable include:

- Division 10 - Appropriation and Use of Groundwater;
- Division 11 - Applications and Permits;
- Division 15 - Water Right Transfers; and
- Division 210 well construction standards; and Division 220 abandonment of wells.

7. DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

This section summarizes the areas and volumes of TSA groundwater contamination exceeding the cleanup levels and the remedial alternatives developed by Boeing and Cascade in the FS. Also included is a summary of additional remedial alternatives developed by DEQ and its contractor, S.S. Papadopulos & Associates, to identify the best feasible remedial alternative for the TSA groundwater contaminant plume.

7.1 Areas & Volumes

The areal extent of the zone within the TSA that contains TCE at concentrations above the 5 µg/L MCL cleanup goal is approximately 300 acres. The areal extent of the zones in the TSA sandstone and conglomerate subunits that contain TCE concentrations above 5 µg/L are both approximately 287 acres, but the footprint of these zones is not the same (Figures 5-2 and 5-3).

There are approximately 3 billion gallons of groundwater (based on an aquifer porosity of 0.25) within the zone of contamination. The volume of contaminated groundwater in the conglomerate subunit is about 40% larger than that in the sandstone subunit, because the average saturated thickness of the conglomerate is greater than that of the sandstone subunit. Approximately 1900 pounds of TCE are contained in the TSA; 1085 pounds dissolved in the groundwater and 815 pounds sorbed to the aquifer matrix (based on a retardation coefficient of 1.75). Over 75% of the contaminated zone in the TSA contains TCE concentrations of less than 50 µg/L, and greater than 90% of the contaminated zone contains TCE concentrations of less than 100 µg/L.

7.2 Common Elements of Alternatives

Five remedial alternatives were developed by Boeing and Cascade in the FS for the TSA, and DEQ analyzed four variations of their Alternative 5. These alternatives were all developed under the FS supported assumptions that restoration of the TSA to MCLs in a reasonable timeframe is feasible, and that the time for restoration can be estimated, based on travel times derived from the numerical groundwater flow model developed for the site and the batch flush model explained below.

Groundwater restoration in the alternatives theoretically occurs as a result of a very simple concept: contaminated groundwater is replaced with clean water. In all alternatives except for alternatives 1 and 2, the contaminated water is actively extracted through extraction wells and clean water is drawn in from beyond the perimeter of the plume toward the extraction wells. In alternatives 1 and 2 the contaminated groundwater passively discharges via natural processes to the Columbia Slough and other surface water bodies. The rate at which aquifer restoration is achieved, in those cases where restoration is possible, is related to the rate at which clean water replaces the extracted water.

The prediction of restoration times for the various remedial alternatives has associated with it a large uncertainty. The cause of this uncertainty has been well discussed in a number of articles and texts (for example, National Research Council, 1994). The FS used the batch flush method as a means of estimating restoration times. This method is the one most commonly used for estimating aquifer cleanup times, but as noted, these estimates have a large uncertainty associated with them. The batch flush method essentially relates the restoration time to how quickly clean water is flushed through the aquifer. The rate of flushing of clean water is defined as the time required to remove one volume of contaminated water from the aquifer.

Each of the remedial alternatives, except for the no action alternative, have several common components. All of the alternatives: 1) assume that remedial actions in the TGA will effectively eliminate contaminant migration to the TSA; 2) include an interim removal action for the SGA; 3) provide an alternate water supply to existing well users within the TSA VOC plume; 4) implement groundwater use controls until TSA restoration is complete; and 5) provide for performance groundwater monitoring. Interim actions for the TGA are discussed in Section 4.5. Final remedial actions for the Boeing and Cascade facilities will incorporate these interim measures, as well as additional remedial components. The remaining common remedial components are discussed below.

7.2.1 SGA Interim Removal Measures

As discussed in Section 5, four water supply wells have low levels of VOCs. To correct this problem, which is believed to be due to leakage along the well casings, six SGA wells will be abandoned, or partially abandoned for conversion to TSA monitoring wells to evaluate remedy performance. They are:

- The Handy well (PMX-195) owned by Silent Creek Joint Venture;
- The Shepard well (PMX-207) owned by Sandy Boulevard Development Corp. (a subsidiary of Cascade);
- Two supply wells owned by Sandy Mobile Villa (PMX 208 and 409);
- A supply well owned by Terrand Mobile Terrace (PMX 410); and
- A supply well owned by Cherry Blossom Manor (PMX 225).

The locations of these wells are shown in Figure 3-2b.

7.2.2 Alternate Water Supply

An existing public water supply system would be extended to serve residences with groundwater wells in the area affected by the TSA VOC plume, to prevent ingestion of TSA groundwater that contains VOCs above MCLs. Six TSA domestic water supply wells (PMX-196, PMX-345, PMX-417, PMX-434, PMX-189 and PMX-198) would be connected to the City of Fairview municipal water supply system (refer to Figure 3-2a for well locations). These wells would either be abandoned to prevent future use or maintained for remedy performance monitoring. The Terrand Mobile Terrace mobile home park would also require an alternate water supply. This will be provided in 1996 and will come either from the Rockwood Water District municipal supply or from a new supply well completed in deeper zones in the SGA.

7.2.3 Groundwater Use Restrictions

All of the remedial alternatives, except for the no action alternative, place restrictions on groundwater use within the area of contamination. The goal of these restrictions is to prevent the spread of contamination in the TSA or the SGA during remediation. The FS indicated that those restrictions could be accomplished through rules of the Oregon Water Resource Commission designating the area a "critical groundwater area" pursuant to ORS 537.730.

7.2.4 Performance Monitoring

Each of the alternatives would include monitoring of water levels and water quality of the TSA and SGA during remedy implementation, to assess progress on restoration of the TSA, and to assess control of the spread of contamination during pumping of the Portland Water Bureau South Shore Well Field. Wells would be monitored semi-annually for up to the first 5 years. The groundwater would be analyzed for VOCs. Section 9 describes the performance monitoring components for the selected remedy.

7.3 Description of Alternatives

7.3.1 Alternative 1

Alternative 1 is a no action alternative. This alternative has no active remedial components, and does not include monitoring for the TSA. The no action alternative is retained for consideration, as required by the 1994 Consent Order, Oregon administrative rules, and consistent with the NCP. This alternative does not meet the RAOs described in Section 6.1.

7.3.2 Alternative 2

Alternative 2 would implement institutional controls along with the following components:

- Monitoring to identify and prevent potential exposure to the affected groundwater, to evaluate impacts on the VOC plume from PWB pumping, and to assess progress toward achieving the RAOs for the TSA;

- Providing alternate water supplies to serve residences with groundwater wells in the area affected by the TSA VOC plume; and

- Applying groundwater use restrictions in and adjacent to the TSA plume area.

This alternative would rely on the TGA source controls described above and on natural aquifer processes to achieve aquifer restoration.

Restoration Time Frame. The time for achieving restoration has been estimated as significantly greater than 100 years.

7.3.3 Alternative 3

Alternative 3 includes the components described for Alternative 2 and adds groundwater extraction for hydraulic control of the TSA contaminant plume, and treatment and discharge of treated groundwater to surface water. The goal of these additional actions is to prevent further spread of the VOC plume in the TSA. The main additional components in this alternative are described below.

Groundwater Extraction. The groundwater hydraulic control system would include installation of 3 new extraction wells and 1 existing TSA extraction well (RPW-2). The system would prevent the spread of the VOC plume in the TSA and protect groundwater quality in the SGA and BLA to the extent practicable during baseline conditions (non-pumping of PWB south shore well field). The extraction system would provide limited aquifer restoration during nonpumping conditions. The wells would have a total extraction rate of approximately 300 gallons per minute (gpm). A conceptual layout of the extraction wells is presented on Figure 7-1.

Groundwater Treatment and Disposal. Groundwater would be treated with an air stripper to remove VOCs. The locations and treatment system configurations would be evaluated during final design. Discharge from the treatment system would be conveyed to the Columbia Slough or other surface waters in the vicinity. Contaminant discharge limits and monitoring requirements for the treated water would be in accordance with DEQ rules.

Restoration Time Frame. Although the primary objective of this alternative is hydraulic control, water quality within the aquifer would gradually improve. The time for achieving full restoration has been estimated as significantly greater than 100 years.

7.3.4 Alternative 4

Alternative 4 includes all the components of Alternatives 2 and 3 as well as additional extraction wells to increase the total groundwater extraction rate. The goals of Alternative 4 are to prevent spreading of contamination, to minimize the areal extent of the TSA that contains VOCs above MCLs (i.e., restore portions of the aquifer), and to provide long-term containment for those areas where concentrations remain above MCLs.

Groundwater Extraction. The groundwater extraction system would provide additional extraction wells and an increased rate of the groundwater extraction, relative to Alternative 3. The groundwater extraction system would include six new extraction wells, one existing TSA extraction well (RPW-2), and one monitoring well (MW-24) converted to an extraction well. A conceptual layout of the extraction wells is presented on Figure 7-2. Existing wells RPW-2 and MW-24, completed in the TSA conglomerate, would be incorporated into the system along with three new wells installed in the TSA sandstone and three new wells in the TSA conglomerate. The conceptual operating scenario includes groundwater extraction at a total rate of approximately 500 gpm during PWB non-pumping, and increased extraction during PWB well field operation.

Restoration Time Frame. Although the primary objectives of this alternative are plume reduction and long-term containment, this alternative would eventually restore the aquifer to MCLs. The time for achieving restoration was estimated as 50 to 60 years in the FS. However, DEQ estimates that about 85 years would be required to restore 80% of the contaminated aquifer volume to MCLs.

7.3.5 Alternative 5

Alternative 5 would incorporate all the components of Alternatives 2 through 4 and provide additional extraction wells and an increased total groundwater extraction rate for restoration of the TSA to MCLs in a reasonable timeframe.

Groundwater Extraction. The details of the groundwater extraction system would be developed during remedial design activities. Based on existing data, the groundwater extraction system would include 12 new and one existing TSA extraction well and one converted existing monitoring well (MW-24) with a total extraction rate of about 1,100 gpm. A conceptual layout of the extraction wells is presented on Figure 7-3. The existing wells RPW-2 and MW-24, completed in the TSA conglomerate, would be incorporated into the system, along with four new wells installed in the TSA sandstone and eight new wells in the TSA conglomerate.

Groundwater Treatment and Disposal. The FS identified air stripping as the primary treatment technology. Advanced oxidation treatment (e.g., ultraviolet radiation, ozone and/or hydrogen peroxide) and beneficial reuse of treated groundwater for public water supply were retained for further evaluation during remedial design. Reinjection/reinfiltration of treated groundwater was also retained for evaluation during remedial design, but was not developed specifically with reinjection/reinfiltration as a component.

Restoration Time Frame. The FS provided estimates indicating Alternative 5 would restore 75% of the TSA to MCLs within 20 years. DEQ has estimated, however, that with the well locations shown on Figure 7-3 and the preliminary estimates of the extraction rates for these wells, 80% of the TSA would be restored to MCLs in 24 years, and 90% would be restored to MCLs in 35 years.

7.3.6 Other Remedial Alternatives

DEQ evaluated four additional remedial action alternatives, beyond those evaluated in the FS. The evaluation of these alternatives is documented in a memorandum from Charles Andrews of S.S. Papadopulos & Associates, to Bruce Gilles of DEQ, dated June 12, 1996. These additional alternatives are all variations of Alternative 5 with the only differences being the number of extraction wells and extraction rates, and in one of the additional alternatives, the addition of reinjection wells. These additional alternatives were developed to evaluate the preliminary design for Alternative 5 provided in the FS, and determine whether restoration times faster than those predicted for Alternative 5 are feasible. The additional alternatives that were evaluated are described below.

Alternative 5A. The primary objective of this alternative, is to evaluate the preliminary design for Alternative 5. This alternative consists of extraction wells placed along the centerline of the contaminant plume in the TSA conglomerate. This alternative has 4 TSA sandstone wells and 13 TSA conglomerate wells. Total pumping from the sandstone is 350 gpm, and total pumping from the conglomerate is 813 gpm. The location of the TSA conglomerate extraction wells are shown on Figure 7-4. The TSA sandstone extraction wells are as described for Alternative 5.

This alternative was initially designed to have identical pumping rates as those in Alternative 5. The additional pumping from the conglomerate above that in Alternative 5 occurs near the Columbia Slough north of the existing TSA recovery well RPW-2. Cleanup times north of RPW-2 are relatively slow in Alternative 5, and the placement of an additional conglomerate extraction well in this area greatly increases the rate of cleanup.

Alternative 5B. This alternative has well locations identical to those in Alternative 5A. The total pumping rate from the sandstone wells is the same, but the pumping rate from the conglomerate is 20% greater or 970 gpm. The objective of this alternative is to evaluate restoration effectiveness and reduction in restoration time frames which might be realized through increased groundwater extraction.

Alternative 5C. This alternative has the same total pumping rate as Alternative 5B. Nineteen conglomerate extraction wells are specified, rather than 13 (Figure 7-5). The additional wells reduce the amount of TSA groundwater drawdown near the wells and shorten the travel time for ~~contaminated groundwater capture. This alternative was developed, in part, to ascertain the~~ sensitivity of total remediation costs to the number of wells.

Alternative 6. This alternative uses reinjection of treated water to shorten the estimated restoration times. The total pumping rate for this alternative is 1,185 gpm from 18 conglomerate extraction wells and 350 gpm from 4 sandstone extraction wells. The injection rate into the conglomerate is approximately 250 gpm using 4 injection wells. The locations of the extraction and injection wells are shown on Figure 7-6.

The amount of extraction from the TSA conglomerate is limited by the available drawdown in the aquifer. Based on model calculations, all of the alternatives are technically feasible. However, it is possible that actual field conditions will be different than those assumed in the model.

Restoration Time Frames. The estimated time to restore 80% of the TSA to MCLs is 20 years for Alternative 5A, 17 years for Alternative 5B, 15 years for Alternative 5C and 12 years for Alternative 6. These cleanup times are faster than the estimated 24 years required to restore 80% of the TSA to MCLs for the extraction well locations and rates described for Alternative 5. The estimated time to restore 90% of the TSA to MCLs for Alternatives 5, 5A, 5B, 5C and 6 are 35 years, 26 years, 22 years, 20 years, and 16 years, respectively.

7.4 Screening of Alternatives

In the FS, Alternatives 2 and 3 were eliminated from further consideration, because they did not satisfy the RAOs summarized in Section 6.1. Alternative 1, the no-action alternative, was retained to provide a baseline for evaluating the remedial alternatives against the protection and feasibility requirements in OAR 340-122-090. Section 8 summarizes the evaluation of alternatives, including the 4 supplemental alternatives developed by DEQ.

8. EVALUATION OF REMEDIAL ACTION ALTERNATIVES

This section presents a comparative evaluation of Alternatives 1, 4, 5, 5a, 5b, 5c and 6 with respect to the remedy selection criteria in OAR 340-122-090 and the NCP requirements (40 CFR § 300.430 (a)(2)(e)(iii)). As discussed in Section 7, Alternatives 2 and 3 were eliminated from further consideration because they did not adequately satisfy the RAOs which identify how requirements in Oregon rules (OARs) and the NCP would be met. The comparative analysis includes a description of the strengths and weaknesses of the alternatives relative to one another for these criteria. The following sections, which detail the comparative evaluation of alternatives, provide the basis for the selected remedial alternative described in Section 9.

8.1 Protection and Feasibility Requirements

8.1.1 Overall Protection of Human Health and the Environment

The evaluation of this criterion is based on how the remedial alternatives satisfy RAO-a through RAO-e which are presented in Section 6.1. RAO-a and RAO-b address protection of human health. RAO-c through RAO-e address protection of the environment which includes both ecological receptors and uncontaminated groundwater resources in east Multnomah County. The evaluation considers protection of human health and the environment under current conditions (e.g., the existing domestic wells within the TSA VOC plume) and future conditions (e.g., existing or new domestic and municipal wells inside and outside of the VOC plume and wells that could be impacted under PWB pumping conditions including the RFM or emergency use scenarios).

Alternatives 5 through 6 provide the greatest level of protection of human health and the environment. They include a combination of restoration of the TSA, abandonment of wells and alternate water supply to prevent current exposures to contaminated groundwater, use of institutional controls including groundwater use restrictions, and monitoring, to reduce the potential for future human exposure to contaminated groundwater.

Alternative 4 generally satisfies the RAOs for protection of human health. Alternative 4 is considered less protective than Alternative 5 because the increased length of the restoration time frame results in a considerable increase in the potential for groundwater quality in the SGA to be affected by migration of contaminants from the TSA where CU2 is thin or absent.

Alternative 1 is not protective of human health and the environment because it does not eliminate existing exposures and does not prevent or control further impacts to groundwater resources in east Multnomah County.

8.1.2 Use of Permanent Solutions and Alternative Technologies

Alternatives 5, 5a, 5b, 5c and 6 are expected to result in permanent aquifer restoration. Alternative 6 would result in the greatest removal of VOCs from the TSA groundwater in the shortest time frame. Alternative 4 would result in a slower rate of VOC mass removal from the TSA, which could result in permanent aquifer restoration, although it would require a significantly longer time frame. No alternative cleanup technologies (e.g. physical barriers) are included in Alternatives 4 through 6.

Alternative 1 would not provide a permanent solution.

8.1.3 Cost-Effectiveness

The estimated costs for each remedial alternative are summarized in Table 8-1. The cost estimates have an order of magnitude accuracy (approximately -30 percent to +50 percent of estimated costs) and are primarily intended to compare the estimated cost of an alternative relative to other alternatives. The estimated cost of the alternative includes the capital construction costs and the operation and maintenance (O&M) costs for the duration of the action.

The evaluation of cost-effectiveness includes the following criteria :

- The cost of a remedial action relative to the costs of another remedial action option that achieves the same concentration level;
- The extent to which the remedial action's short term and long term incremental costs are proportionate to its incremental results; and
- The extent to which the remedial action's short term and long term total costs are proportionate to its total result.

Alternative 4 has the lowest cost and rates highest under the first criterion, followed by Alternatives 5, 5b, 5a, 5c and 6. The increases in capital costs are related to the increased number of extraction or injection wells, treatment system(s), conveyance piping, easements and contingencies (35 percent of total cost). Generally, those alternatives with lower capital costs have higher O&M costs due to the longer time frame to restore the TSA.

For evaluation of the second criterion, DEQ compared the relative rate of VOC mass removal in pounds per year (incremental result) against the relative increase in short term costs (capital costs) and long term cost (O&M costs) between Alternatives 4 and Alternative 5, and between Alternative 5 and Alternatives 5a, 5b, 5c and 6. The objective of this analysis is to determine whether the incremental capital investment provides proportionate benefits in the short term (increased mass removal resulting in reduced volume of TSA plume) and reduction in long term cost for O&M. As shown in Table 8-1, the incremental increase in capital costs between Alternatives 4 and Alternatives 5 is proportionate to the incremental increase in mass/volume removal. This holds true for the same comparison between Alternative 5 and Alternatives 5a, 5b and 5c. The increase in capital cost between Alternative 5 and Alternative 6 becomes somewhat disproportionate with the percent increase in mass/volume reduction, but not significantly. The long term benefits in terms of decreased O&M are not realized for Alternative 6, largely due to significant maintenance costs for injection wells assumed in the cost estimate.

For evaluation of the third criterion, DEQ evaluated the short term and total costs against the incremental difference in time to achieve restoration of the TSA plume (total result). This evaluation shows that the decrease in cleanup time between Alternative 4 and Alternative 5, and between Alternative 5 and Alternatives 5a through 6, is proportionate to the short term, and total costs.

In summary, Alternatives 5 through 6 are cost-effective in comparison to Alternative 4, as is Alternative 5a and 5b and 5c in comparison to Alternative 5. Alternative 6 is less cost-effective than Alternative 5 under the first two criterion, but is cost-effective under the third criterion. However, Alternative 5 will likely require more wells than those identified which would make the differential between Alternative 5 and Alternative 6 less than shown.

Alternative 1 is not cost-effective, because it does not achieve any contaminant mass or volume reduction.

8.1.4 Effectiveness

In evaluating whether a remedial action alternative is effective, DEQ considers:

- the expected reduction in toxicity, mobility and volume of contaminants;
- the short-term risk posed to the community, workers and the environment during implementation of the alternative;
- the length of time until full protection is achieved;
- the magnitude of residual risk in terms of amounts and concentrations of hazardous substances remaining following implementation of the alternative;
- the type and degree of long-term management required including monitoring and O&M;
- the long term potential for exposure to remaining contaminants;
- the long term reliability of engineering or institutional controls; and
- the potential for failure of the remedial action.

In addition to these criteria, DEQ evaluated RAO-f under the effectiveness criteria to determine to what extent existing uses of groundwater resources are restored by the remedial alternatives.

Reduction in Toxicity, Mobility and Volume. To evaluate reduction in toxicity, mobility, and volume of contaminants, DEQ estimated the initial VOC mass removal rates from the TSA (see Table 8-1), and the reduction in size or area of the TSA contaminant plume over time.

Alternative 6 would provide the greatest reduction in toxicity, mobility and volume in the shortest timeframe with and estimated 315 pounds of TCE being removed in the first year (Table 8-1). Alternatives 5b and 5c provide nearly equivalent initial mass removal rates estimated at 310 pounds. Alternative 5a is predicted to removed less VOCs than Alternative 5b or 5c but more than Alternative 5. Alternative 4 is predicted to remove approximately half the amount of VOCs as Alternative 5 in the first year.

Alternative 6 is predicted to reduce the areal extent of the plume in the shortest timeframe, with the area north of Sandy Boulevard and the western half of the Boeing facility being restored in 10 years and the remaining portion of the plume restored in approximately 20 years.

Alternatives 5b and 5c are predicted to reduce the size of the plume similar to that of Alternative 6 with the exception of the TSA mound area. Alternative 5 and 5a reduce the areal extent of the plume in a longer timeframe than Alternatives 5b through 6. No significant reduction in the areal extent of the TSA plume is expected from Alternative 4 in 20 to 30 years. Alternatives 5 through 6 would likely provide a greater degree of hydraulic control of the VOC plume during PWB wellfield operation than Alternative 4. Alternative 1 would not achieve reduction in VOC mass except through natural attenuation.

Short-term Risk. The short-term risks associated with remedy implementation are slightly greater for Alternatives 5 through 6, which have a greater degree of construction activities (e.g., installation of extraction wells) as compared to Alternative 4. However, short-term risks could be controlled by the use of appropriate construction techniques and health and safety procedures.

Time to Full Protection. Alternative 6 would achieve full protection through aquifer restoration in the shortest timeframe (16 years for 90% restoration), followed by Alternative 5c, 5b, 5a and 5 respectively. Near-term protection would be achieved by providing alternate water supplies and institutional controls to prevent exposure to TSA groundwater.

Residual Risk. Alternatives 4 through 6 are all designed to restore the TSA to MCLs and therefore result in the same residual risk (10^{-6}). As noted above, the primary difference between these alternatives is the time necessary to achieve MCLs: Alternative 1 would maintain relatively high residual risks of human exposure to VOCs in TSA groundwater.

Type and Degree of Long-Term Management. All the alternatives have similar requirements in terms of monitoring, and operation and maintenance of the groundwater pump and treat systems. Alternative 4 involves fewer wells and associated treatment facilities but would need to be managed for 60 to 80 years. Alternatives 5 through 5c have comparable long term management requirements. Alternative 6 would have the highest level of management requirements related to maintenance of injection wells and monitoring to ensure hydraulic control of reinjection areas.

Reliability. Alternatives 5 through 5c are considered highly reliable and are unlikely to require replacement. Alternative 6 is considered slightly less reliable because the technical feasibility of reinjection of treated groundwater would need to be pilot tested. The likelihood of failure, however, is considered low because the TSA groundwater does not contain high levels of dissolved minerals or nitrates that might lead to clogging of injection wells. Alternative 4 is considered the least reliable because it may be ineffective in controlling the spread of TSA contaminant plume during PWB pumping of the South Shore Well Field.

The reliability of institutional controls has a high degree of uncertainty. The reliability of designation of the critical groundwater area (see Section 7.2.3) in controlling use of the TSA during restoration would need to be evaluated over time.

Allowing Existing Uses of Groundwater Resources. Alternatives 5 through 6 would allow the greatest amount of existing use of groundwater resources. DEQ evaluations indicate that these alternatives would allow unrestricted use of the PWB supply wells in the TSA and BLA aquifers without adversely spreading the TSA contaminant plume during remediation. The PWB TSA and BLA wells reportedly can produce up to 60 million gallons per day. However, pumping from the PWB's SGA supply wells, especially wells 7, 8, and 14, results in significant depression of water levels in the SGA beneath the TSA contaminant plume including areas where the TSA conglomerate is contaminated and CU2 is either thin or absent (see Figures 3-3 and 3-8). To minimize potential contaminant transport from the TSA to the SGA in these areas, average hydraulic gradients between the TSA and SGA would need to be maintained upward. DEQ has determined that Alternatives 5 through 6 could achieve this criteria, if the PWB uses a risk management approach to operation of its SGA wells. Vertical gradients between the SGA and the TSA can be maintained upward on an annual average basis during remedy implementation if all SGA supply wells (equivalent to 38 million gallons per day) are pumped up to 60 days, and if all SGA supply wells except wells 7, 8 and 14 (equivalent to 30 million gallons per day) are pumped up to 90 days on an annual basis. Alternative 4 would be less effective in restoring existing use of SGA pumping from the South Shore Well Field than Alternatives 5 through 6. Alternative 1 would be ineffective in allowing existing uses of groundwater without detrimental effects to groundwater resources in EMC.

8.1.5 Implementability

Alternative 1 has no actions to implement. Alternatives 4 through 6 would be implemented with established construction techniques, would also have high operational reliability (extraction wells and treatment systems) with regularly scheduled maintenance, and would require authorization from state and local agencies for construction and for discharge from treatment systems.

Alternatives 5 through 6 may have significant implementability issues involved with abandonment of private supply wells, and/or placement of extraction wells and necessary conveyance piping on private properties. Although alternate water supplies are readily available in the area through Rockwood Water District or the city of Fairview, private parties may refuse to have their wells abandoned and to accept an alternate water supply, or may refuse access for remediation. Generally, the alternatives with more wells on private properties (e.g. Alternative 5c and 6) are likely to be the most difficult to implement.

Alternative 6 would potentially require the shortest duration of groundwater use controls. Alternatives 4 and 5 included designation of a Critical Groundwater Area by the Oregon Water Resources Commission. This process requires rule making which would likely take a considerable time period, could face public opposition, and have an uncertain outcome. It is unclear that this is a workable mechanism for achieving groundwater use controls. An appropriate mechanism will be determined during the remedial design stage.

8.1.6 Compliance with Other Regulatory Requirements

Each of the alternatives has been developed to comply with all other regulatory requirements including NPDES, RCRA and air quality. In addition, federal requirements in CERCLA and the NCP were also considered.

8.2 Evaluation Summary

Alternatives 5 through 6 satisfy the protection and feasibility requirements in OAR 340-122-090. The evaluation of these alternatives indicates that Alternative 5 can be designed to satisfy the RAOs for the site and to restore the TSA in a reasonable time frame of 20 years, by refining the number and location of extraction wells and implementing of reinjection of treated groundwater, in a cost-effective manner.

9. THE SELECTED REMEDIAL ACTION

DEQ has selected Alternative 5, modified as discussed below, as the remedial action alternative for cleanup of the TSA. The selection is based on the evaluation and comparison of remedial alternatives presented in Section 8 and consideration of public comment on the recommended remedy. Alternative 5 is modified by increasing the number, location and extraction rates for extraction wells, similar to DEQ Alternatives 5b, 5c and 6. Institutional controls will be implemented during remediation to prevent exposure to contaminated TSA groundwater or adverse spread of contamination due to pumping. The estimated cost for the selected remedy is $9 to $11 million. The capital costs are estimated to range from $4 million to $5 million, and long-term operation and maintenance costs from $5 million to $6 million.

The goal of the remedial action is to restore groundwater to its beneficial use, which at this site is a drinking water source. The cleanup levels to be achieved by the remedy are the drinking water MCLs presented in Table 6-1. Based on a careful analysis of all remedial alternatives, DEQ believes the selected remedy, with appropriate modifications, can restore the TSA to these levels in 20 years and significantly reduce the areal extent of contamination exceeding MCLs in 10 years.

Section 9.1 provides a detailed description of the selected remedial alternative. Section 9.2 describes how the selected alternative satisfies the remedy selection criteria in DEQ's current rules and is consistent with the NCP and Oregon's revised environmental cleanup law.

9.1 Description of Selected Alternative

Components of the selected alternative include groundwater extraction from the TSA, treatment of extracted groundwater using air stripping technology, discharge of treated groundwater to surface water and, if feasible, reinjection of treated groundwater into the TSA, and performance monitoring. The remedy includes additional protective measures, including abandonment of supply wells in the SGA, institutional controls, and contingency measures. Each of these components is described below.

9.1.1 Aquifer Restoration Pumping

The selected remedy includes groundwater extraction for an estimated period of 20 years. The aquifer restoration pumping will extract sufficient groundwater to meet the following performance criteria:

- Maintain horizontal hydraulic control of the TSA contaminant plume exceeding the MCL cleanup levels;

- Maintain an upward hydraulic gradient between the TSA and SGA where the TSA conglomerate is contaminated at levels equal to or exceeding MCLs and the confining layer separating the TSA and SGA is thin or absent; and

- Remove at least 350 gpm from the TSA sandstone and at least 970 gpm from the TSA conglomerate, on a monthly average basis.

The remedy will include sufficient groundwater monitoring points at the perimeter of the plume to demonstrate that the horizontal gradients are inward toward the extraction wells on an annual average basis, and will include sufficient monitoring wells to demonstrate that the vertical gradient is upward on an annual average basis. The horizontal gradient criteria shall apply at all times. The vertical gradient criteria shall apply at all times with the following exceptions: when all of the PWB's SGA supply wells are operated for a continuous period of more than 60 days; when the PWB's SGA wells with the exception of wells 7, 8, and 14 are operated for a continuous period of more than 90 days; and when an equivalent level of pumping from a subset of the PWB's SGA supply wells occurs. The contingency plan described in Section 9.1.5 shall be implemented when an emergency affecting the City's primary water supply necessitates continuous operation of all PWB wells for more than 60 days.

The spatial distribution of extraction will be similar to that described for Alternative 5B and 5C. Subject to DEQ approval, specified minimum groundwater extraction rates may be adjusted annually based on the current volume of water exceeding the MCL cleanup levels (e.g., extraction rates may decrease proportionate to the decrease in plume size and volume). The specified minimum extraction rates ensure that the remedy is designed to:

- Restore groundwater in the TSA sandstone and conglomerate to MCLs within 10 years of implementation of Phase 2 of the remedy in the area north of Sandy Boulevard, and in the area south of Sandy Boulevard, east of 205th Avenue, and west of a north-south trending line from well BOP-44 to DEQ-5, as shown in Figure 9-1; and

- Restore the remaining portion of the TSA sandstone and conglomerate to the MCL cleanup levels within 20 years of implementation of Phase 2 of the remedy.

The number of wells and well locations for the extraction wells that will be used for aquifer restoration will be determined during the remedial design phase and remedy implementation, but 17 to 22 extraction wells will likely be required, as shown on Figure 9-1.

The remedial design activities will include an evaluation of the following three components for achieving the performance criteria for the selected remedial alternative:

- Evaluate the number of extraction wells needed to extract the specified minimum total pumping rates, their locations and individual pumping rates;

- Evaluate the technical feasibility and implementability of reinfiltration or reinjection and assess whether this technology should be integrated into the remedy to accelerate aquifer restoration; and

- Evaluate beneficial reuse options and appropriate treatment or conveyance requirements for the extracted groundwater.

Remedial design will be performed concurrently with remedy implementation. The remedy will be implemented in three phases.

Phase 1 Early Implementation. Phase 1 implementation began in 1996, and includes the following actions:

- Providing an alternate water supply to Terrand Mobile Terrace mobile home park, which currently obtains its water from SGA supply well PMX-410;

- Abandonment, or conversion to monitoring wells, six SGA supply wells (PMX-195, -207, -208, -225, 409, and -410);

- Installation of one TSA monitoring well and two SGA monitoring wells to further characterize the extent of groundwater contamination in those aquifers;

- Collection of water samples from the TSA and/or SGA during the abandonment of SGA supply wells, to obtain additional water-quality data for those aquifers in the area of the TSA VOC plume, and resolve uncertainties;

- Installation of at least three TSA extraction wells and conversion of two existing monitoring wells to TSA extraction wells, performance of aquifer tests, design and installation of groundwater treatment and discharge systems, and initiation of groundwater extraction and treatment from these wells.

Phase 2 Implementation. The second phase of remedy implementation shall involve installation of all the additional extraction wells required to achieve the performance criteria described above. An additional 10 to 12 extraction wells are likely to be required at the locations shown in Figure 9-1. Detailed remedial design activities will evaluate a range of extraction well locations and numbers, and reinjection, for effectiveness and implementability (e.g., site access constraints).

Phase 3 Implementation. Phase 3 shall be implemented if, after the remedy has operated for three to four years, the aquifer monitoring data indicate that the restoration time frames described above are unlikely to be obtained. The likelihood of obtaining the restoration time frames will be assessed by projecting the best fit line to the logarithms of average annual aquifer concentration as a function of time; or an equivalent method. This phase would optimize and enhance the performance of the remedy by improving the rate of aquifer flushing. Modifications may include any or all of the following:

- Installation of additional extraction wells to expedite restoration of the TSA;

- Alternating extraction at wells to eliminate stagnation areas within the aquifer;

- Pulse pumping;

- Reinjection or reinfiltration of treated groundwater, if technically feasible.

The modifications would be such that the total groundwater extraction and injection rates do not exceed those described for Alternative 6, as this alternative approaches the limits of feasibility as defined in DEQ rules.

Performance Monitoring. A detailed monitoring plan will be developed during remedial design to monitor system performance against the criteria described above. The plan shall include performance monitoring at the perimeter of the TSA plume and in the underlying SGA to address the remedy performance criteria including plume containment. Subject to DEQ approval, the monitoring program may be modified to decrease monitoring locations based on the progress of remediation, and shall be expanded if areas of TSA contamination beyond the limits of contamination currently understood, or contamination in the SGA is discovered. The performance monitoring program shall include, but not be limited to, the following:

Groundwater Elevation Measurements — Groundwater level measurements shall be taken at the TSA monitoring wells shown on Figures 9-2 and 9-3, and at the SGA monitoring wells shown on Figure 9-4. Measurements shall be taken continuously at selected wells with electronic data collection systems, and periodically at other wells with hand-held equipment. Continuous water-level monitoring will be conducted at 24 TSA well locations and 7 SGA well locations. The TSA wells to be continuously monitored are near the boundaries of the VOC plume, and the SGA wells are in areas where VOC concentrations in the TSA conglomerate are above MCLs and CU2 is thin or absent, and groundwater flow is downward during pumping of the PWB SGA wells. Manual groundwater level measurements shall be taken monthly at the locations shown on Figures 9-2 through 9-4, and every two weeks when PWB pumps its SGA wells.

Water-Quality Sampling — Semi-annual and annual water quality samples for VOCs will be taken at the locations shown on Figures 9-2 through 9-4. The sampling schedule is listed on Table 9-1. Monitoring for additional parameters in a subset of wells may also be required during remedial design and remedy implementation to evaluate reinjection or beneficial reuse of treated groundwater. The sampling program will be reevaluated annually and modified, if appropriate, on the basis of the past year's performance.

Performance evaluation reports will be submitted to DEQ annually until Phase 3, if necessary, is complete and operated for a period of two years, and at five year intervals thereafter. Monitoring reports documenting compliance with hydraulic gradient criteria and groundwater quality shall be submitted to DEQ annually during the entire period of remedy implementation. At a minimum, the performance evaluations shall assess compliance with the remedy gradient control criteria, document groundwater and VOC mass removal rates, assess TCE concentration reductions, provide an assessment of the groundwater extraction and performance monitoring network, and propose modifications to the pumping program (e.g. variable or pulse pumping and eventually termination of groundwater extraction).

9.1.2 Groundwater Treatment

Extracted groundwater will be treated using one or more packed air-stripping treatment units with a VOC removal efficiency of at least 95%. Advanced oxidation (ozone, peroxide, and/or ultraviolet radiation) treatment may be used instead of air stripping treatment, if beneficial reuse of treated groundwater is implemented, to potentially eliminate the requirement for chlorination of the water. The advanced oxidation treatment process must meet all applicable state and federal performance standards for disinfection. The final number, location and capacity of the treatment units will be determined during remedial design.

The remedial design shall evaluate VOC air emissions for each treatment system proposed to be sited within 100 meters of residential properties. No treatment systems shall be allowed closer than 100 meters from a residential property, unless the VOC emissions assessment demonstrates that VOC inhalation exposure would be less than 1×10^{-6} excess cancer risk.

9.1.3 Groundwater Disposal, Reinjection or Beneficial Reuse Requirements

Treated groundwater shall be discharged to surface water bodies and/or reinjected into the TSA to enhance aquifer flushing. Discharge requirements will be specified in the consent order for implementation of the selected remedy, pursuant to OAR 340-45-062 or in a permit. Contaminant discharge limits will be established at the MCLs shown in Table 6-1. Groundwater treatment is expected to reduce contaminant concentrations to below detectable levels of 0.5 ug/L. Treatment system effluent samples will be collected and analyzed monthly for VOCs, and quarterly for nitrate and nitrite, orthophosphate, total phosphate, lead, and hardness. Provisions will also be included in the order or permit for flow management or other measures necessary to avoid violation of water quality standards related to a water quality-limited parameter.

Boeing and/or Cascade may beneficially use treated groundwater for their respective industrial processes or enter into agreements with local water districts or private parties to beneficially use treated groundwater. Applicable requirements of the Oregon Water Resource Department (WRD) and the Oregon Health Division must be satisfied prior to DEQ approval of these actions.

9.1.4 Additional Protective Measures

Abandonment of Private SGA Water Supply Wells. As discussed in Section 7.2.1, six existing private water wells completed in the SGA and located within the TSA contaminant plume have been identified as potential pathways of contaminant migration between the TSA and the SGA. These wells shall be abandoned in accordance with Water Resource Department regulations. New replacement SGA supply wells designed with a telescoped seal between the TSA and CU2 to prevent leakage of contaminated groundwater from the TSA to the SGA, may be installed, subject to DEQ approval and satisfaction of the following criteria:

- Groundwater extraction rates are less than 15,000 gallons/day (gpd); or
- There is an existing water right for the well or user can obtain a water right if groundwater use would exceed the 15,000 gallon/day exemption established under WRD regulations; and
- The groundwater usage would not result in the reversal of vertical gradients between the TSA and SGA on an annual average basis where CU2 is thin or absent and the lower TSA conglomerate is contaminated;

Private TSA Water Supply Wells. TSA supply wells that have been contaminated at levels exceeding MCLs (PMX-417 and PMX-198) will be taken out of service and supplied with municipal water from the city of Fairview. These wells will be evaluated during remedial design for possible conversion to extraction wells.

Institutional Controls. Institutional control components for the selected remedy include monitoring of any existing supply wells within or in the vicinity of the TSA plume, provisions for alternate water supply for existing groundwater users whose wells are or become contaminated above MCLs, and restricting groundwater use in the area of the TSA contaminant plume. Each of these institutional controls are described below.

<u>Assessment</u> — TSA supply wells PMX-196, PMX-345, PMX-434, PMX-189, and SGA supply well PMX-192 will be evaluated to determine whether their continued use could spread the TSA contaminant plume once Phase 2 of the remedy is operational. Well pumping that compromise the remedy's horizontal or vertical hydraulic control shall be taken out of service, and provided municipal water supply.

<u>Monitoring</u> — Monitoring of existing private water supply wells (including any replacement supply wells discussed above) will be performed semi-annually for VOCs. In the event that VOCs are detected at or above the MCLs, the well will be resampled within 6 weeks of the initial sampling event. Municipal water supply shall be provided within 6 months for groundwater users whose well has been confirmed to be contaminated at or above the MCL

<u>Alternate Water Supply</u> — All groundwater users whose wells are to be abandoned or taken out of service shall be provided with municipal water supply. Extensions to existing water supply mains and connections to individual users will be designed in coordination with the local public water suppliers (e.g., the City of Fairview or Rockwood Water District).

<u>Groundwater Use Controls</u> — The selected remedy vertical gradient criteria is protective of water quality in the SGA. To ensure overall protectiveness of the remedy, DEQ assumes that the PWB will develop and implement wellfield operational strategies to minimize the threat to the SGA aquifer, by, consistent with the ROD assumptions, limiting annual pumping of all of the PWB's SGA supply wells to 60 days, or SGA wells except 7, 8 and 14 for 90 days, except in the event of an emergency affecting the City's primary water supply from Bull Run. DEQ will request that the PWB submit a pumping plan describing their well field operational strategies, to facilitate implementation of this ROD and protection of the SGA.

During remedial design, DEQ, Boeing, Cascade, and other parties identified by DEQ, will evaluate mechanisms to control use of groundwater within and in the vicinity of the TSA contaminant plume. The objectives of these measures are to prevent exposure to contaminated groundwater and/or spreading contamination to currently unaffected portions of the TSA or to the SGA. Options which may be considered include designation of a Critical Groundwater Management Area, modifications to comprehensive land use plans for the area, coordination between DEQ and Oregon Water Resources Department (WRD) on water right applications, and periodic review of start cards filed with WRD for well installations. If necessary, other vehicles for groundwater use controls also will be developed.

9.1.5 Contingencies

Contingency Plan for PWB Emergency Pumping. A contingency plan shall be developed during Phase 2 of remedy implementation. The contingency plan shall be activated in the event of an emergency affecting the City's primary water supply which necessitates continuous operation of all PWB supply wells for more than 60 days.

The additional response actions to be incorporated into the contingency plan include:

- Increased extraction rates from TSA extraction wells to minimize the magnitude of gradient reversal between the TSA and SGA where CU2 is thin or absent, and the TSA conglomerate is, or becomes, contaminated, and to ensure horizontal hydraulic control of the plume;

- Increased frequency of monitoring for TSA and SGA detection monitoring wells;

- Identifying the location for additional monitoring wells in the TSA and/or SGA and the criteria and schedule for installation;

- Identifying locations, criteria and schedule for installation and operation of SGA extraction wells to hydraulically control the spread of contamination if detected in the SGA above MCLs.

The contingency plan will be reevaluated during remedy performance monitoring reviews and, subject to DEQ approval, modified or terminated based on progress in the restoration of the TSA.

Long- Term Containment. Restoration of limited areas of the TSA may be technically impractical to achieve within 20 years, due to on-going uncontrollable migration of VOCs from the TGA to the TSA or due to asymptotic leveling of contaminant concentrations. In this event, Boeing and Cascade shall provide long-term hydraulic control of these areas, to minimize the areal extent of TSA contamination above MCLs.

9.2 Satisfaction of Protection and Feasibility Requirements

The selected remedy is protective of human health and the environment. Restoration of the TSA to drinking water MCLs would result in a residual excess lifetime cancer risk of approximately 1×10^{-6} and a non-carcinogenic hazard index less than one, which is protective of human health and would allow beneficial use. Restoration of the TSA to the MCL for TCE will result in residual concentrations for the other VOCs that are well below their respective MCLs. Alternate water supplies will be provided to existing groundwater users whose wells have been contaminated at levels equal to or exceeding the MCLs. Institutional controls and contingency measures will be utilized during the TSA restoration process, to control exposures to groundwater contamination exceeding MCLs or the spread of contamination within the TSA or to the SGA.

9.2.1 Permanent Solutions and Alternative Technologies

The selected remedy will permanently remove contaminants from soil and groundwater within the TSA. Groundwater contaminant concentrations are predicted to be reduced to MCLs or lower. Institutional controls and hydraulic control of portions of the TSA exceeding MCLs will be maintained until cleanup levels are achieved.

9.2.2 Cost-Effectiveness

As discussed in Section 8.1.3, the selected alternative is cost-effective, because the incremental and total costs are proportionate to the incremental and total results.

9.2.3 Effectiveness

Reduction in Toxicity, Mobility, and Volume. The selected remedy is expected to remove a significant mass of VOCs from the TSA and significantly reduce the areal extent of groundwater contamination exceeding MCLs.

Short-term Risks

Protection of Community During Remedial Action — The primary potential risk to the community during implementation of the selected remedy is from air emissions from the groundwater treatment systems. However, VOC emissions from groundwater treatment systems will not be significant and will not pose an unacceptable risk to neighboring residents.

Protection of Workers During Remedial Action — Compliance with state occupational safety and health codes, and enforcement of site health and safety plan provisions, will ensure the protection of on-site workers during installation of the remedial systems. Operation, maintenance, and monitoring of these systems pose only minimal risks to remediation workers.

Environmental Impact — The selected remedy is expected to effectively control potential threats to water quality in the SGA. Contingency measures will minimize adverse impacts to the SGA should they occur. No adverse ecological impacts are predicted from the discharge of treated groundwater to surface water.

Time Until Full Protection Is Achieved — Full protection of human health through groundwater restoration may take up to 20 years. Alternate water supplies to affected groundwater users, and institutional actions to control future exposures, should be in place within 1 year of DEQ's selection of a final remedy.

Magnitude of Residual Risk After Implementating Remedial Action — Based on the information obtained during the RI/FS and the analysis of all remedial alternatives, DEQ believes that the selected remedy will be able to achieve MCLs presented in Table 6-1.

Type and Degree of Long-term Management, Including Monitoring and Operation and Maintenance. — Groundwater contamination may be persistent in the vicinity of the TSA mound, and near the TGA outcrop north of Cascade, where concentrations are relatively high. The ability to achieve cleanup levels throughout the plume area cannot be determined, until the remedy has been implemented, modified as necessary, and plume response monitored over time. The selected remedy will require intermediate to long-term groundwater monitoring. Long-term operation and maintenance, and performance monitoring will be required. The degree of long-term management will be reduced through time, as the areal extent of the contaminant plume decreases.

Long-term Potential for Exposure of Human and Environmental Receptors to Remaining Contaminants — The potential for exposure to contaminants remaining after completion of the remedy is low. The selected remedy includes contingencies for long-term containment and continued institutional controls, for those areas which cannot be restored to protective levels.

Potential for Failure of Remedial Action or for Need to Replace Remedy — The selected remedy is not expected to fail or has a low potential for failure. As noted in Section 9.1.1, modifications to the remedy may be necessary through time to improve performance.

9.2.4 Implementability

Degree of Difficulty. The technologies to be used are proven and readily implementable. A pilot test on reinjection of treated groundwater into the TSA would be necessary, to evaluate the effectiveness of this option and complete design specifications.

The selected remedy may have significant implementability issues involved with the abandonment of private supply wells, and/or placement of extraction wells and necessary conveyance piping on private properties. Although alternate water supplies are readily available in the area through the Rockwood Water District or the City of Fairview, private parties could refuse to have their wells abandoned or accept an alternate water supply, and/or may refuse access for remediation activities. Private party agreements will need to be obtained, or DEQ's statutory authorities may need to employed, if these private agreements cannot be negotiated in a timely manner or are unsuccessful.

Expected Operational Reliability. The groundwater extraction and treatment technologies that will be used for TSA restoration are commonly used, proven, and generally reliable. The reliability of reinjection of treated groundwater would be determined through a pilot test.

Need to Coordinate with and Obtain Approval from Other Agencies. Implementation of the selected alternative would involve DEQ's establishment of discharge requirements in a consent order or permit, for groundwater disposal to surface water and reinjection, and should not pose any significant delays or problems. Continued coordination with PWB on wellfield pumping will be necessary to effectively implement horizontal and vertical control gradient criteria components of the remedy. The Oregon Water Resources Department will need to issue water rights or water rights transfers for beneficial reuse of treated groundwater.

Availability of Equipment and Specialists. Equipment for the groundwater extraction and treatment system is readily available.

Available Capacity and Location of Treatment, Storage, and Disposal Services. Hazardous wastes are not expected to be generated for off-site treatment, storage and/or disposal.

Ability to Monitor Effectiveness of Remedy. The selected remedy can be effectively monitored and modifications implemented, to satisfy the remedy performance criteria. Implementation of the monitoring program may require long-term access to private properties, which can be obtained through private party agreements or DEQ's statutory authorities.

9.2.5 Compliance with Other Regulatory Requirements

Alternative 5 would comply with the regulatory requirements under the Clean Air Act, Clean Water Act, Safe Drinking Water Act, and Resource Conservation and Recovery Act as follows:

Clean Air Act. An Air Contaminant Discharge Permit would not be required for the air-stripping treatment unit(s). VOC emissions from the treatment unit(s) would be approximately 2 orders of magnitude below DEQ's significant emission rates for TCE. An air quality Notice of Construction would be filed with DEQ, in accordance with OAR 340-20.

Clean Water Act. DEQ will specify monitoring requirements for discharge of treated groundwater to Fairview Lake or the Columbia Slough, through direct discharge or via conveyance through the Multnomah County drainage system, in the consent order for remedy implementation pursuant to OAR 340-45-062 or by NPDES permit The contaminant discharge limits will be the MCLs specified in Table 6-1. Monitoring for nutrients (e.g., nitrate, nitrite, total phosphate and orthophosphate), lead, and hardness will also be performed.

Authorization of reinfiltration or reinjection of treated groundwater into the TSA, to facilitate flushing of contaminants, will be as described for surface water discharges.

Safe Drinking Water Act. Beneficial reuse of treated groundwater for drinking water supplies shall comply with all applicable requirements specified under OAR 333, Division 61.

Resource Conservation and Recovery Act. The hazardous waste generator requirements under 40 CFR Part 262 and OAR 340-100 do not apply to groundwater extracted from the TSA under this selected remedy. Drill cuttings generated during extraction well installations in source areas at the Boeing facility shall be characterized to determine whether they are a hazardous waste. Soils determined to be hazardous waste will be managed in accordance with applicable regulations under 40 CFR Parts 262, 263, 264 and 268. Soil drill cuttings from other well installation locations may be used as clean fill at the Boeing or Cascade facilities.

CERCLA. The selected remedy satisfies remedy threshold and balancing criteria in CERCLA and the NCP. The selected remedy is protective of human health and the environment, and complies with all ARARs.

9.2.6 Consistency with Revised Oregon Environmental Cleanup Statutes

The State of Oregon's Environmental Cleanup Statutes (ORS 465.315 through 465.325) were amended in 1995 by the 68th Oregon Legislative Assembly. Certain provisions became effective July 18, 1995. Other provisions will not become operative until rulemaking by DEQ is completed. DEQ, nonetheless, is required to select remedial actions consistent with the purpose and intent of the revised statutes, to the maximum extent practicable within the bounds of existing cleanup rules. This section evaluates consistency of the selected remedial action with the amendments in the statute.

Protectiveness. Under the revised statutes, the protectiveness of a remedial action is determined by application of both acceptable risk levels prescribed by the statute and a risk assessment undertaken for the site in question. This provision will not be fully operative until rulemaking is completed. The selected remedial action is nonetheless consistent with this provision of the revised statutes and the current rules.

The acceptable risk levels prescribed by the revised statutes for human health are 1×10^{-6} excess lifetime cancer risk for individual carcinogens and a hazard index of one for non-carcinogens. The selected remedy restores the TSA aquifer to MCLs for drinking water which are essentially equivalent to 1×10^{-6} excess cancer risk and below a hazard index of one for non-carcinogens.

Treatment of Hot Spots. Once the revised statutes become fully operative, treatment of hot spots of contamination will be required to the extent feasible. The TSA groundwater contaminant plume is considered a hot spot because the TSA is currently used as a source of residential drinking water supply, and the presence of contamination at concentrations exceeding MCLs has an adverse effect on existing and reasonably likely future beneficial use of both the TSA and SGA groundwater resources in eastern Multnomah County. The selected remedy requires treatment of groundwater contamination at concentrations equal to or exceeding MCLs.

Remedial Methods. The selected remedy is consistent with the remedial methods described in the revised statutes, by including a combination of groundwater removal and treatment using "presumptive or generic" remedies such as groundwater "pump and treat", institutional controls, and other measures such as monitoring and maintenance.

Balancing Factors. Under the revised statutes, remedial actions selected by DEQ will balance effectiveness, implementability, long-term reliability, short-term risk, and reasonableness of cost. The evaluation included in Section 8.1 of this document includes consideration of each of these criteria. Alternative 5 selected by DEQ provides the best balance against these criteria. The increase in cost for modifications of Alternative 5 to accelerate restoration of the TSA is reasonable, because the benefits (e.g., mass removal/risk reduction and time until full protection is achieved) are proportionate to the increase in cost.

Land Use. The revised statutes requires DEQ to consider current and reasonably-anticipated future land uses at the facility and surrounding properties when selecting a remedial action. The selected cleanup levels for groundwater are based on current and future use of the TSA aquifer as a source of residential drinking water supply.

10. PUBLIC NOTICE AND COMMENTS

DEQ's notice of the proposed remedial action was published in the Secretary of State's Bulletin on September 1, 1996, and in the Gresham Outlook and Oregonian newspapers on September 14, 1996, and September 15, 1996, respectively. On September 1, 1996, DEQ also mailed copies of a fact sheet and proposed plan (8-10 page summary of the DEQ Staff Report) to people on the DEQ mailing list for the site. Copies of the DEQ Staff Report describing the proposed remedial action, the RI and FS Reports, and other documents in the Administrative Record for the site were made available for public review at DEQ headquarters in Portland and at the Rockwood Public Library. The 60 day public comment period began on September 1, 1996 and ended on October 30, 1996.

DEQ participated in several public meetings held during the public comment period to describe aspects of the DEQ recommended remedial action for the Cascade Corporation site and the Troutdale Sandstone Aquifer site:

- September 4, 1996 - Friends of Blue and Fairview Lake Community Group
- September 10, 1996 - Portland Water Quality Advisory Committee
- September 24, 1996 - Regional Water Supply Managers Meeting
- October 2, 1996 - Fairview City Council Meeting
- October 17, 1996 - Friends of Blue and Fairview Lake

DEQ held two public hearings to accept verbal comments from the general public on the recommended remedial action for the TSA. DEQ issued press releases to the media several days prior to the public hearings, to remind the public of the scheduled public hearings. The first hearing was held on October 10, 1996, from 7:00 PM to 9:00 PM at the Gresham City Council Chambers located at 1333 N.W. Eastman Parkway, Gresham, Oregon. The second public hearing was held on October 30, 1996, from 1:30 to 3:00 P.M. at DEQ Headquarters located at 811 S.W. 6th Avenue, Portland, Oregon. Section 11 provides a summary of the public comments received on the proposed cleanup plan for the TSA.

11. CONSIDERATION OF PUBLIC COMMENTS

This section summarizes the verbal and written public comments received by DEQ on the recommended remedial action for the TSA. The comments are summarized by major topics followed by a detailed discussion of issues raised by the public or the responsible parties and DEQ's response to the issues raised. The Administrative Record Index (Appendix A) identifies the comment letters received and any DEQ response to individual comment letters.

11.1 Ambiguity of Recommended Remedy

Commenters: Columbia Corridor Association, Boeing, Cascade Corporation, City of Portland, Oregon Environmental Council.

Comment: Two parties commented that DEQ had not identified and evaluated the feasibility of remedial alternatives that would achieve superior cleanup more rapidly.

Response: DEQ did evaluate more aggressive remedial alternatives than the alternatives developed in the FS. DEQ believes that Alternative 5C and 6, which are very aggressive remediation options, approach the limits of feasibility in terms of groundwater extraction, contaminant mass removal rates and implementability. DEQ concurs that the FS prepared by Boeing and Cascade, although it met the minimum requirements specified in the consent order, did not make the case that Alternative 5 represented the best feasible remedial alternative. The variations of Alternative 5 developed by DEQ's contractor and under DEQ's direction, focused on improving the design and predicted performance of Alternative 5.

Comment: DEQ did not consider non-restoration costs and benefits, such as increased or reduced impacts on beneficial uses of water, in its cost-effectiveness evaluation.

Response: These types of costs and benefits are not considered when evaluating the cost-effectiveness of a remedy under state rules.

Comment: Did the components of the alternatives evaluated comprise the universe of activities that could be used to clean up such contamination?

Response: The FS evaluated a full range of treatment technologies and process options potentially applicable to remediation of the TSA. Groundwater pump and treat is the principal method employed to clean up groundwater contamination nationwide. Reinjection of treated groundwater was retained for further evaluation as an option that might increase aquifer flushing rates and groundwater extraction rates.

Comment: DEQ has set an extraction drawdown limit in the TSA, but has not conducted any analysis or provided any explanation of why that limit was chosen.

Response: DEQ has not set an extraction drawdown limit in the TSA. However, DEQ does believe that excessive drawdown of the saturated thickness of the TSA, to allow some incremental increased pumping of the Portland South Shore Wellfield's SGA wells, is counterproductive to effective remediation of the TSA because it would lead to long term dewatering of the TSA leaving contamination trapped in void spaces in the aquifer.

Comment: The recommended alternative selected by DEQ is ambiguous, because it does not identify a specific alternative, but instead relies on specific performance criteria. This approach is misleading, because the impression is given that there is no limit on the number, location or extraction rates for wells to be installed as part of the remedy. Therefore, the final remedy should clearly indicate that the components identified in Alternative 5 (and its variations, Alternative 5A through 6) serve as bounds for the alternative.

Response: DEQ concurs. The recommended remedy was not intended to be open ended. The groundwater restoration components of the final remedy include a minimum groundwater extraction rate equal to the groundwater extraction rates in Alternatives 5B and 5C. The final remedy also indicates that modifications to Alternative 5 will not result in total groundwater extraction and injection rates which exceed those described for Alternative 6.

11.2 Proposed Cleanup Levels and Residual Risk

Commenter: City of Portland

Comment: DEQ should consider pumping the remedy's extraction wells long enough to achieve background. The commenter also noted that the excess cancer risk at the MCL for TCE, reported as 1×10^{-6} in the Staff Report, does not appear consistent with EPA Region III 1995 Risk Based Calculations and Guidance. The Commenter further noted that DEQ failed to consider inhalation risk to children, which when considered, results in a residual excess lifetime cancer risk of 2×10^{-6} at the TCE MCL.

Response: The FS demonstrated that cleanup to background levels was impractical, because it would take two to four times longer than cleanup to the MCL for TCE. With respect to the EPA Region III Guidance, the document states that: "the guidance document should generally not be used to set cleanup levels at CERCLA sites or RCRA Corrective Action site". Also, the Region III Guidance used the oral slope factor for TCE withdrawn from IRIS.

DEQ acknowledges that the estimated residual excess lifetime cancer risk increases when children exposure is considered. However, the increased risk is still well within EPA's acceptable risk range of 10^{-4} to 10^{-6}. The MCL is the standard established by EPA for safe public water supply systems. In addition, Oregon Rules for Public Water Systems (OAR 333-61-097(1)(A)) states that the MCL is considered safe.

Lastly, it should be noted that excess cancer risk level at the MCL is based on a 30 year exposure timeframe. In reality, TCE concentrations will continue to decline through natural attenuation, following the completion of the remedial action. It is therefore highly unlikely that future groundwater users within the present area of TSA contamination would be exposed to TCE at the MCL level for 30 years, and actual risks should be much lower than presented here.

11.3 Proposed Remedy Performance Criteria

Commenters: City of Portland, Columbia Corridor Association, Friends of Blue and Fairview Lake, Boeing, Cascade Corporation, and Water Managers Advisory Board of Bull Run Water Users.

11.3.1 Restoration Time Frames

Comment: The 10 year and 20 year restoration time frame performance criteria should be identified as goals and not absolute standards for noncompliance. As noted in several locations in Section 7 of the Staff Report, the methods used to derive cleanup time frames have a high degree of uncertainty in them. The final remedy should specify the time frames as design goals which the remedy may or not be able to achieve, despite best efforts and implementation of the most aggressive alternative - Alternative 6.

Response: DEQ concurs. The remedy may not restore water quality within the entire contaminated portion of the TSA to MCLs, within the time frame specified in the recommended remedy. The final remedy retains the restoration time frames as design criteria and specifies that, if restoration is not achieved within these time frames through implementation of a remedy designed to do so, then groundwater pump and treat would continue in those areas where MCLs have not been achieved, until restoration is achieved.

Comment: The specification of time-based performance criteria in a ROD is unprecedented. A review of RODs throughout the country showed no examples of time-based performance standards being set for contaminated aquifers, either at EPA or at the State level.

Response: Although RODs issued by EPA and States may not have explicitly specified restoration time frames, DEQ believes the restoration time frames are an implicit element of these selected remedies. As noted above, DEQ has revised the final remedy to address the inherent uncertainties related to restoration time frame estimates.

11.3.2 Horizontal and Vertical Gradient Control

Comment: The final ROD should provide a more explicit description of the performance criteria, to include time requirements for implementing response actions, should the performance criteria be exceeded. One commenter provided specific language and times for response actions, should contamination be detected beyond the limits of the TSA contaminant plume or within the SGA.

Response: DEQ understands the commenter's concerns, but does not believe it is appropriate for the performance criteria to explicitly address potential non-attainment of the remedial action objectives, such as spreading of the plume in the TSA or expansion of the plume to the SGA. Rather, response actions to address non-attainment of the performance criteria are more appropriately addressed as contingency measures and are described in Section 9.1.5. Response times are more appropriately addressed by the Consent Order for implementation of the selected remedy, and/or work plans developed pursuant to the Consent Order requirements.

11.4 Request for More Explicit Definition of Remedy Components

Commenters: Oregon Environmental Council, Friends of Blue and Fairview Lakes, City of Portland, and Water Managers Advisory Board of Bull Run Water Users.

11.4.1 Timing of the Initiation of Hydraulic Control and Restoration

Comment: The final ROD should specify deadlines for when the remedy must be in place, specifically, July 1998.

Response: DEQ will specify an enforceable schedule for implementation of the final remedy, in a consent order to be issued following DEQ selection of the final remedy. DEQ will take this comment into consideration during consent order negotiations.

Comment: The ROD should also state that DEQ will take steps within its legal authority, to ensure that access to private property for remedy implementation is accomplished in a timely manner.

Response: DEQ intends to use its legal authority to obtain property access, if the responsible parties cannot obtain access after reasonable efforts and as necessary to ensure timely implementation of the final remedy. As requested, a statement of this fact has been added to Section 9.2.4 of the ROD for clarity.

11.4.2 Performance Evaluations

Comment: The ROD should describe how DEQ will assess whether the remediation plan is working by establishing interim benchmarks, and identifying the steps that would be taken if remediation seems to have lagged behind schedule.

Response: DEQ will assess performance of the remedy by evaluating predicted VOC concentration reductions at various locations throughout the contaminant plume. The final remedy identifies one such method for assessing remedy performance, and others may be developed. This method involves projecting contaminant concentration reductions as a function of time. The final remedy specifies minimum groundwater extraction rates, which will result in the removal of one pore volume of the contaminant plume in approximately 3 to 4 years. VOC concentrations should decline by approximately 40% with the removal of the first contaminant plume pore volume. Phase 3 would be implemented if TCE concentrations have not declined by approximately 40% after 3-4 years of implementation of Phase 2 of the final remedy. Any steps to be taken by DEQ in regard to an implementation schedule will be specified in the negotiated consent order for remedy implementation.

Comment: More frequent performance evaluations should be included in the early years of implementation.

Response: The performance evaluations will be conducted at a frequency that is consistent with the relatively slow rates of change in groundwater quality expected during remedy implementation, as noted above. The final remedy specifies that performance evaluations will be submitted to DEQ annually until Phase 3 is installed (if Phase 3 is necessary) and operated for two years, and at five year intervals thereafter. In addition, monitoring reports documenting compliance with gradient criteria and groundwater quality would be submitted to DEQ annually, during the entire period of remedy implementation. At a minimum, the performance evaluations would assess compliance with the remedy gradient control criteria, document groundwater and VOC mass removal rates, assess TCE concentration reductions, provide an assessment of the groundwater extraction and performance monitoring network, and propose modifications to the pumping program (e.g. variable or pulse pumping and, eventually, termination of groundwater extraction).

Comment: The computer model has flaws that make its use to formulate management decisions limited. Specifically, the model overpredicts the efficiency of the remediation efforts, under-predicts point concentrations of the plume in the SGA as a result of pumping by the COP wellfield, and overpredicts the time the plume would take to reach the COP wells. The management decisions made by DEQ must carefully show which ones are based on field data and which ones are based on model predictions.

Response: DEQ acknowledges that all computer models have an inherent degree of uncertainty. However, DEQ does not believe that this model has significant flaws that seriously affect its predictive capabilities. The model has been calibrated and validated by a number of aquifer tests. The model has accurately simulated the hydraulic effects of the operation of portions of the Portland South Shore Wellfield on a number of occasions. Accordingly, DEQ concluded that the model is a useful tool for understanding the groundwater system. DEQ anticipates that the model will be used to design the final groundwater extraction system and will be used to assess potential changes in the extraction system during remedy implementation.

It is important to clarify, however, that compliance with the remedy performance criteria will be assessed on the basis of field measurements, not on computer model projections. These field measurements will include water level data to assess compliance with the gradient control criteria, pump rates to assess compliance with the minimum extraction rate criteria, and water-quality data to assess the rate of aquifer restoration.

11.4.3 Groundwater Monitoring

Comment: The ROD should specify performance criteria for the groundwater monitoring program. Specific language was recommended describing how and where monitoring wells will be placed in both the TSA and SGA.

Response: Typically, details of the monitoring program are not determined until remedial design and during remedy implementation, when the dynamics of the system are better understood. The final remedy requires sufficient groundwater monitoring points to demonstrate that both the horizontal and vertical gradient control criteria are being attained, and includes considerable details of the monitoring program not typically specified in a ROD (see Section 9.1.1). In addition, the final remedy specifies that additional monitoring wells, beyond those existing or currently being installed, may be necessary to demonstrate compliance with the remedy gradient control performance criteria. The groundwater monitoring network developed during remedial design will be evaluated during remedy implementation and, if the monitoring network is found to be inadequate, then additional well(s) will be installed.

11.5 Air Emissions from Air Stripper Treatment Systems

Commenters: Friends of Blue and Fairview Lakes, Metro, and Oregon Environmental Council.

Comment: The impact of the remediation plan has not been formally evaluated by DEQ for inhalation risk from air-stripping towers. The high density of the pump and treat systems for both the TGA and TSA raise concerns about the amount of contaminants that will be volatilized into the air.

Response: The FS Report evaluated VOC air emission rates against significant emission rates (SERs) established by DEQ's Air Quality Control Division. SERs were developed by DEQ to provide a link between point source emissions (e.g., air stripping towers) and potential harmful effects resulting from offsite ambient air concentrations. The SERs assume that the closest human receptor is located 100 meters (328 feet) downwind of the emission source. The SER for TCE is 15,000 pounds per year (lb/yr). The excess cancer risk to an individual living 100 meters downwind of an emission source discharging 1500 lb/yr of TCE is 1×10^{-6}. The estimated annual VOC emissions for TCE associated with the selected remedy is less than 300 lb/yr, or two percent of the SER. The excess cancer risk to an individual living within 100 meters of a centralized air stripper would therefore be in the range of 1×10^{-8} (one in one hundred million).

In response to public concerns of VOC emissions from multiple cleanups, DEQ evaluated the combined VOC emissions from the TGA cleanups at Boeing and Cascade Corporation sites and the VOC emissions from the TSA cleanup. The TGA remediation at the Boeing and at the Cascade facilities are predicted to produce approximately 1 lb/day and 0.5 lb/day, respectively. With the projected 1 lb/day VOC emissions from the TSA remedy, the total VOC emissions are expected to be less than

3 lb/day, or less than 1000 lb/year which is again well below the SER for TCE. The final remedies for Cascade and Boeing in the TGA and the TSA could involve 6 to 8 air stripping systems, with the highest emission source being the air stripper on the Boeing facility, located approximately 1000 feet from the nearest residential property. Residents within the area would not be subjected to significant risk from inhalation of VOCs, due to the dispersion of VOCs in the atmosphere from the multiple emission sources.

Lastly, the final remedy requires a further assessment of VOC emissions, as part of the remedy design for any air stripping system proposed to be located closer than 100 meters to residential properties, to ensure protection of these populations.

Comment: The staff report does not address the risks associated with, or treatment for, the degradation products of PCE and TCE. Vinyl chloride is the most hazardous of this group. The monitoring and treatment should effectively address the degradation compounds as well.

Response: Vinyl chloride has not been detected in the TSA. The SER for vinyl chloride is 310 lb/yr. As noted above, the estimated annual VOC emissions for TCE is less than 300 lb/yr. Even if all the TCE were degraded to vinyl chloride, which is improbable, the emissions would still be below the vinyl chloride SER.

11.6 Groundwater Disposal, Reinjection or Beneficial Reuse

Commenters: Friends of Blue and Fairview Lake, City of Portland, Oregon Environmental Council, and Cascade Corporation.

11.6.1 Establishing Discharge Limits at MCLs

Comment: Will the reduction of TCE to the MCL be sufficiently protective of beneficial uses in the surface waters to which waste water will be discharged?

Response: Yes. As noted in Section 6.2 of the ROD, the chronic ambient water quality criteria for TCE is 21,000 ug/L, which is 4,000 times higher than the MCL.

Comment: Vinyl chloride has been detected in 11 percent of the groundwater samples. The monitoring and treatment should effectively address such degradation products, as well as the parent compounds.

Response: To clarify, vinyl chloride has not been detected in the TSA, but has been detected in 11% of the groundwater samples from the TGA at the Cascade Corporation facility. Vinyl chloride has been added to the list of cleanup criteria in Table 6-1 of the ROD, because it is a breakdown product of TCE, and although unlikely, might appear in the TSA.

Comment: The proposed treatment system discharge limitations are too stringent. Although the treatment systems will have the ability to bring concentrations below drinking water standards, the actual discharge limits in the NPDES permit should be set at applicable concentration for the receiving waters as laid out in applicable state and federal law.

Response: DEQ regulations specify that "best available technologies" will be employed to minimize pollutant discharges to surface water. The air stripping systems in operation at the site, since as early as 1989, have demonstrated that treatment removes VOCs to levels well below their respective MCL, without significant system maintenance requirements. Accordingly, the proposed discharge limits are not overly stringent and are consistent with DEQ regulations.

11.6.2 Consideration of Metals and Nutrients Contamination and Discharge to Fairview Lake or Columbia Slough

Comment: An oversight in the staff report has been to propose remediation strategies without linking these strategies to surface water discharge limitations that are being formulated, as a result of the total maximum daily load (TMDL) process for the Columbia Slough. Until the TMDLs are established, state regulations do not allow new discharges into water quality-limited water bodies such as the Columbia Slough. DEQ appears not to have assessed the effects on the Slough of plume co-contaminants, such as metals, as well as naturally occurring compounds such as phosphorus and other nutrients, iron, manganese, and low levels of dissolved oxygen. DEQ's plan should include a system to monitor for these constituents in the treatment plant discharges, and should incorporate alternate discharge strategies, in case discharges exceed TMDLs or other established limits.

Response: Toxics which have been found to be imparing beneficial uses in the Slough include DDT and its metabolites, dieldrin, dioxins, lead and PCBs. None of these toxics, with the exception of lead, were detected in the TSA during investigations conducted by DEQ, EPA, Boeing and Cascade prior to issuance of the 1994 Consent Order. Lead was detected in only 10 of 160 groundwater samples collected from the TSA. Of the six wells where lead was detected, four have subsequently been tested with no lead being detected (analytical detection limit of 2 ug/L). Based on existing data, DEQ has concluded that the TSA is not impacted with lead at levels that exceed chronic criteria contained in Table 20 of OAR 340-41-445. Therefore, the discharge of treated groundwater is not prohibited due to toxics pursuant to OAR 340-41-26(3)(a).

The Slough is also water quality limited for dissolved oxygen (DO) and temperature, and discharge of pollutants that would indirectly cause the receiving stream to violate water quality standards would be prohibited. The presence of nutrients such as nitrates and phosphates in treated groundwater could potentially indirectly affect DO concentrations in the Slough by promoting algae growth or increased biological oxygen demand for in-stream sediments. Nitrates and phosphates are present in the TSA, in the area of remediation presumably related to historical agriculture practices in the area. Nitrate and phosphate concentrations in treated groundwater are expected to be in the range of 3 mg/L and 0.15 mg/L, respectively. TSA groundwater within the project area currently discharges either to Fairview Lake or the Slough.

Monitoring of the Slough has shown frequent and long-term depressions in dissolved oxygen (DO), within the project area near the outlet from Fairview Lake. Flow from Fairview Lake is limited by summer operations designed to keep the water level high in the lake. The limited flow to the Slough from the lake creates a stagnant area which exhibits concentrations of DO below state water quality standards. Because the groundwater is being treated by air stripping, the effluent would contain high levels of oxygen, not low levels as the comments suggest. The discharge of treated groundwater should aid in restoring the beneficial uses of the Slough due to the following:

1. The discharge of highly oxygenated groundwater (approximately 2.5 cubic feet per second) would offset stagnant areas in the Slough, by increasing summer time low flows and help off-set current in-stream low DO concentrations;

2. Average nitrate concentrations within the TSA remediation area are comparable to concentrations measured in surface water discharges to Fairview Lake from Fairview Creek and from Taggard spring to the Slough;

3. Average phosphate concentrations within the TSA remediation area are comparable to concentrations measured in surface water discharges to Fairview Lake from Fairview Creek and from Taggard spring to the Slough, and approximately 3 times the instream concentrations measured at the dam at Fairview Lake. Measureable increases in instream phosphate concentrations attributable to the discharge of treated groundwater are not expected;

4. In the absence of remediation, groundwater containing elevated nutrients would otherwise discharge to the Slough without the benefits of oxygenation; and

5. The remediation of the TSA will decrease the rate of natural groundwater recharge to the Slough and Fairview Lake and could lead to increased stagnation, resulting in lower DO concentrations in the project area, if treated groundwater were discharged to an alternate water body such as the Columbia River.

The discharge of highly oxygenated treated groundwater containing nutrients should not indirectly cause the Slough to violate water quality standards and being designated water quality limited, and the discharge of treated groundwater should not be prohibited pursuant to OAR 340-41-026(a)(C)(i). In addition, through its TMDL program, DEQ is likely to use flow management or the Slough to restore beneficial uses; the increased flow from the remedy may be a tool which will aid in the flow managment strategy. However, DEQ acknowledges that the nature of the nutrient discharges is different than what would occur from natural groundwater discharge, and unanticipated adverse effects might occur. Therefore, the final remedy and the implementing order or permit for discharge will include flow management or other measures as necessary to avoid violation of water quality standards related to a water quality-limited parameter.

11.6.3 Reinjection of Treated Groundwater as a Remedy Component

Commenter: Friends of Blue and Fairview Lake,and Cascade Corporation.

Comment: Before reinjection is attempted, an evaluation of the possible effects on the sandstone need to be carried out. Injection of oxygenated water into the TSA would oxidize the vitric sandstone and create clay minerals and palagonite which may greatly decrease the porosity and permeability of these deposits. Also the introduction of oxygenated water into the TSA may lead to degradation of TCE to the more-toxic vinyl chloride.

Response: The upper vitric sandstone portion of the TSA is either unsaturated or has very limited saturated thickness in the area identified for reinjection. Reinjection of treated groundwater would likely occur into the lower conglomerate and would therefore not be expected to cause significant clogging of the gravel.

The reinjection of treated, oxygenated water into the TSA is not expected to promote significant biological degradation of TCE to vinyl chloride. Aerobic biological degradation of TCE requires a "co-metabolite" or a food source to the natural bacteria present in soil (e.g., toluene or phenol, as described in the DEQ Staff Report for Cascade Corporation for the TGA). Even if vinyl chloride were generated, it would degrade at rates higher than TCE. Therefore, significant accumulation of vinyl chloride is considered unlikely.

Properties where the TSA mound exists have been used extensively for agriculture for years. In recent years, spray irrigation at rates as high as 100,000 gallons per day have occurred in the area of the mound. Vinyl chloride has not been produced as a result of infiltration of irrigation water, nor has mineralization of the sandstone been documented in samples collected from the sandstone during well installations. DEQ believes that recharge to the TSA can be achieved either with wells, as described in Alternative 6, or by surface infiltration of treated groundwater in the area of the mound, without significant adverse impacts.

Comment: Reinjection is simple to model, but the actual field implementation has been shown to be more difficult and is not a well proven or documented technology.

Response: DEQ disagrees. Artificial recharge (reinjection with wells, infiltration basins, etc.) has been employed at a number of sites throughout the country, as a method to increase flushing rates in contaminated aquifers. The presence of non-aqueous-phase-liquids (NAPLs) within the aquifer matrix is generally one limiting factor on whether reinjection, used to increase flushing rates and reduce restoration time-frames, is successful. No conditions have been documented that suggest NAPLs are present in the TSA. Another limiting factor is high dissolved solids naturally occuring in groundwater causing precipitation and clogging injection wells. This condition is not expected to occur due to the relatively low dissolved solids concentrations in TSA groundwater at the site.

11.6.4 Beneficial Reuse of Treated Groundwater

Comment: The use of treated groundwater by the City of Portland would be an expensive source of water for the City's customers most of the year, because it would require pumping to Powell Butte. The City requests that it, and other water providers in the region be participants in a process to evaluate the future use of treated water.

Response: DEQ recognizes that, because of contractual arrangements with other local water districts and water rights, the City of Portland will need to be involved in beneficial use evaluations. The timing of these evaluations have not yet been determined. The evaluations may be scheduled for completion after Phase 2 of the remedy has been installed and is operational.

11.7 Additional Protective Measures

11.7.1 Abandonment of Private Water Supply Wells and Alternate Water Supply

Commenters: Friends of Blue and Fairview Lake, Cascade Corporation, John Simpson owner of Sandy Mobile Villa, and Loraine McCurdy owner of Terrand Mobile Terrace.

Comment: Private SGA water supply wells PMX-195 (Handy well) and PMX-410 (Terrand Mobile Terrace water supply well), that have had several detections of TCE, should be immediately prohibited from use for public consumption.

Response: The Handy well (PMX-195) was abandoned this summer, pursuant to a Prospective Purchaser Agreement between DEQ and Silent Creek Joint Venture. A monitoring well has been installed to assess whether contamination exists in the area of the abandoned well.

DEQ has been working with the owner of Terrand Mobile Home Terrace and Cascade Corporation since May 1996, to abandon their well and provide an alternate water supply. Monitoring of their well has been performed in the interim. One sample showed very low concentrations (less than 2 ug/L), the second non-detect. Accordingly, continued use of the well as a domestic water supply, while an alternate source is being provided, should not pose a significant risk.

Comment: We were forced to discontinue use of our well in 1988, due to contamination in our area, even though our well tested under federal drinking water limits. Our costs for operating the well were $1200 per year, and now we pay over $20,000 per year for Rockwood water. We need relief.

Response: DEQ is sympathetic to the plight of this commenter. It is unfortunate when innocent parties are adversely affected (in this case financially) by contamination caused by others. DEQ requested the cooperation of several well owners in the area of contamination to discontinue use of their well to reduce the potential for adverse spread of groundwater contamination due to pumping, during the RI/FS. DEQ cannot compensate affected parties for their losses, and does not posses the legal authority to stipulate financial compensation between affected parties and the parties responsible for the contamination. DEQ will, however, continue to work with existing well owners whose wells have been identified for abandonment, to receive the alternate water supply of their choice from the responsible parties. Installation of new, groundwater supply well(s) is an option, provided the use of groundwater does not result in the further spread of contamination horizontally within the TSA or vertically to the SGA, as discussed in Section 11.7.2.

Comment: The proposed TSA well abandonments should be reconsidered. Two of the wells have been identified as potential extraction wells. The remainder are either not contaminated at levels exceeding drinking water standards or are used for irrigation and do not adversely impact the spread of contamination.

Response: The recommended remedy did not stipulate abandonment of the TSA wells. There was a discrepancy in the FS which stated that the wells would be abandoned (see Section 5.2.2.2) and also would be used for performance monitoring.

Alternate water supplies will be necessary to replace the Claflin well (PMX-417) and the Hoyt well (PXM-198). Although DEQ will consider conversion to extraction wells, there will be a need for monitoring points in the area of 205th Avenue, to assess remedy performance. No formal assessment has been performed for the remaining TSA wells located north/northeast of 205th Avenue. The final remedy requires an assessment of the potential adverse impacts of continued use of these wells, during the institutional controls evaluation. A final decision on the continued use of these wells will be based on the results of this evaluation.

11.7.2 Groundwater Use Controls

Commenters: City of Portland, Oregon Environmental Council, Friends of Blue and Fairview Lake, Water Managers Advisory Board of Bull Run Water Users, and Columbia Corridor Association.

Comment: The final remedy should include a moratorium on all new supply well construction in the EMC site, in order to protect against reversing the gradient between the TSA and the SGA. If this is not automatic in a state cleanup site, perhaps the groundwater management area designation can be invoked even though it is not commonly done. What good are pumping restrictions on the Portland Water Bureau, if new wells can be drilled?

Response: One of the remedial action objectives for the cleanup is to allow existing groundwater use in eastern Multnomah County. The final remedy includes criteria for determining whether or not to allow new replacement SGA supply wells. There would not be a significant threat to the SGA provided these criteria are met.

DEQ and the responsible parties will evaluate whether the critical groundwater management area designation is the appropriate tool for managing groundwater resources in eastern Multnomah County during cleanup. Other options which may be considered include modifications to comprehensive land use plans for the area, coordination between DEQ and Oregon Water Resources Department (WRD) on water right applications, and periodic review of start cards filed with WRD for well installations.

As previously noted, the final remedy does not impose PWB wellfield use restrictions, but does assume, consistent with the ROD assumptions, that PWB will implement well operation strategies to reduce the threat of contamination to the SGA.

Comment: Are the limitations on the pumping of the Portland supply wells sufficiently protective against the migration of the contamination in the TSA to the SGA? Could other existing supply wells in the area have an effect on the plume? Why are no other entities restricted even in the event of a Bull Run emergency when Portland will be allowed to pump their wells? Will the parties pay to supply water to the customers whose use may need to be curtailed under Portland's restrictions as they do for the local communities that have had to move off their drinking water wells?

Response: Maintaining the vertical gradient criteria is protective of the SGA. The RI/FS focused on the pumping of the Portland supply wells and did not specifically address other existing users, except those identified with potential leaky well casings. Remaining wells will be evaluated during remedial design and implementation, and may need to be taken out of service. If this is the case, the responsible parties and the well owner may negotiate the terms for compensation.

Comment: The potential impacts on SGA water levels, and therefore, vertical hydraulic gradients could be significant (e.g. Terrand Mobile Villa), thus further reducing the ability of the City to pump its SGA wells. New SGA wells should be avoided during the early stages of the remedy to achieve the greatest good for the greatest number unless it is stated that the parties' responsibility to meet the performance criteria remain unchanged, irrespective of SGA pumping by others.

Response: The level of pumping for a new supply well for Terrand Mobile Terrace (approx. 12,000 gallons per day, based on 40 households using an assumed 300 gallons per day) is approximately 10% of the historical pumping of the Shepard well (PMX-207) for irrigation. Shepard well pumping resulted in water level drawdowns at DEQ-3, a vertical gradient compliance point, of approximately 1 foot. With one tenth the level of pumping, DEQ would expect SGA water level drawdowns at DEQ-3 from a new supply well at Terrand to be in the range of one to two tenths of a foot, which is insignificant in comparison to the 40 or more feet of drawdown in the SGA that result from pumping of the City's SGA supply wells. The vertical gradient criteria would apply irrespective of other SGA groundwater users.

Comment: The City of Portland would agree to limit pumping of its SGA wells, and will enter into an agreement with DEQ, with the conditions that: the City have the right to exceed the limits for environmental and economic reasons; the responsible parties must agree to pay additional costs incurred or revenues lost, as a result of actions taken in order to not exceed the guidelines; the ROD must unambiguously state that Boeing and Cascade are responsible for controlling and remediating their pollution; and Boeing and Cascade must meet the horizontal and vertical gradient control criteria.

Response: Since DEQ does not have the authority to mandate compensation to the City by Boeing and Cascade, it cannot enter into an agreement with the City under the conditions specified by the City. DEQ will, however, continue to work with the City, as it has in the past, including discussions of agreements to facilitate implementation of the remedy and use of the wellfield.

Comment: The City of Portland needs to operate its wellfield with the understanding that their actions can substantially affect the plume's movement. Any unilateral pumping by the City, without regard for the plume movement, could endanger the existing groundwater supply of the community of Blue and Fairview Lake.

Response: DEQ agrees. DEQ recognizes that the City's cooperation in operating its wellfield during cleanup will help ensure that the remedial action objectives are met and that water quality in the TSA is restored in a timely and efficient manner. The City has also acknowledged this.

11.8 Contingency Plan

Commenter: City of Portland.,

Comment: The description of the circumstances under which the contingency plan will be invoked are not sufficiently inclusive, and should include performance standards.

Response: The contingency plan in the final remedy requires additional response actions to be implemented to minimize the spread of contamination within the TSA or to the SGA, including the identification of location for additional monitoring and/or extraction wells and criteria for implementation of additional hydraulic control in the TSA and SGA. The final remedy does not, however, include establishing a 10-year time-frame for restoration of an SGA plume of contamination. DEQ believes that if a plume were created, it would be minor compared to the TSA, and could be addressed in a much shorter time-frame than 10 years.

11.9 Other Issues

Comment: The vertical hydraulic conductivity of CU2 cited in the staff report does not necessarily reflect the actual range in vertical conductivity values measured, or even all the estimated values. The staff report should recognize the possibility that contaminant time of travel from the TSA to the SGA could be very short (e.g., weeks to months).

Response: DEQ agrees the contaminant time of travel from the TSA to the SGA could be short in areas where CU2 is thin or absent. This was acknowledged in the first paragraph on Page 3-7 of the Staff Report which stated: "Groundwater travel times between the TSA and the SGA..., were estimated to be in the range of 30 to 190 days." Detailed discussion of hydraulic conductivities and contaminant transport are presented in the RI, which are the basis for the ROD.

Comment: I am not convinced that there is not a connection between Blue Lake, the Blue Lake Aquifer and the TSA.

Response: The RI/FS and the DEQ Staff Report do not claim that there is no connection. Studies performed by the U.S. Geological Survey and the Portland Water Bureau have demonstrated a connection between the BLA, Blue Lake and the TSA. Pumping of the City's BLA wells, however, does not cause significant hydraulic influences (e.g. water level depressions and gradient variations) in the area of the TSA contaminant plume that would result in the significant spread of contamination to Blue Lake or the BLA.

Comment: The description of well field capacity and well field use patterns found in the Staff Report is not exact. The City suggests that it be amended to reflect the information contained in their comments.

Response: Section 3.1.2 of the ROD have been revised consistent with the comment.

12. DOCUMENTATION OF SIGNIFICANT CHANGE

As noted in Section 11, several changes were made in the selected remedial action, in response to public comments received on the recommended remedial action. The changes to the recommended remedy are summarized below.

Remedy Performance Criteria. The aquifer restoration time frame criteria for the recommended remedy were changed to design criteria for the selected remedy. As noted in Section 7, the restoration time frames have an inherent decree of uncertainty and the selected remedy may not be able to achieve these restoration times. Accordingly, the remedy does not specify a time frame, but DEQ has added minimum groundwater extraction rates to the selected remedy to insure that the remedy is designed to achieve the restoration time frame goals.

Remedy Implementation Phases. Phase 2 and Phase 3 of the selected remedy were changed. Phase 2 will require installation of sufficient extraction wells to achieve the minimum groundwater extraction rates specified in the final remedy. Phase 2 had previously contemplated groundwater extraction rates equivalent to Alternative 5, which are approximately 25 percent less than the rates for Alternative 5B. Phase 3, which was to be implemented after Phase 2 had operated for one year, will now be implemented after 3-4 years. This time frame is necessary to determine whether the selected remedy is reducing the area and concentration of groundwater contamination above the cleanup levels at a rate necessary to achieve restoration time frames. Time is also needed to develop the design for reinjection of treated groundwater, if minimum extraction rates cannot be sustained without excessive dewatering of the TSA. It is unlikely that any definitive determinations of remedy performance could be made after only one year of extraction.

Upper Bounds of Selected Remedy. The final remedy includes upper limits on the rate of groundwater extraction and injection, as defined by Alternative 6. Alternative 6 represents the upper bounds of remedial components evaluated and demonstrated to be feasible in the remedy selection process.

Assessment for Air Emissions. The final remedy requires an air emissions assessment in the remedial design, for air stripping systems proposed to be located closer than 100 meters from any residential property. The 100 meter distance was used by DEQ in significant emission rate calculations for the contaminants of concern.

Groundwater Disposal. The final remedy includes provisions to monitor additional constituents which may be present in treated groundwater, and which are of interest for the TMDL development process for the Columbia Slough.

Criteria for New SGA Supply Wells. The final remedy incorporates criteria for determining whether new SGA supply wells will be installed to replace those SGA wells identified for abandonment.

Abandonment of TSA Supply Wells. The recommended remedy indicated that 6 TSA supply wells would either be abandoned or taken out of service and used for remedy performance monitoring. The final remedy does not require abandonment of existing TSA supply wells and defers a final decision on whether the wells will be taken out of service, based on an assessment of pumping influences and hydraulic control of the contaminant plume. This assessment will be completed during Phase 2 remedy implementation.

13. FINAL DECISION OF THE DIRECTOR

The selected remedial action for the East Multnomah County Troutdale Sandstone Aquifer site is protective, and to the maximum extent practicable, uses permanent solutions and alternative technologies, is cost-effective, effective and implementable. It therefore satisfies the requirements of ORS 465.315, and OAR 340-122-040 and 340-122-090. The detailed evaluation of how the selected remedial action meets the regulatory requirements is provided in Section 9.2.

13.1 Director's Signature

Langdon Marsh — 12-31-96

Langdon Marsh, Director — Date

Department of Environmental Quality

TABLES

POTENTIAL GROUNDWATER USERS SUMMARY
TSA WELLS

PMX Well ID	Common Well Name	Aquifer	Is well within current TSA VOC plume, beneath surface expression of TSA VOC plume, or have VOC been detected?[a]	Potentially Impacted Well?[b]	Proposed Action[c]
PMX 199	City of Fairview No. 4	TGA and TSA	No	No	No action at present
PMX 129/130	Big Eddy Marina[d]	TSA	No	Possible	No action at present
PMX 196	Andrews	TSA	Yes	–	Supply municipal water; use for monitoring
PMX 345	Edwards	TSA	No	Possible	Supply municipal water; use for monitoring
PMX 417	Claflin	TSA	Yes	–	Supply municipal water; evaluate for possible extraction well; use for monitoring
PMX 434	Schmautz	TSA	Yes	–	Supply municipal water; use for monitoring
PMX 169	Schloredt	TSA	No	No	No action at present
PMX 183	City of Fairview	TSA	No	No	No action at present
PMX 189	Watters	TSA	Yes	–	Supply municipal water; use for monitoring
PMX 198	Hoyt	TSA	Yes	–	Supply municipal water; evaluate for possible extraction well; use for monitoring
PMX 226	Rockwood Water District	TSA	No	No	No action at present
PMX 124	PW-3	TSA	No	No	No action at present
PMX 128	PW-5	TSA	No	No	No action at present
PMX 120	PW-15	TSA	No	No	No action at present
PMX 232	Union Plaza	TSA	No	No	No action at present

TABLE 3-1

POTENTIAL GROUNDWATER USERS SUMMARY
SGA WELLS

PMX Well ID	Common Well Name	Aquifer	Is well within current TSA VOC plume, beneath surface expression of TSA VOC plume, or have VOC been detected?	Potentially Impacted Well?	Proposed Action
PMX 166	W. Interlachen Water Corp.	SGA	No	No	Monitor
PMX 174	Interlachen Corp.	SGA	No	No	Monitor
PMX 192	Wade (Peffry)	SGA	No	Possible	Supply municipal water and monitor[e]
PMX 195	Handy	SGA	Yes	--	Abandon well[e]
PMX 207	Shepard	SGA	Yes	--	Abandon well[e]
PMX 410	Terrand Mobile Terrace	SGA	Yes	--	Abandon well[e]
PMX 193	Willard	SGA	No	Possible	Monitor[e]
PMX 202	Rolling Hills	SGA	Yes	Possible	Monitor[e]
PMX 225	Cherry Blossom	SGA	Yes	--	Abandon well[e]
PMX 409	Sandy Mobile Villa	SGA	Yes	--	Abandon well[e]
PMX 176	Columbia Acres	SGA	No	No	No action at present
PMX 208	Sandy Mobile Villa	SGA	Yes	--	Abandon well[e]
PMX 185	City of Fairview No. 3	SGA	No	No	No action at present
PMX 184	City of Fairview No. 5	SGA	No	No	No action at present
PMX 122	PW-4	SGA	No	No	No action at present
PMX 126	PW-9	SGA	No	No	No action at present
PMX 136	PW-7	SGA	No	No	No action at present
PMX 132	PW-14	SGA	No	No	No action at present
PMX 142	PW-8	SGA	No	No	No action at present
PMX 419	Big Eddy Marina[d]	SGA	No	No	No action at present

TABLE 3-1

POTENTIAL GROUNDWATER USERS SUMMARY
BLA & UNKNOWN CONSTRUCTION WELLS

PMX Well ID	Common Well Name	Aquifer	Is well within current TSA VOC plume, beneath surface expression of TSA VOC plume, or have VOC been detected?[a]	Potentially Impacted Well?[b]	Action[c]
PMX 163	Multnomah County	BLA	No	Yes	No action at present
--	Toombs No. 1	BLA	No	Yes	No action at present
--	Toombs No. 2	BLA	No	Yes	No action at present
PMX 164	Multnomah County	BLA	No	Yes	No action at present
PMX 159	Multnomah County	BLA	No	Yes	No action at present
PMX 158	PW-19	BLA	No	No	No action at present
PMX 162	PW-13	BLA	No	No	No action at present
PMX 148	PW-17	BLA	No	No	No action at present
PMX 150	PW-12	BLA	No	No	No action at present
PMX 155	PW-18	BLA	No	No	No action at present
PMX 149	Multnomah County	?	No	No	No action at present
PMX 173	Interlachen Corp.	?	No	No	No action at present
PMX 175	Tuttle	?	No	No	No action at present
PMX 168	Blue Lake Water District	?	No	No	No action at present
PMX 285	Nielsen	?	No	No	No action at present
PMX 197	Kirchern	?	No	No	No action at present
PMX 437	Sasaki	?	No	No	No action at present
PMX 433	Schmidt	?	No	No	No action at present
--	Nyquist	?	No	No	No action at present

TABLE 3-1

POTENTIAL GROUNDWATER USERS SUMMARY
BLA & UNKNOWN CONSTRUCTION WELLS

PMX Well ID	Common Well Name	Aquifer	Is well within current TSA VOC plume, beneath surface expression of TSA VOC plume, or have VOC been detected?	Potentially Impacted Well?	Proposed Action
–	Paulson	?	No	No	No action at present
–	Shepard	?	No	No	No action at present

(a) TSA VOC plume as defined in Endangerment Assessment Report
(b) Potentially impacted (i.e. above MCLs) wells are based on results of modeling 20 year simulation periods with various PWB pumping conditions and no remedial action.
(c) See Table 9-1 for monitoring frequency for wells to be monitored as part of the recommended remedy.
(d) There are two TSA (PMX 129 and PMX 130) and one SGA well (PMX 419) for Big Eddy Marina
(e) Based on recommendations in EMCON TSA/SGA Data Gap Investigation Report.

TABLE 5-1
EAST MULTNOMAH COUNTY GROUNDWATER CONTAMINATION SITE
SUMMARY OF GROUND-WATER CONTAMINANT CONCENTRATIONS [1]

Compound	Troutdale Sandstone Aquifer (TSA)				Sand and Gravel Aquifer (SGA)			
	No. of Samples	No. of Detects	Range (µg/L) Min.	Range (µg/L) Max.	No. of Samples	No. of Detects	Range (µg/L) Min.	Range (µg/L) Max.
trichloroethene	549	457	0.42	410	130	34	0.6	16.8
tetrachloroethene	546	314	0.1	16	130	10	0.4	1.3
cis-1,2-dichloroethene	538	271	0.2	210	98	4	0.7	1.2
1,1,1-trichloroethane	541	25	0.2	8.5	130	0	--	--
methylene chloride	541	19	0.4	2.4	119	0	--	--
1,1-dichloroethene	547	16	0.22	15	130	0	--	--
trans-1,2-dichloroethene	541	13	0.2	2.6	--	--	--	--
chloroform	541	9	0.4	2.6	130	17	0.85	7.6

1/ Include all volatile organic compounds detected in more than two percent of the total samples.

TABLE 5.2

SUMMARY OF VOLATILE ORGANIC COMPOUNDS IN COLUMBIA SLOUGH WEST OF FAIRVIEW LAKE [1]

Compound	Number of Samples	Number of Detects	Range (µg/L)	
			Minimum	Maximum
trichloroethene	16	6	0.8	2.3
toulene	16	1	--	7
cis-1,2-dichloroethene	16	2	0.29	0.5

[1]/ Summary of data from surface water sampling stations CS-A and CS-8, which were located 900 feet and 1800 feet, respectively, downstream of Fairview Lake.

TABLE 5-3

EAST MULTNOMAH COUNTY GROUNDWATER CONTAMINATION SITE
SUMMARY OF RISK ESTIMATES FOR CURRENT EXPOSURE SCENARIOS

Scenario (Water Source)	Excess Lifetime Cancer Risk[a]		Constituent Most Responsible	Noncancer Hazard Index[a]		Constituent Most Responsible
	CTE	RME		CTE	RME	
Occupational (TSA)[1]	1.3e-10	2.4e-09	TCE	NC	NC	
Residential (TSA)[2]	4.8e-06	4.0e-05	TCE	3.3e-01	6.9e-01	TCE
Residential (SGA)[2]	4.6e-07	3.4e-06		2.6e-02	5.6e-02	TCE
Residential (Columbia Slough)[3]	NC	NC		6.9e-05	1.7e-04	TCE
Recreational (Columbia Slough)[4]	NC	NC		7.0e-07	2.5e-06	TCE

Abbreviations:

CTE	central tendency exposure case
RME	reasonable maximum exposure case
TSA	Troutdale Sandstone Aquifer
SGA	Sand and Gravel Aquifer
1,1-DCE	1,1-dichloroethene
TCE	trichloroethene
PCE	tetrachloroethene
cis-1,2-DCE	cis-1,2-dichloroethene
VOCs	volatile organic compounds
NC	not calculated or not calculable

[a]Risks correspond to the following exposure point concentrations:

TSA		
	1,1-DCE	0.51 µg/L
	cis-1,2-DCE	9.7 µg/L
	PCE	2.2 µg/L
	TCE	122 µg/L
SGA		
	cis-1,2-DCE	1.2 µg/L
	PCE	1.3 µg/L
	TCE	8.7 µg/L
Columbia Slough		
	cis-1,2-DCE	0.5 µg/L
	TCE	2.3 µg/L

Notes:

[1] Inhalation of VOCs released during occupational use of groundwater and as soil-gas that migrates through cracks in foundation and accumulates in buildings.

[2] Includes ingestion, inhalation and dermal exposure of VOCs contained in or released from groundwater during normal household uses.

[3] Includes ingestion of homegrown produce exposed to chemicals in surface water.

[4] Includes dermal contact with surface water during recreational use of Slough.

TABLE 6-1

GROUNDWATER CLEANUP LEVELS FOR THE TSA

COPC	Groundwater Cleanup Level (µg/L)[a]	Corresponding Excess Cancer Risk Level[b]	Corresponding Noncancer Hazard Quotient[b]
TCE	5	1x10-6	0.03
PCE	5	5x10-6	0.02
cis-1,2-DCE	70	NC	0.2
1,1-DCE	7	1x10-4	0.03
vinyl chloride	2	7x10-4	NC
Total Estimated Risk at MCLs[c]		1x10-4	0.3

Notes: NC Not considered carcinogenic or calcuable due to lack of reference dose.

a) Based on Federal MCL.

b) Based on RME exposure for residential ingenstion of, inhalation of, and dermal contact with drinking water.

c) Cleanup of TCE to MCL will reduce other chemicals of potential concern to levels well below the MCL. Risk at MCL not reflective of risk to future groundwater users at the completion of cleanup.

TABLE 8-1

EAST MULTNOMAH COUNTY GROUNDWATER SITE
REMEDIAL ALTERNATIVE COST-EFFECTIVENESS EVALUATION

Remedial Alternative	Present Worth Cost[a]			Incremental Increase in Cost[b]			Estimated Mass Removed in 1 Year (lbs of TCE)[c]	Incremental Increase in Mass Removal[b]	Estimated Cleanup Timeframe (years for 90% restoration)	Incremental Decrease in Cleanup Timeframe[b]
	Capital	O&M	Total	Capital	O&M	Total				
Alternative 4	$2.0	$6.6	$8.6	0%	0%	0%	110	0%	104	0%
Alternative 5	$3.5	$5.6	$9.1	75%	-15%	6%	230	113%	35	66%
Alternative 5a	$4.0	$5.8	$9.8	14%	4%	8%	270	17%	26	26%
Alternative 5b	$4.1	$5.2	$9.3	17%	-7%	-2%	310	34%	22	37%
Alternative 5c	$4.8	$6.2	$11.0	37%	-11%	21%	310	34%	20	43%
Alternative 6	$5.3	$6.5	$11.8	51%	16%	31%	315	37%	16	54%

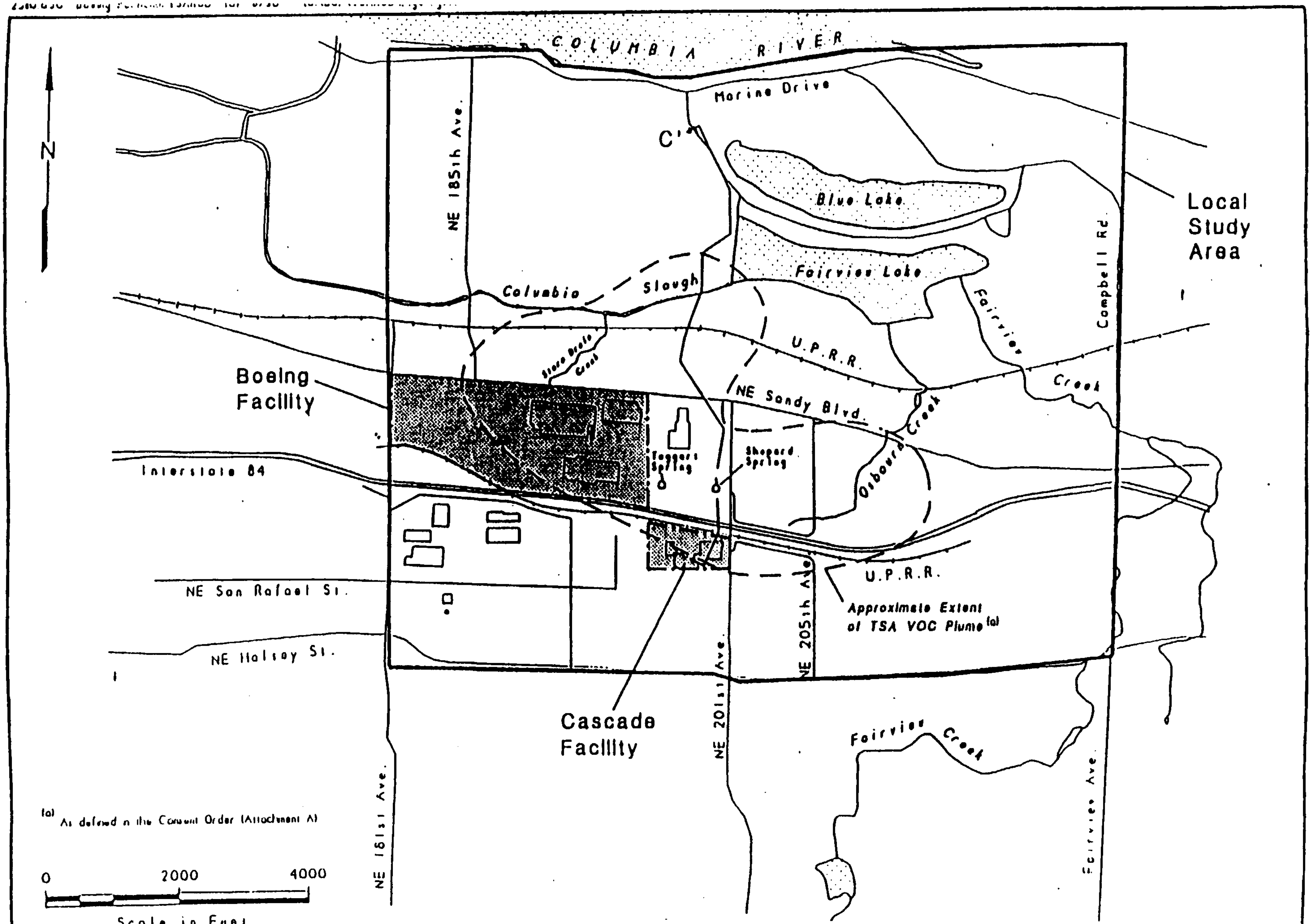
[a] Costs in $millions in 1995 dollars w/ net present value (NPV) using 5% discount rate (from Andrews Memorandum, dated June 1996 - Table 1).
[b] Incremental Difference calculated between Alternative 4 and 5, and Alternative 5 and 5a, 5b, 5c, and 6.
[c] Mass removal estimates based on extraction well pumping rates and average TCE concentration within 300 feet of extraction wells for each alternative.

TABLE 9-1
PERFORMANCE MONITORING
WATER QUALITY SAMPLING PLAN

TSA Sandstone Monitoring Point		TSA Conglomerate Monitoring Point		SGA Monitoring Point	
Well	Frequency[a]	Well	Frequency	Well	Frequency
Perimeter Wells[b]		Perimeter Wells:			
BOP-22(ds)	Annually	BOP-20(dg)	Annually	BOP-68(usg)	Semiannually
BOP-41(ds)	Annually	BOP-22(dg)	Annually	CMW-14(usg)	Semiannually
BOP-42(ds)	Annually	BOP-41(dg)	Annually	DEQ-3(d)	Annually
CMW-19(ds)	Annually	BOP-43(dg)	Annually	DEQ-3(usg)[c]	Semiannually
CMW-20(ds)	Annually	BOP-44(dg)	Annually	DEQ-4(d)	Semiannually
CMW-29(ds)	Annually	CMW-23(ds)	Annually	PMX-138.370	Annually
D-15(ds)	Annually	CMW-26(dg)	Annually	PMX-140	Annually
D-16(ds)	Annually	CMW-29(dg)	Annually	PMX-166	Annually
D-18(ds)	Annually	D-15(dg)	Annually	PMX-174	Annually
EMC-1(ds)	Annually	D-16(dg)	Annually	PMX-192	Annually
PMX-138.180	Annually	D-18(dg)	Annually	PMX-193	Annually
PMX-141	Annually	EMC-1(dg)	Annually	PMX-202	Annually
PMX-189	Annually	EMC-2(dg)	Annually	PWB-1(usg)	Semiannually
RPW-1(ds)	Annually	PMX-138.250	Annually	PWB-2(usg)	Annually
		PMX-192(dg)	Annually	MW-A[d]	Semiannually
Interior Wells:		PMX-196	Annually		
BOP-13(ds)	Semiannually	PMX-345	Annually		
BOP-20(ds)	Semiannually	PMX-434	Annually		
BOP-31(ds)	Semiannually	PWB-2(lts)	Annually		
BOP-43(ds)	Semiannually	RPW-1(dg)	Annually		
BOP-44(ds)	Semiannually	DEQ-4(s)	Annually		
BOP-60(ds)	Semiannually				
BOP-61(ds)	Semiannually	Interior Wells:			
CMW-10(ds)	Semiannually	BOP-13(dg)	Semiannually		
CMW-17(ds)	Semiannually	BOP-23(dg)	Semiannually		
CMW-26(ds)	Semiannually	BOP-23(ds)	Semiannually		
PWB-1(uts)	Semiannually	BOP-31(dg)	Semiannually		
PMX-417	Semiannually	BOP-42(dg)	Semiannually		
CMW-18(ds)	Semiannually	BOP-60(dg)	Semiannually		
		BOP-61(dg)	Semiannually		
		CMW-8(dg)	Semiannually		
		CMW-10(dg)	Semiannually		
		CMW-14(dg)	Semiannually		
		CMW-14(ds)	Semiannually		
		CMW-20(dg)	Semiannually		
		CMW-22(ds)	Semiannually		
		CMW-22(dg)	Semiannually		
		CMW-25(dg)	Semiannually		
		D-17(dg)	Semiannually		
		D-17(ds)	Semiannually		
		DEQ3(i)	Semiannually		
		DEQ3(s)	Semiannually		
		EMC-2(ds)	Semiannually		
		PWB-1(lts)	Semiannually		
		PMX-198	Semiannually		

w monitoring wells or wells with new screen locations will be sampled quarterly for 1 year and then at the indicated frequency.
nitoring wells were identified as perimeter monitoring well if TCE concentrations since 1994 have been less than 5 ppb (the MCL for TCE).
eens in these wells will be installed at the top of the SGA or new wells will be installed.
e monitoring well will be installed near or downgradient of PMX-195.

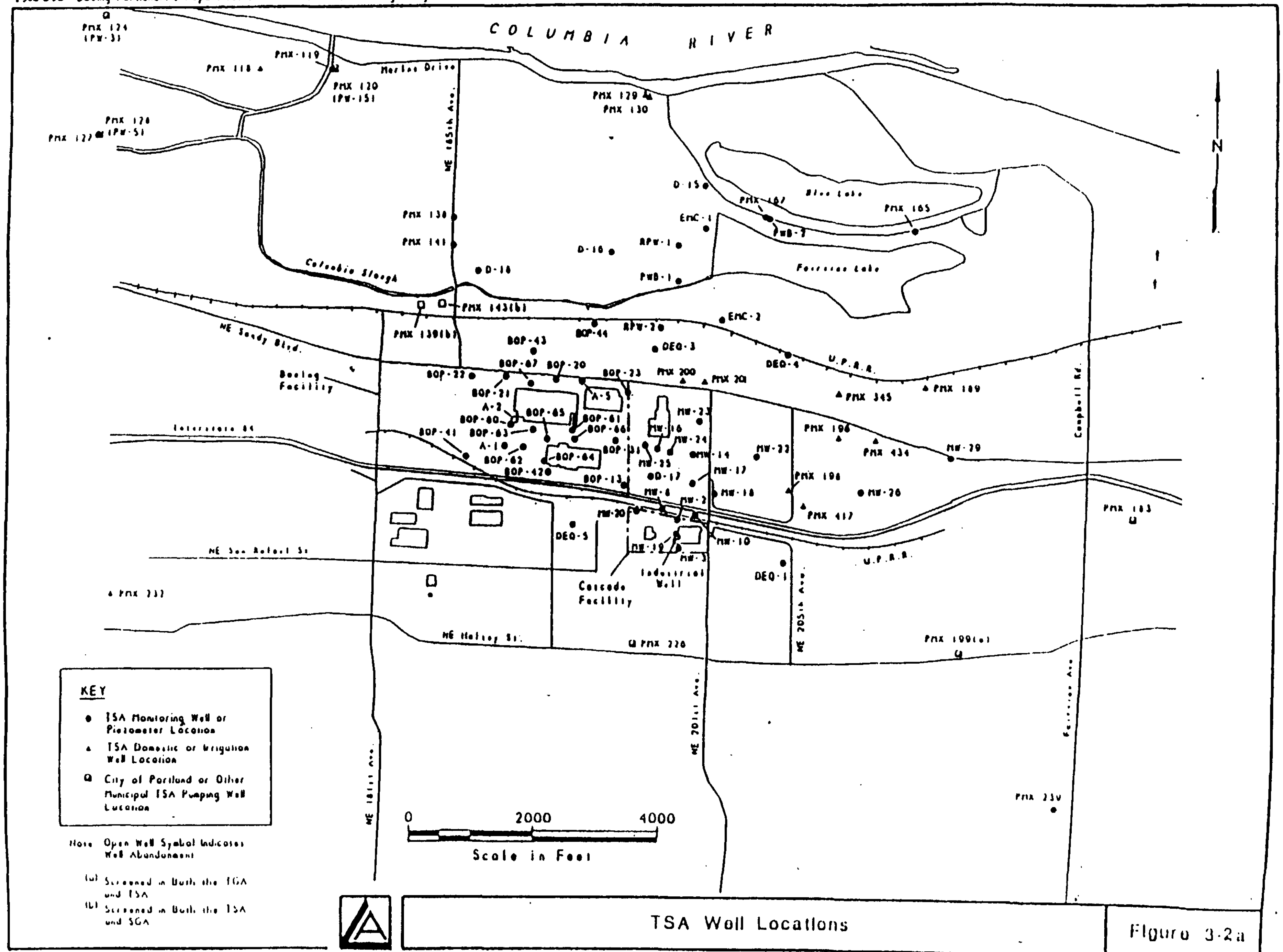
FIGURES



Project Area

Figure 3-1

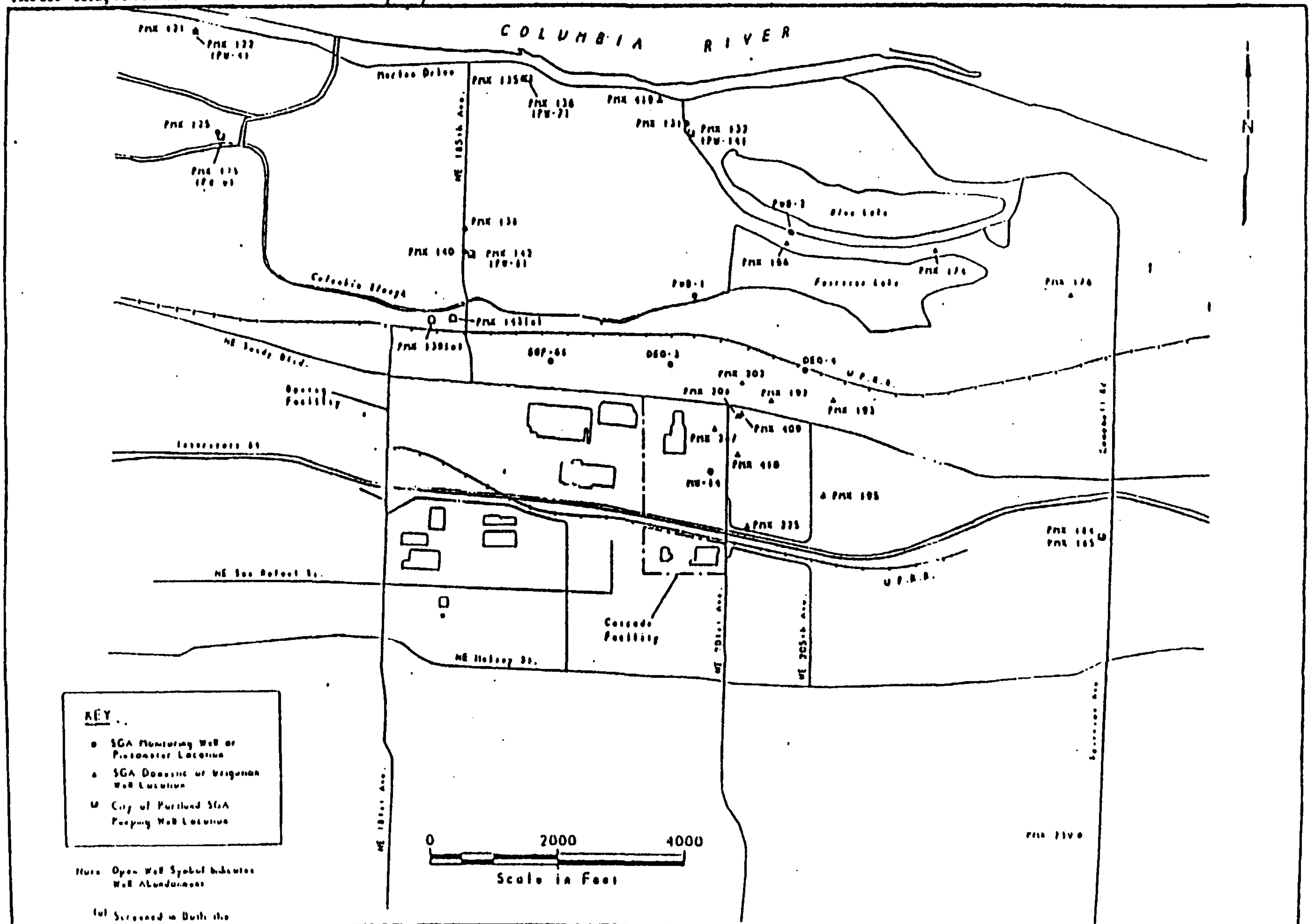
2500.630 Boeing Portland/FS Report (G) 8/96 (0:\BOP\ESAROD\Fig3-2a.gcd)



TSA Well Locations

Figure 3-2a

7500 630 Boeing Portland/TSAROD (G) 8/98 (0:\BOP\TSAROD\Fig3-7B.gcd)



SGA Well Locations

Figure 3-2b

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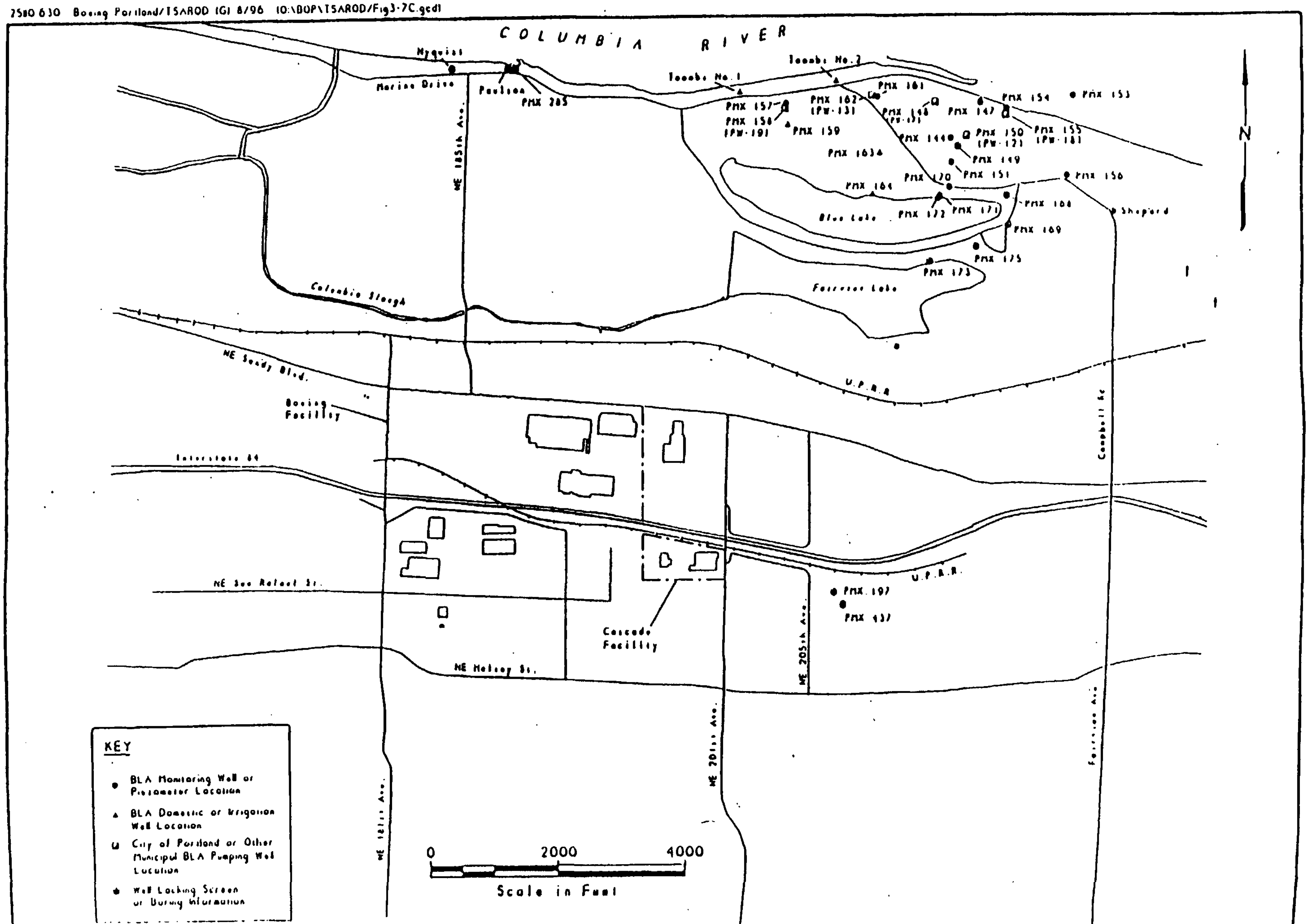
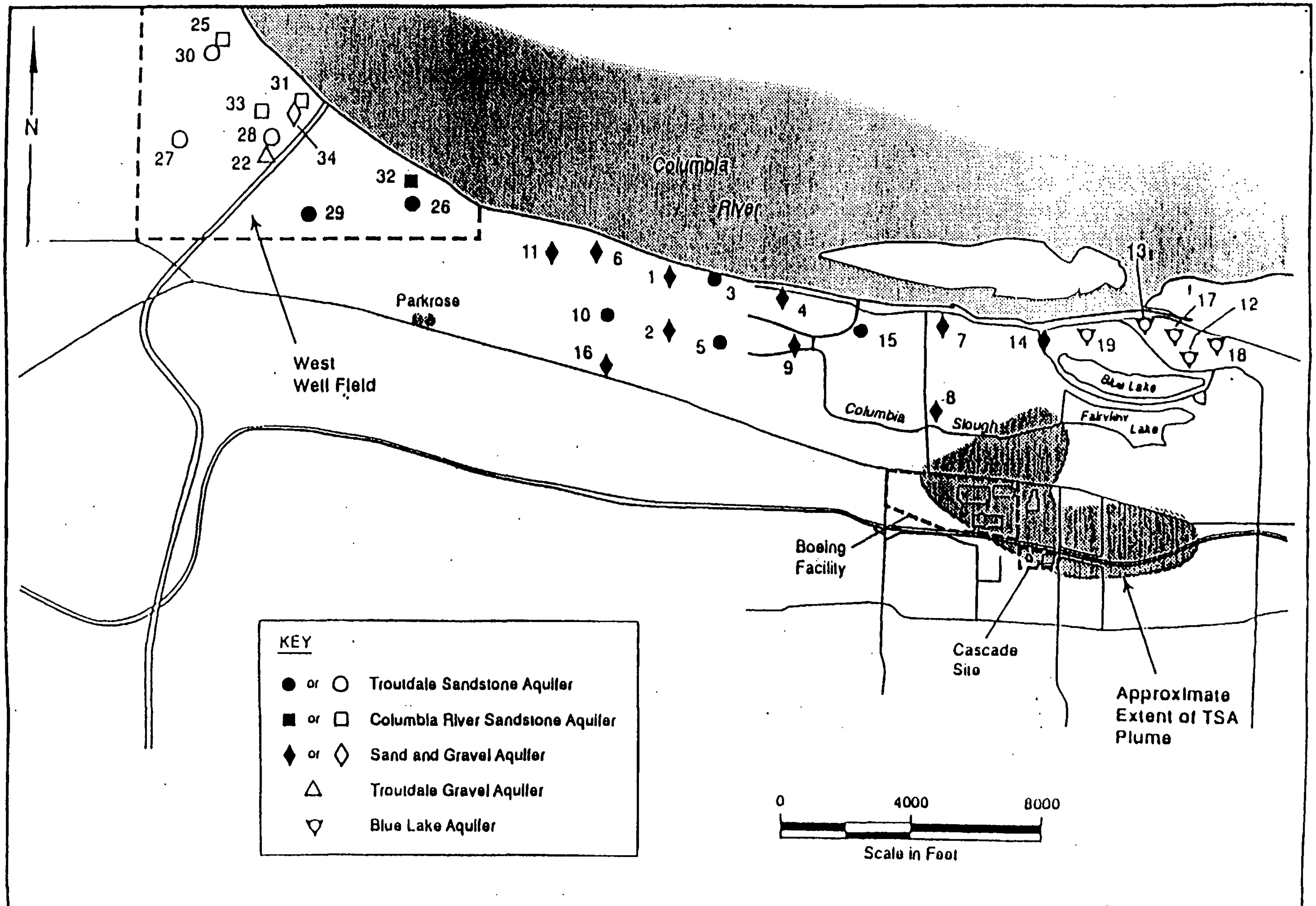


BLA Well Locations
and Well Locations with Uncertain Aquifer Designations

Figure 3-2c

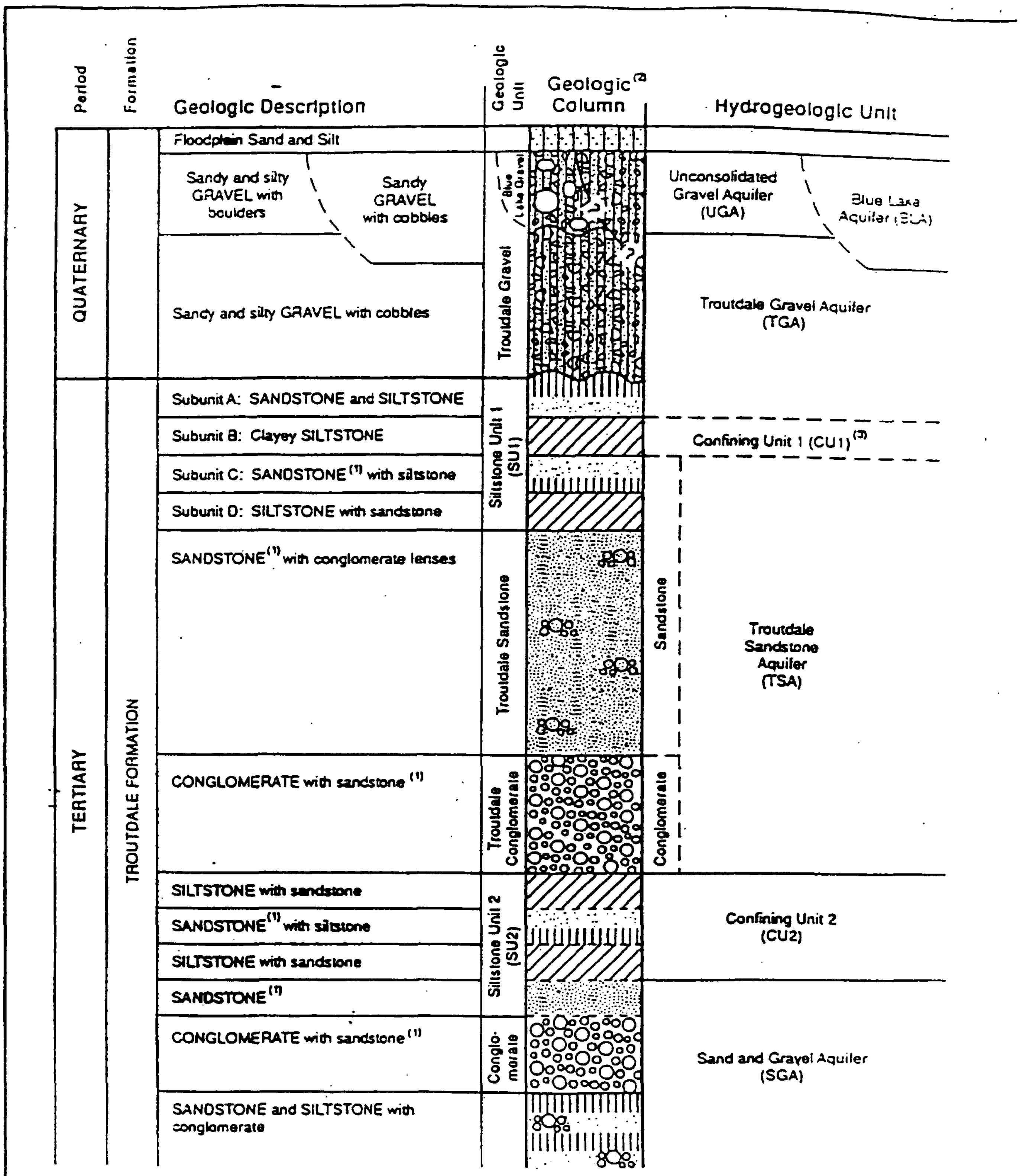
25110.630 Boeing Portland/TSAROU/Fig. 3-8 (M) 8/98



Note: Open symbol indicates well is not operational.

Locations of PWB Production Wells

Figure 3-3

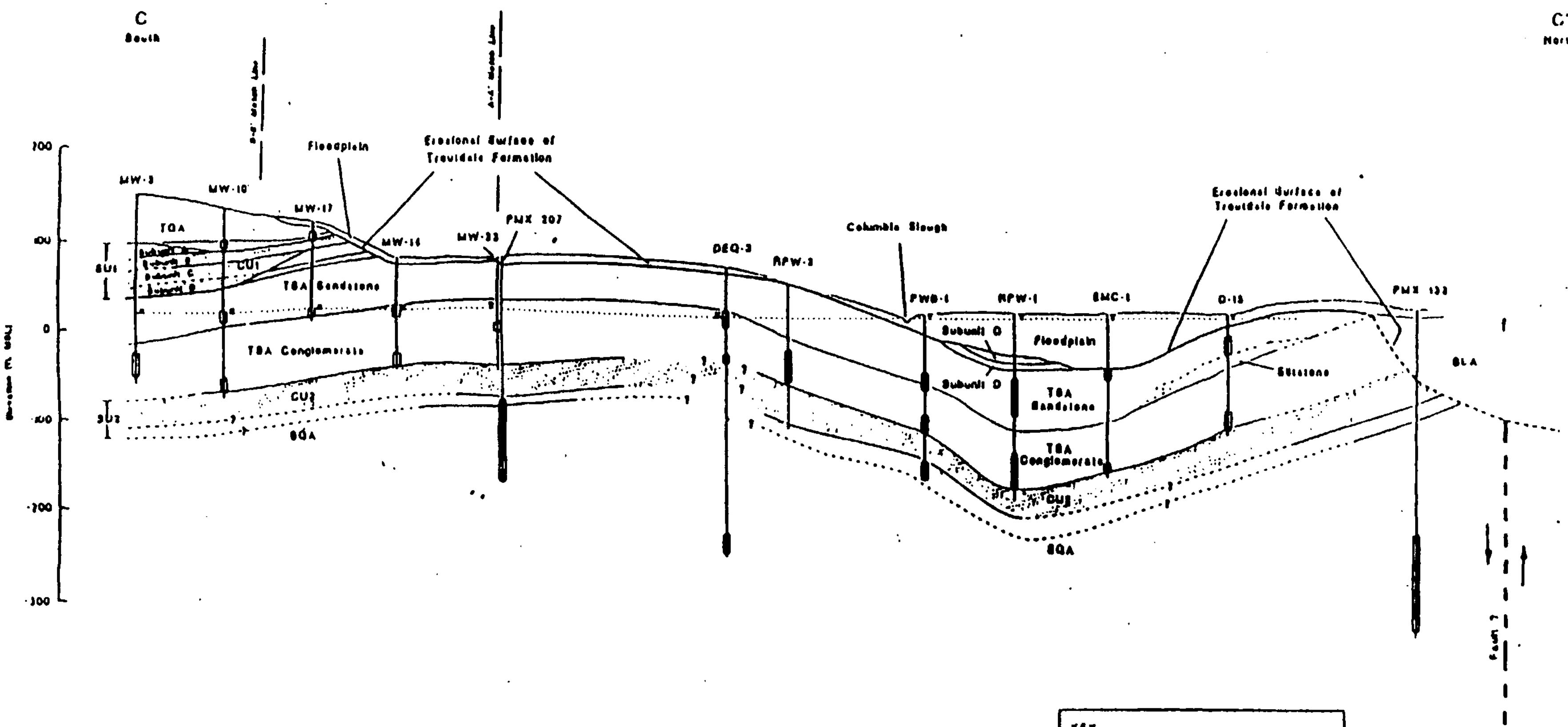


Notes:
1. Sandstone may contain large amounts of vitric lithic sand.
2. Geologic column is intended to represent a composite for the study area. Local variations may exist.
3. The designation of CU1 in this report is based on designations used by Landau (1995c), but different than designations used by EMCON (1995b) and the TSA RI report (EMCON and Landau Associates 1995a). Landau (1995c) designates CU1 as being equivalent to SU1 Subunit B.

25110.630 Boeing Portland/TSAROD/Fig. 3-2 (M) 8/98

Typical Geologic and Hydrogeologic Column

Figure 3-4



Notes: 1 See Figure 3-1 for further detail on geologic and hydrogeologic units.

2 At locations with more than one well, the geology and hydrogeology shown are based on data from the deeper well.

3 Natural gamma logs were incorporated into geologic and hydrogeologic interpretations when available.

4 A different CU2 boundary criteria was used for DEQ-3(d). The published well log indicates a 'silty sand' and 'sandy gravel' present where CU2 would be expected to be encountered (see text for further detail).

Horizontal Scale in Feet

Vertical Scale: 1 inch = 120 ft
Vertical Exaggeration: 5x

KEY

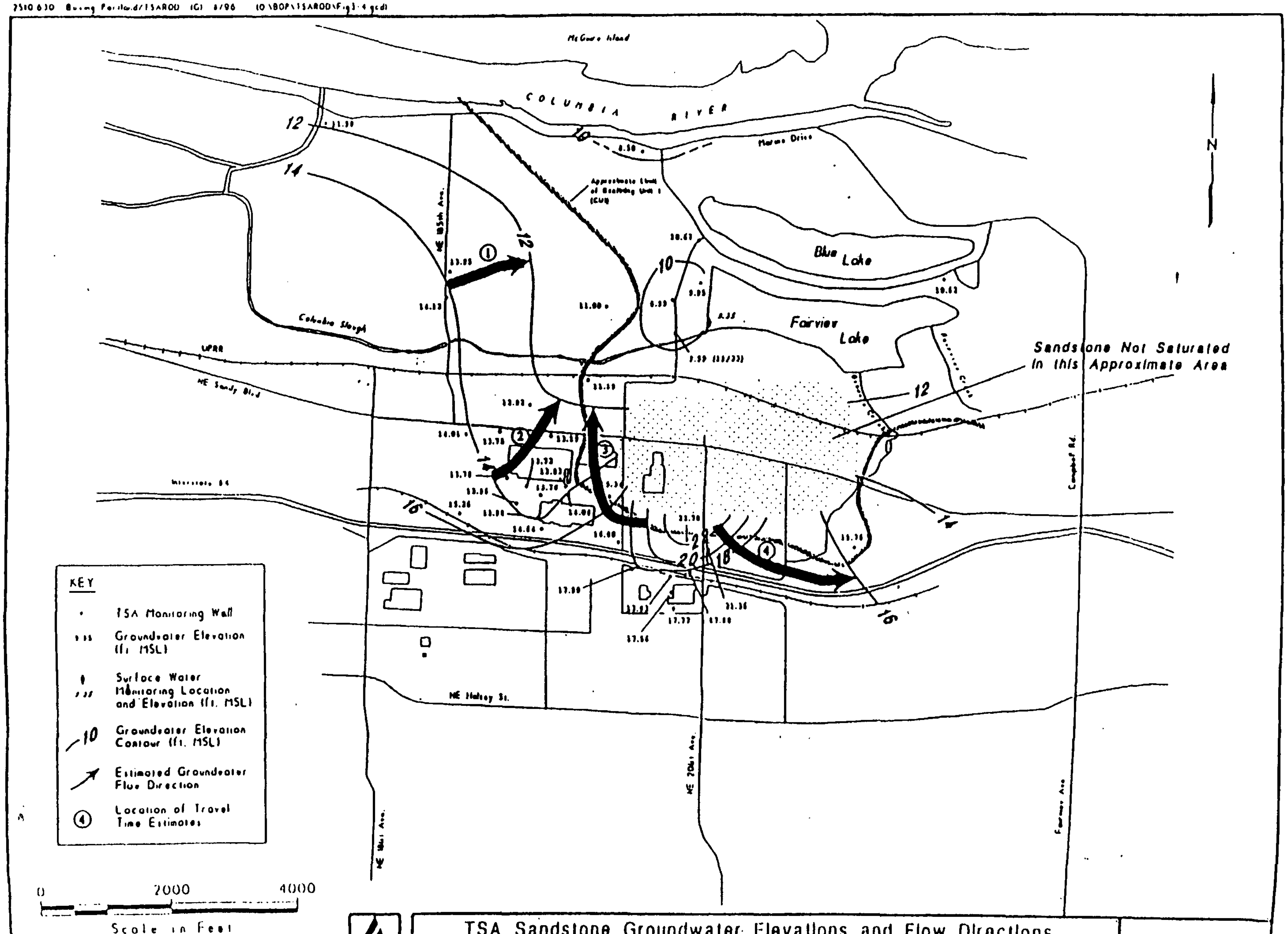
TSA Water Elevations Measured on 11/20 and 11/20/86 (ds and dg averaged where available)

Screened or Perforated Interval

Confining Unit

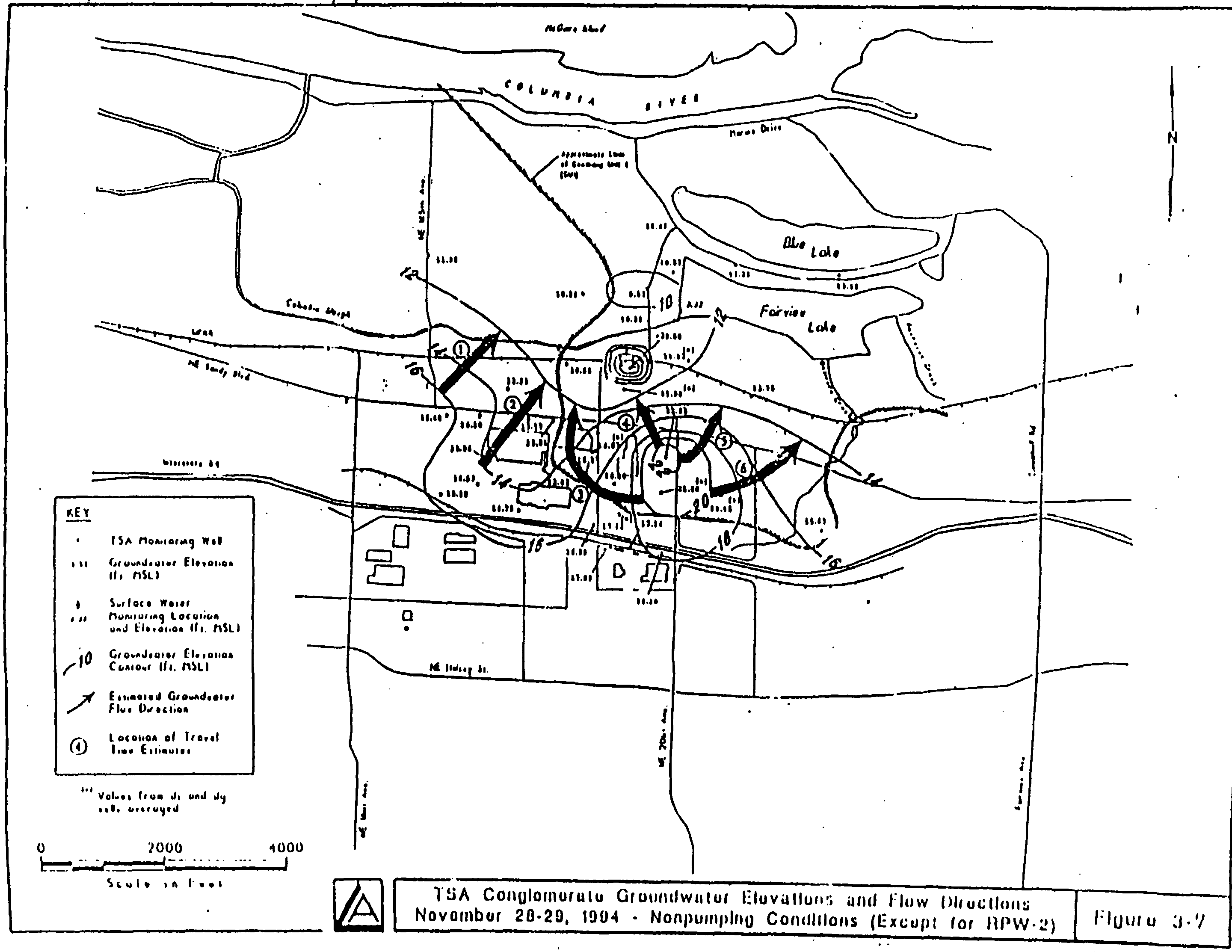
Geologic and Hydrogeologic Cross Section C-C'

Figure 3-5



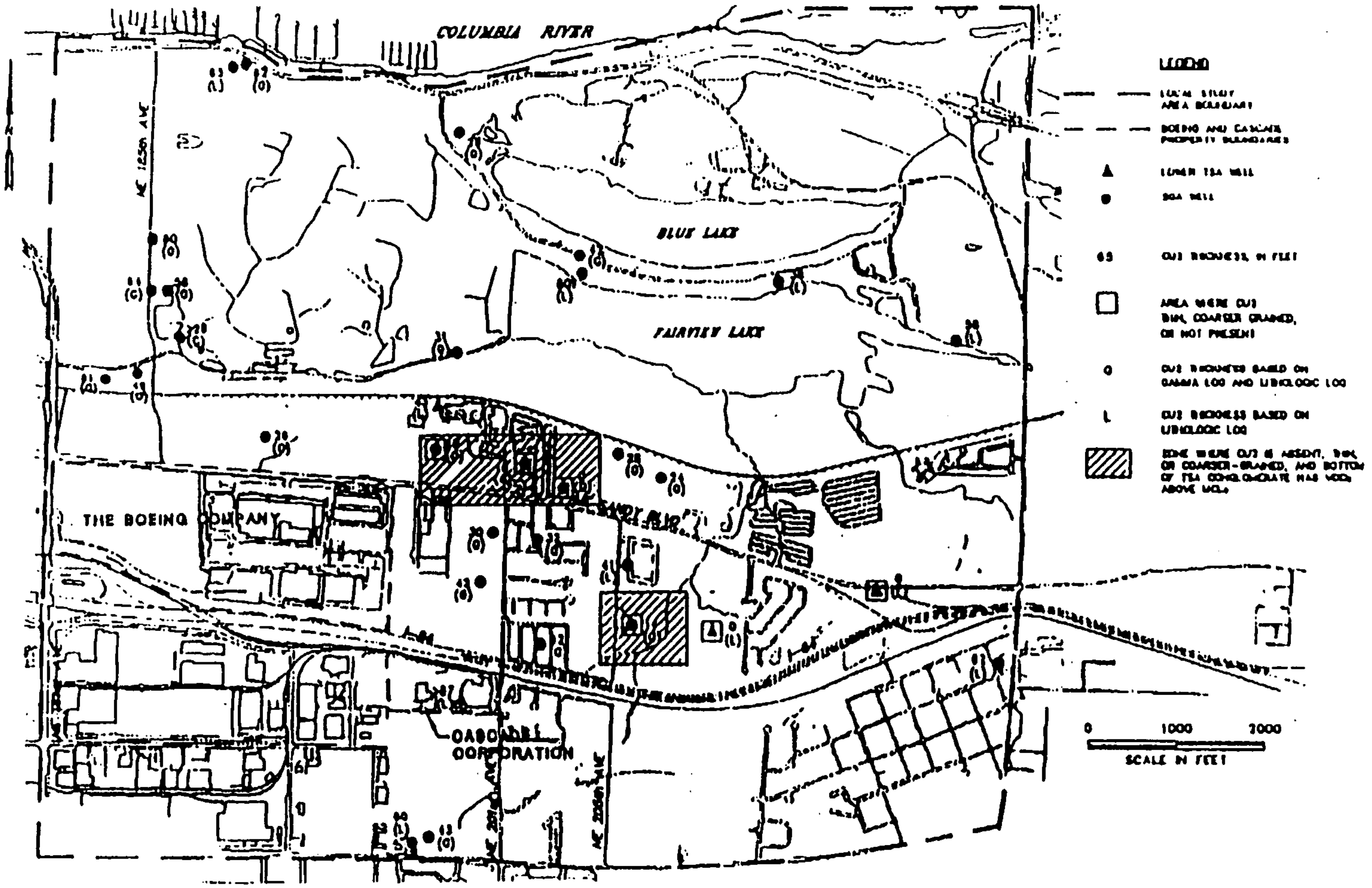
TSA Sandstone Groundwater Elevations and Flow Directions
November 28-29, 1994 - Nonpumping Conditions

Figure 3-6



TSA Conglomerate Groundwater Elevations and Flow Directions
November 28-29, 1994 - Nonpumping Conditions (Except for RPW-2)

Figure 3-7



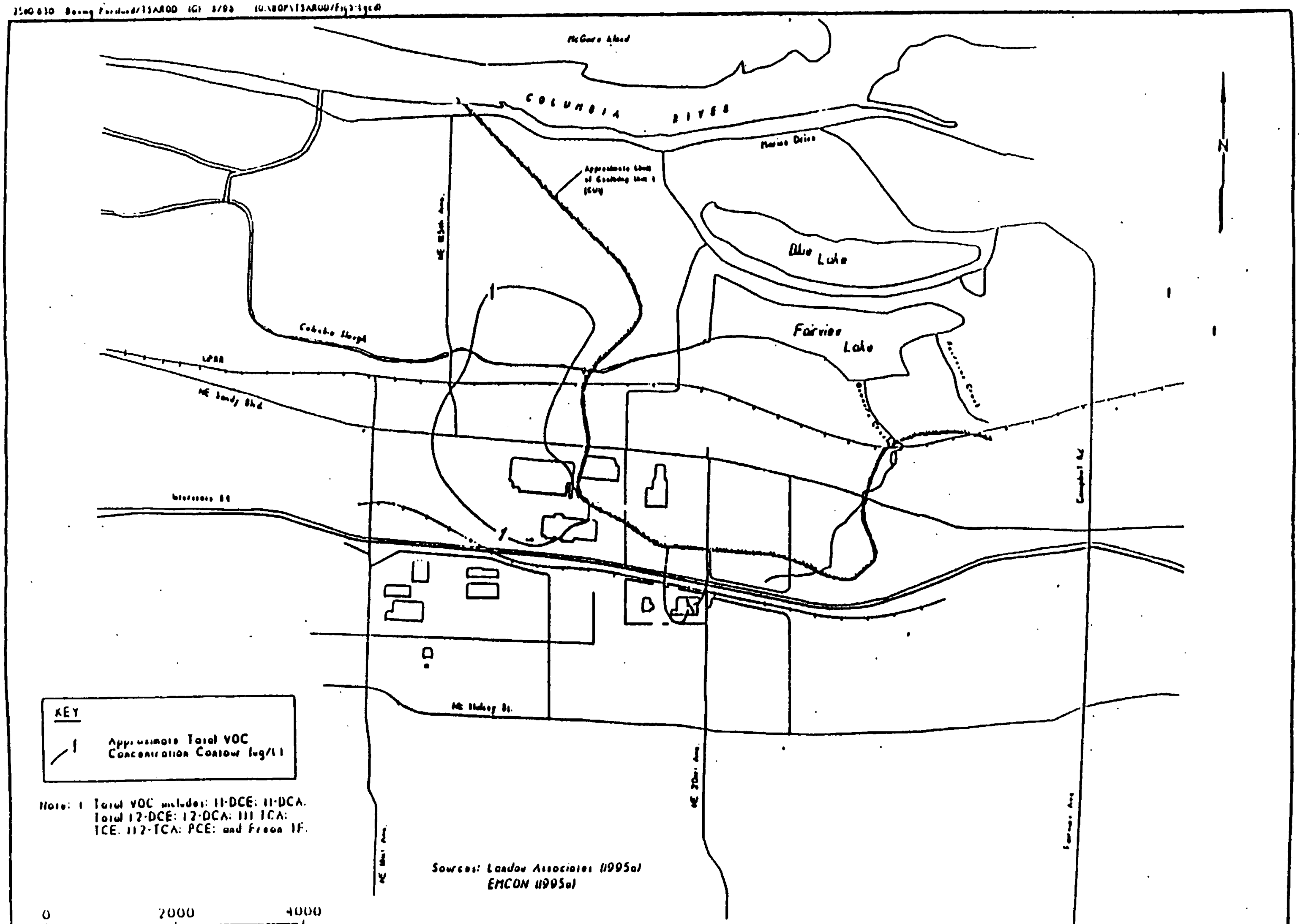
EMCON

DATE 2/96
DWN. MK
APPR.
REVIS.
PROJECT NO.
40683008.006

Figure 3-8

CU2 THICKNESS AND EXTENT

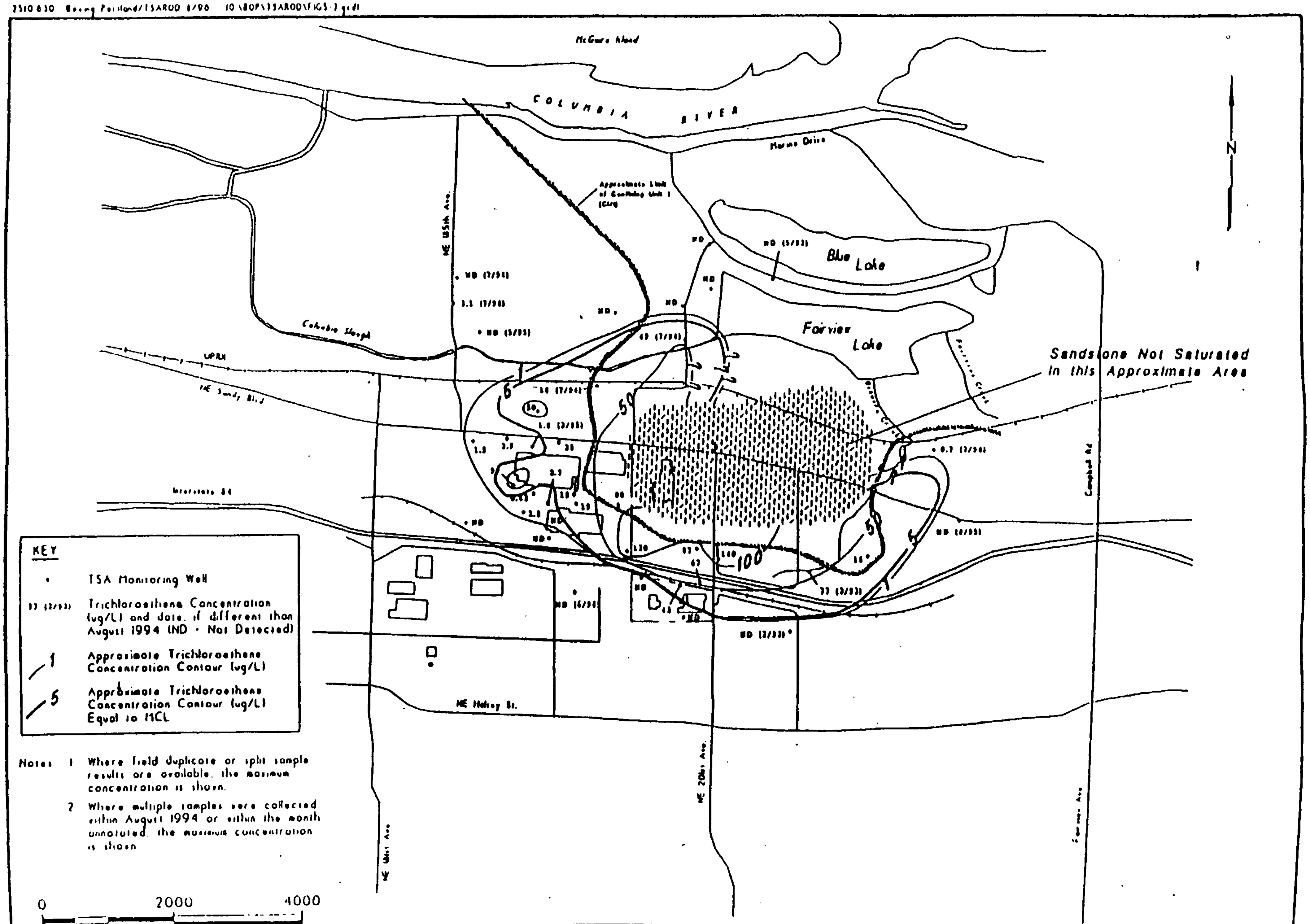
C:\DWG\0683\008\8CU2-5 6/13/96 mk PLOT 1=2000



Total VOC Concentrations in the TGA: Summer 1994

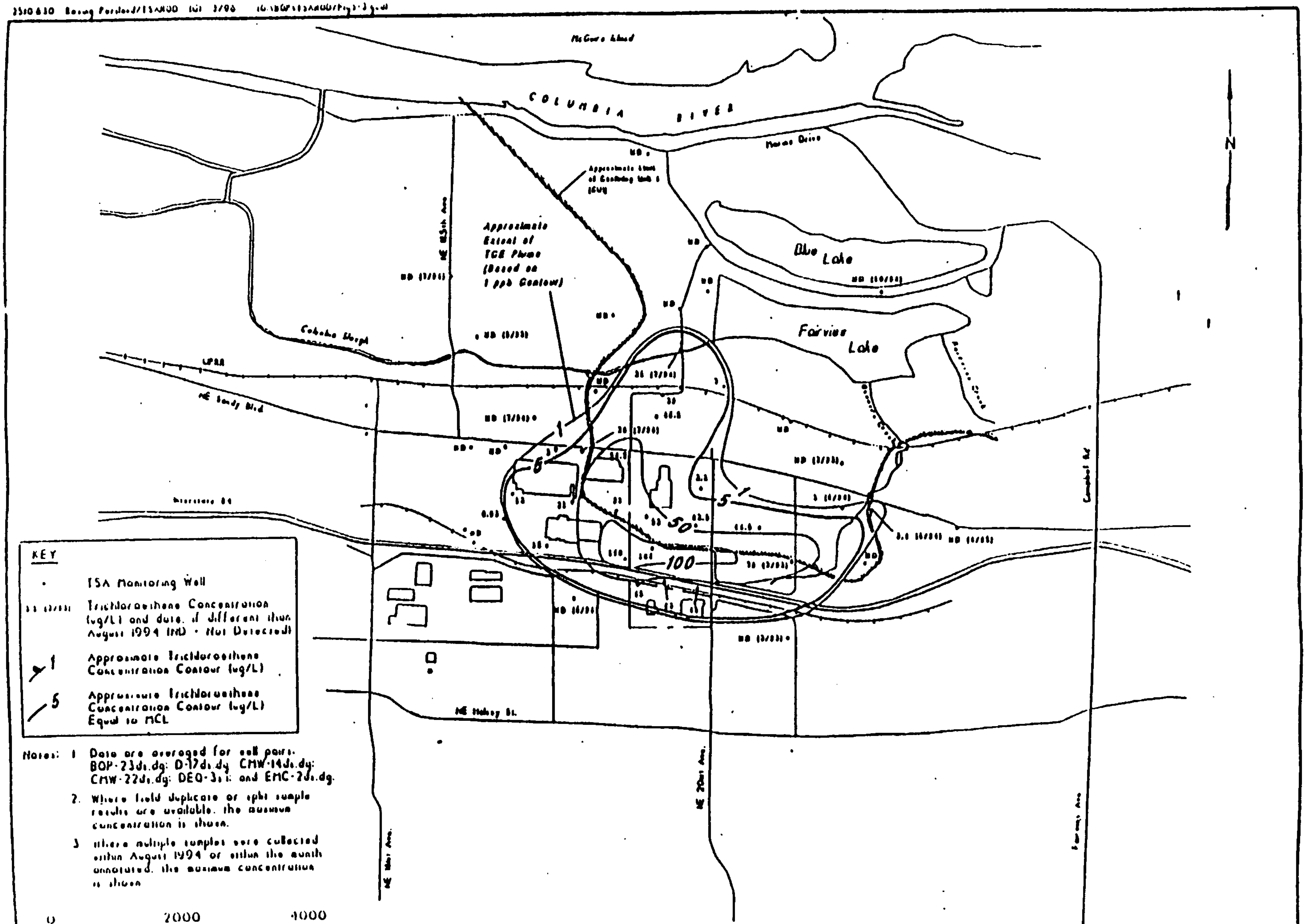
Figure 5-1

2510 630 Boeing Portland/TSAROD 8/96 10 \BOP\TSAROD\FIGS-2



Approximate Extent of TCE In TSA Sandstone: August 1994

Figure 5-2



Approximate Extent of TCE in the TSA Conglomerate: August 1994

Figure 5-3

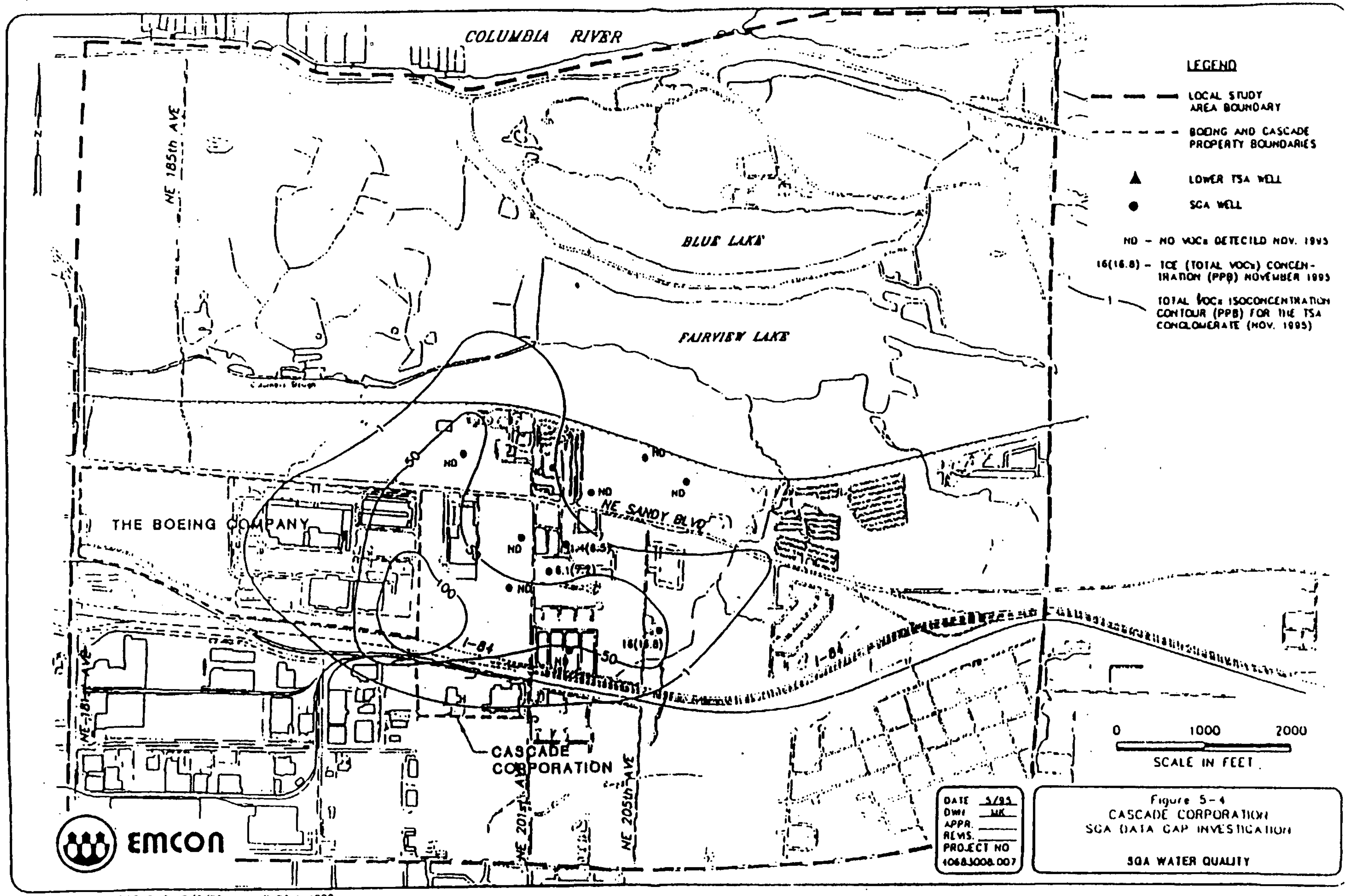
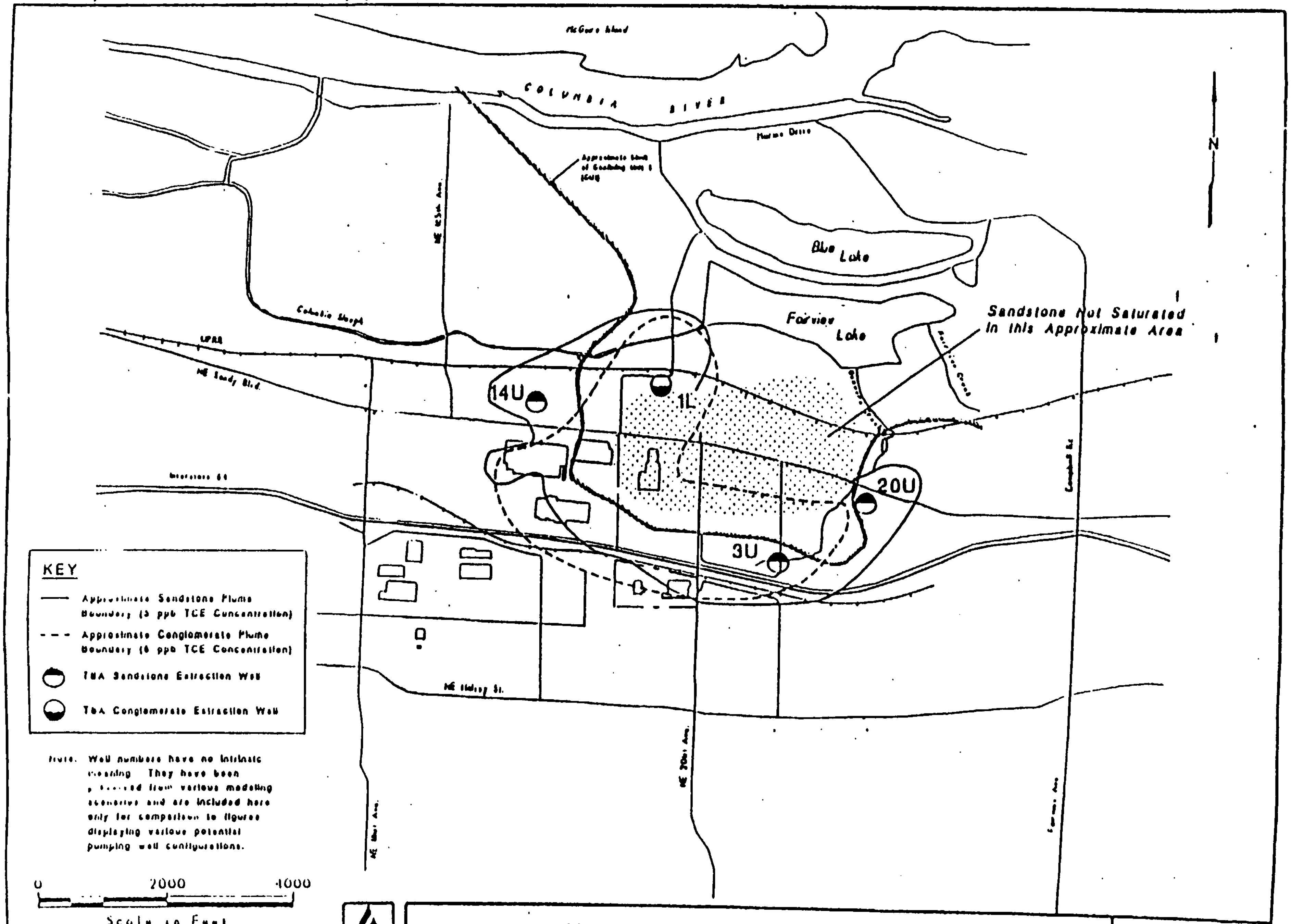


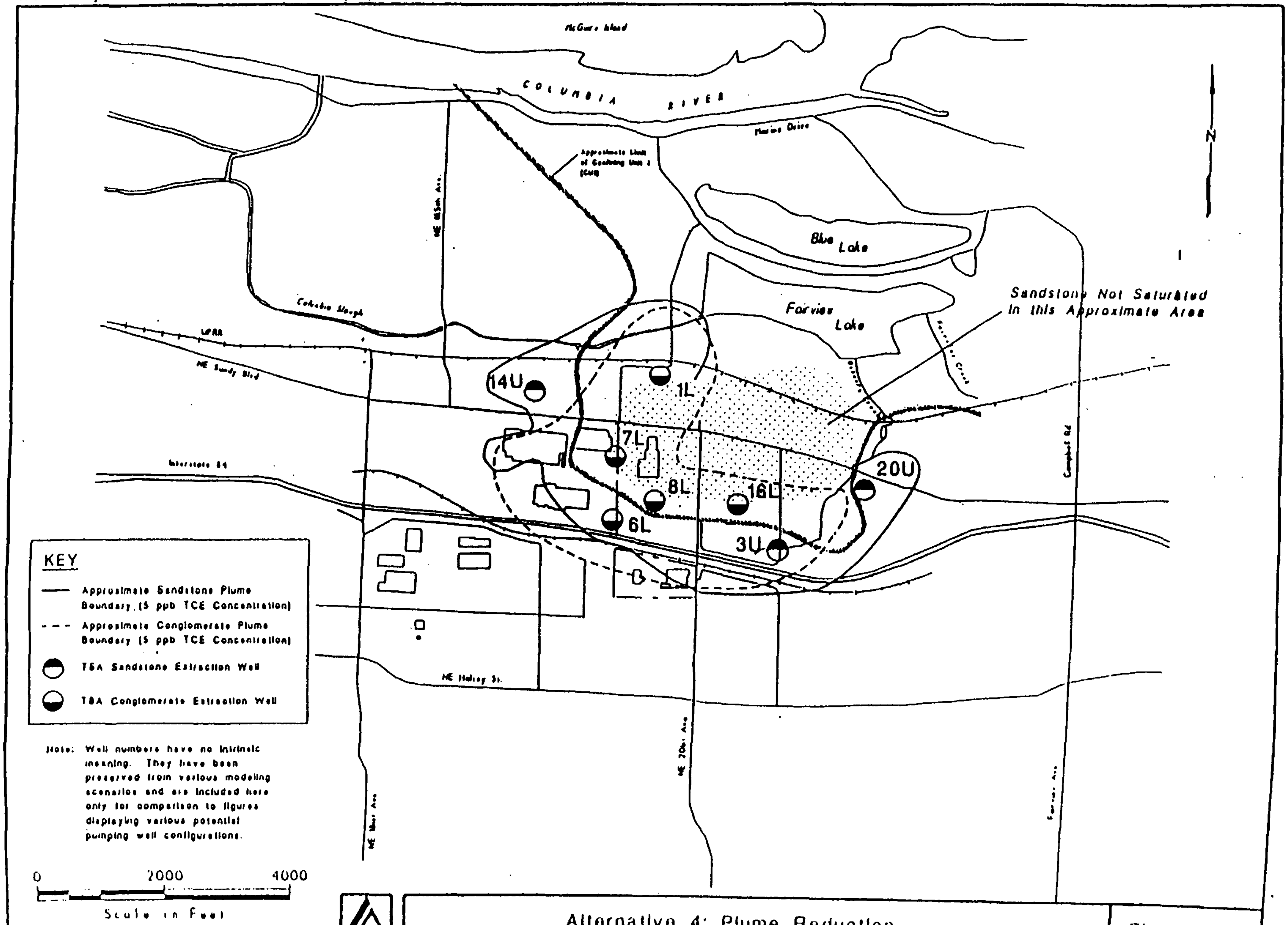
Figure 5-4
CASCADE CORPORATION
SGA DATA GAP INVESTIGATION
SGA WATER QUALITY

C.\DWG\0683\008\8CU2-3 8/7/96 MK PLOT 1=1000



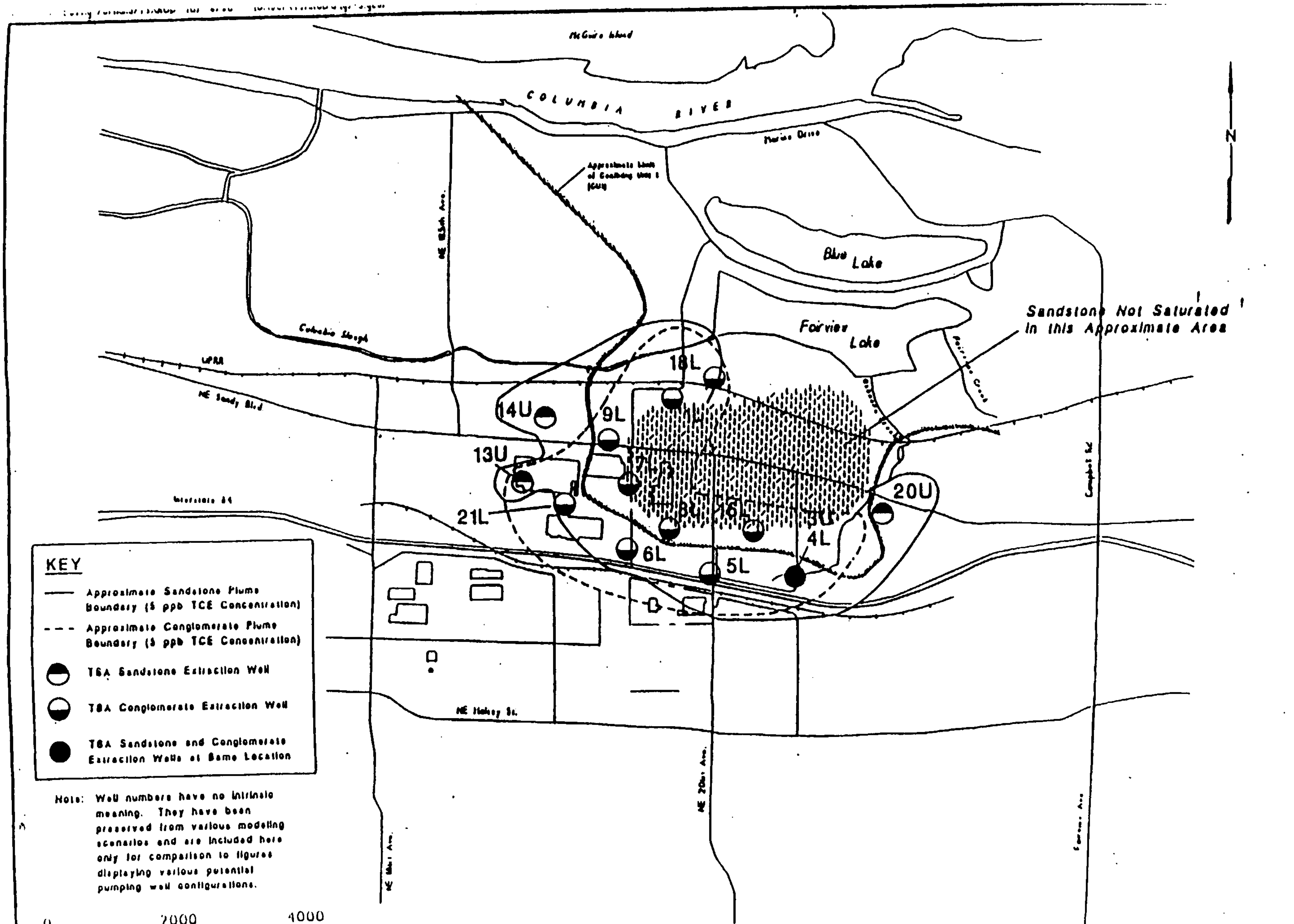
Alternative 3: Hydraulic Control

Figure 7-1



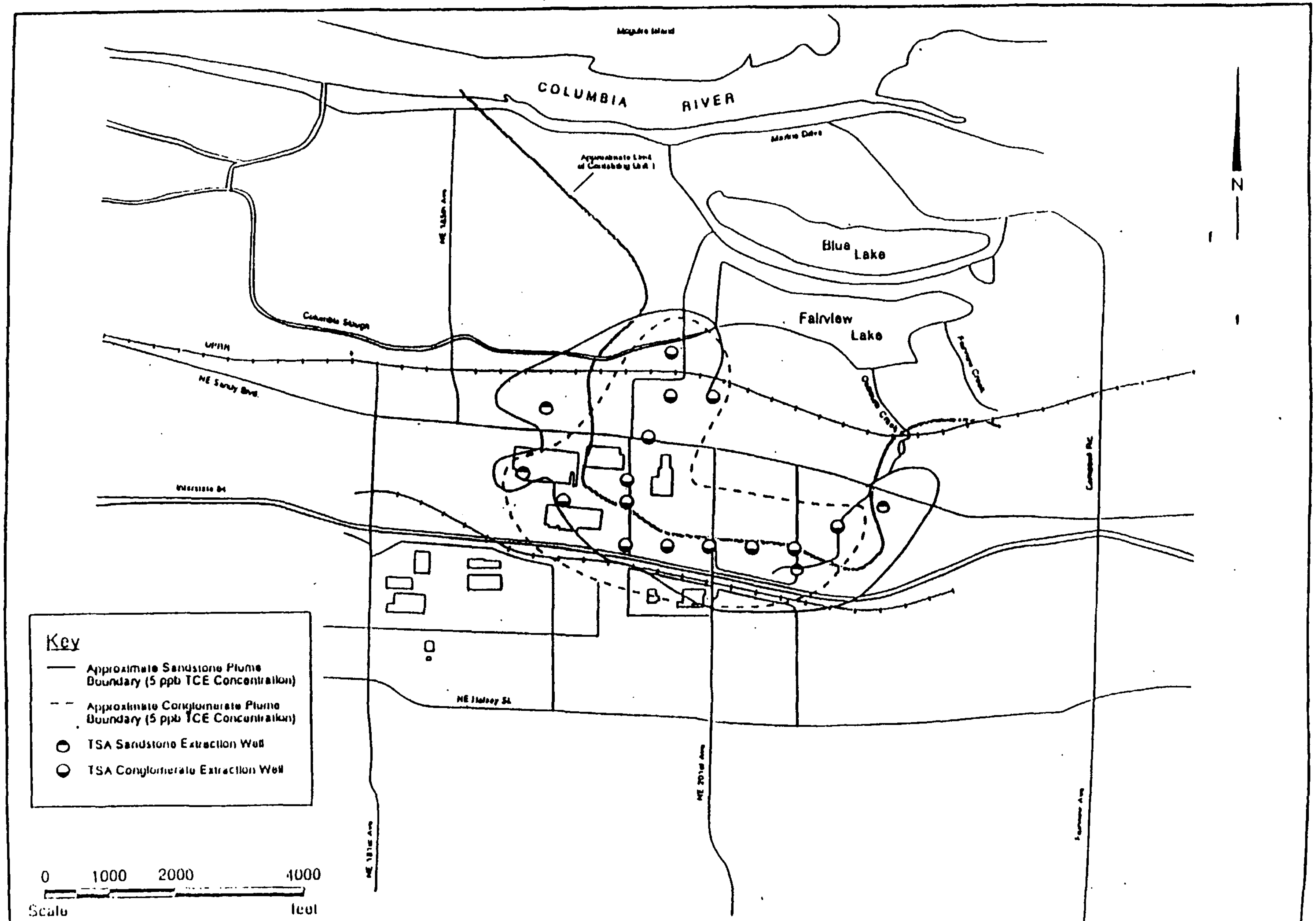
Alternative 4: Plume Reduction

Figure 7-2



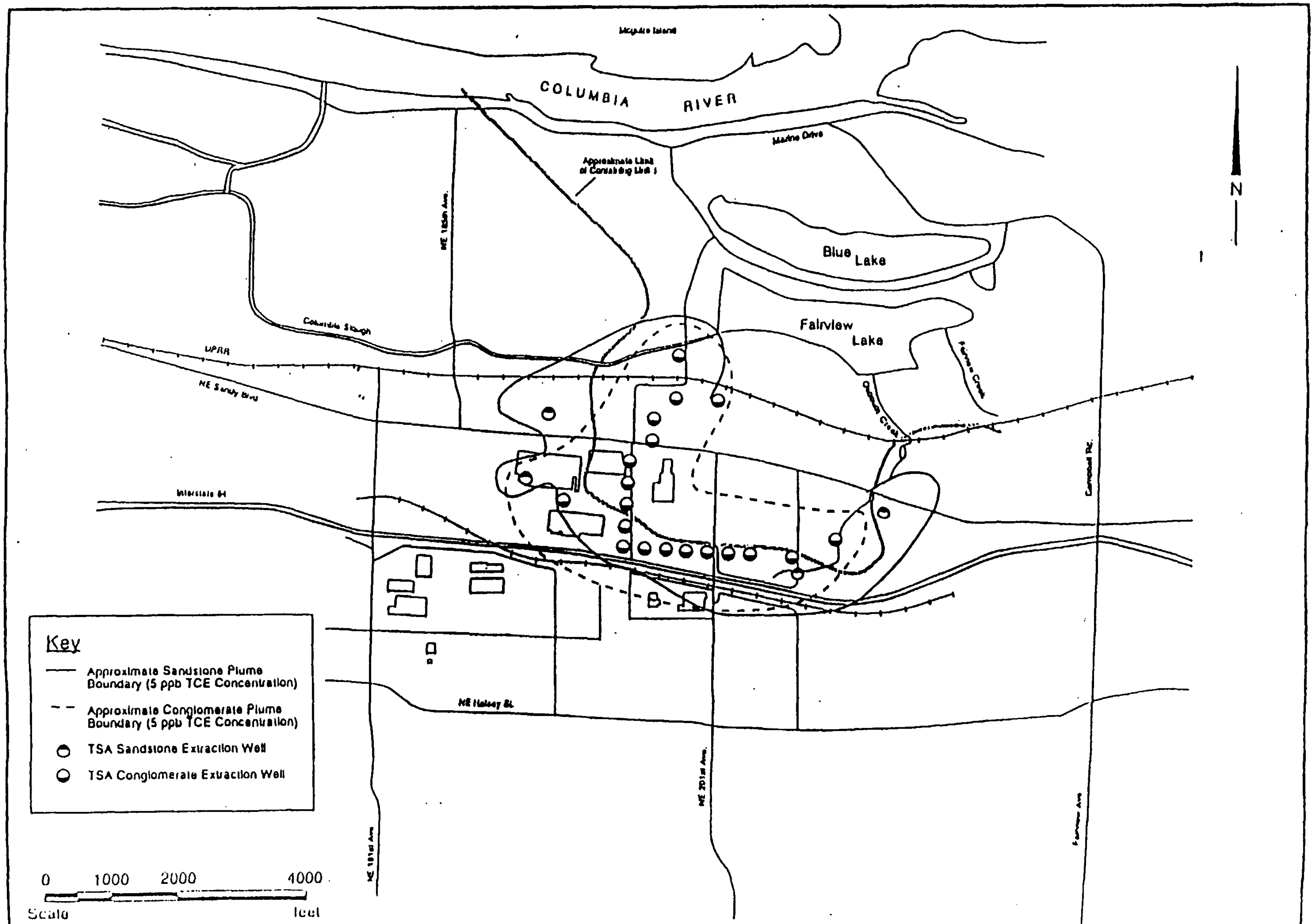
Alternative 5: Aquifer Restoration

Figure 7-3



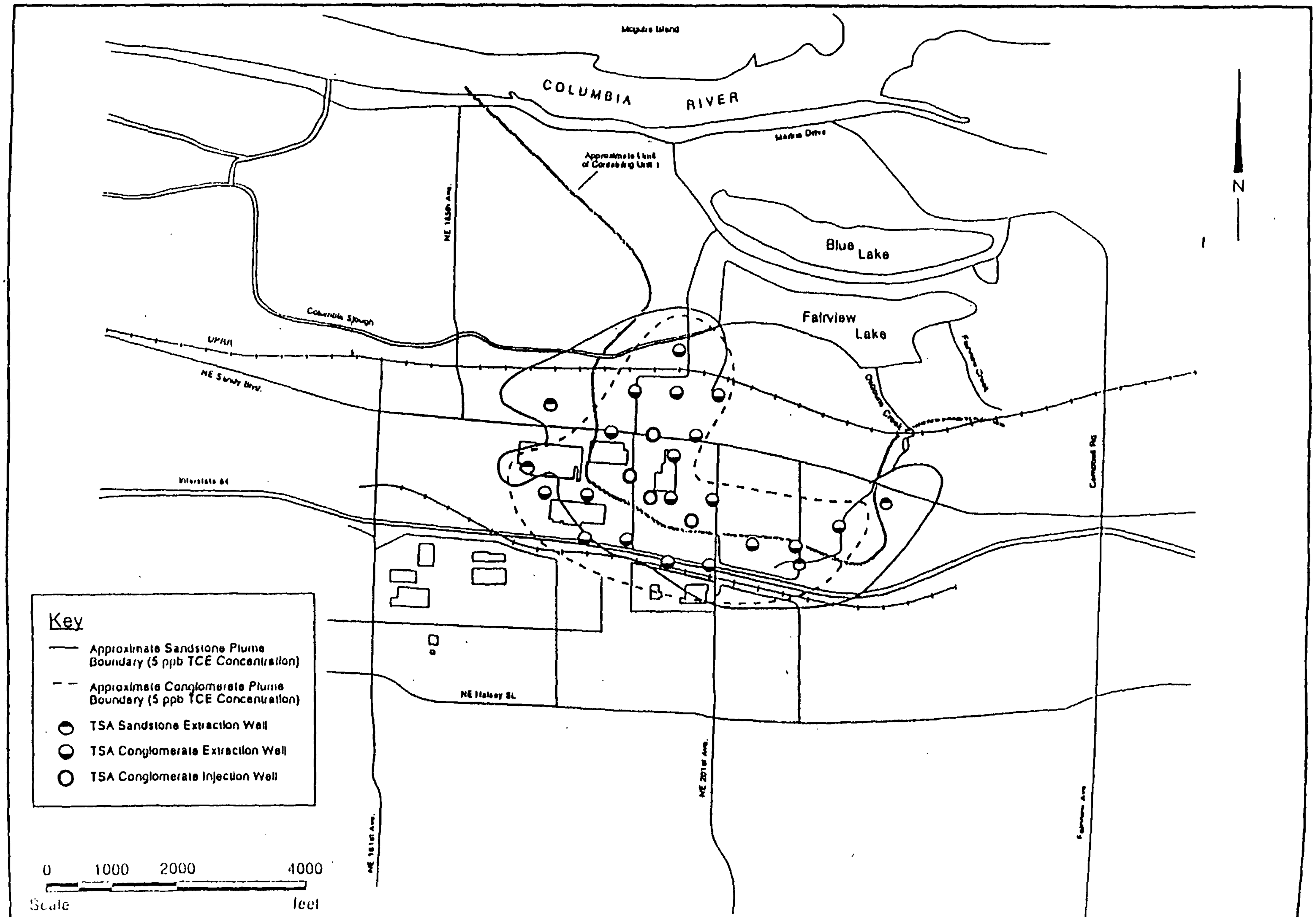
Alternatives 5A and 5B

Figure 7-4



Alternative 5C

Figure 7-5

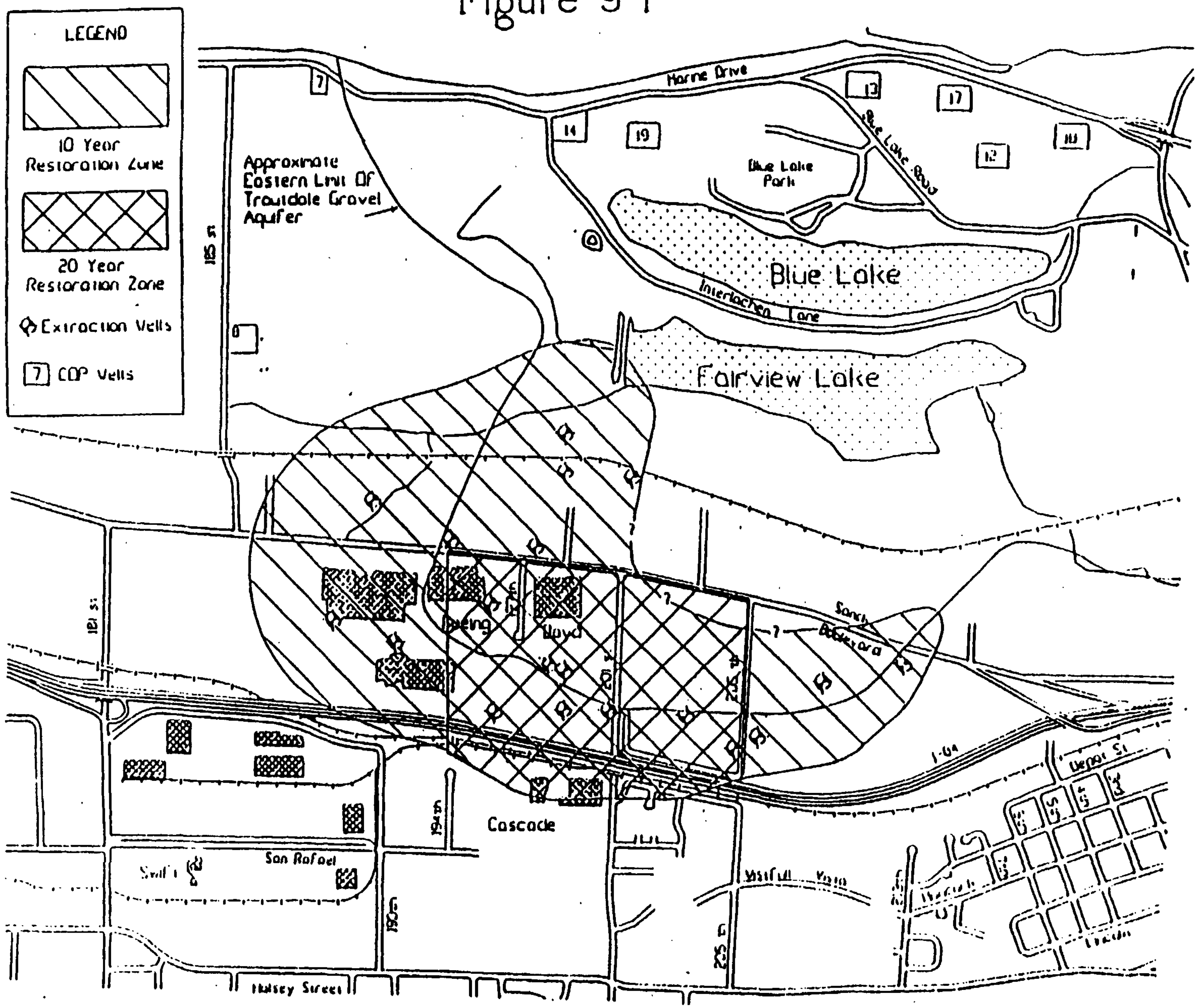


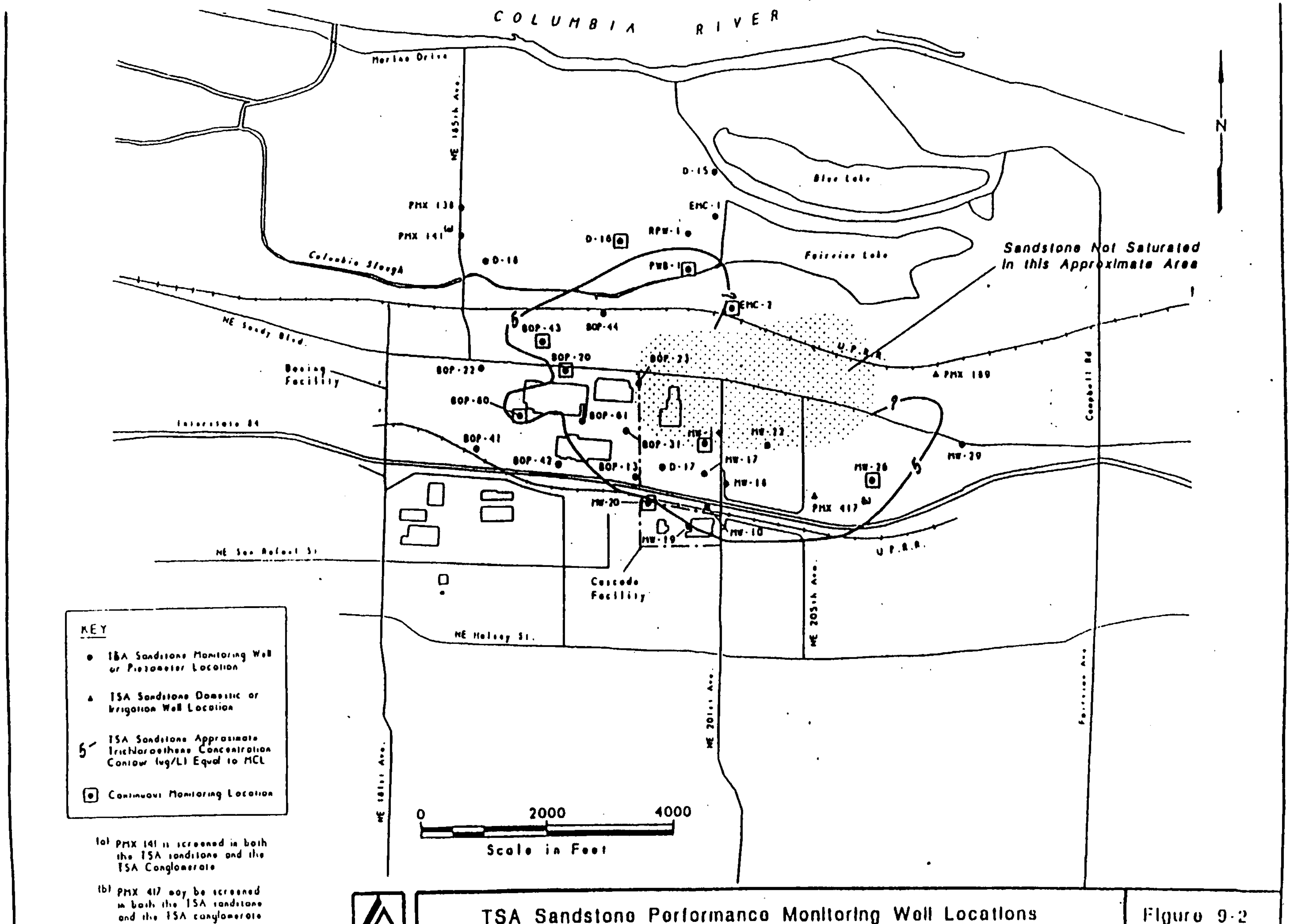
Alternative 6

Figure 7-6

Alternative 5: Potential Extraction Well Locations

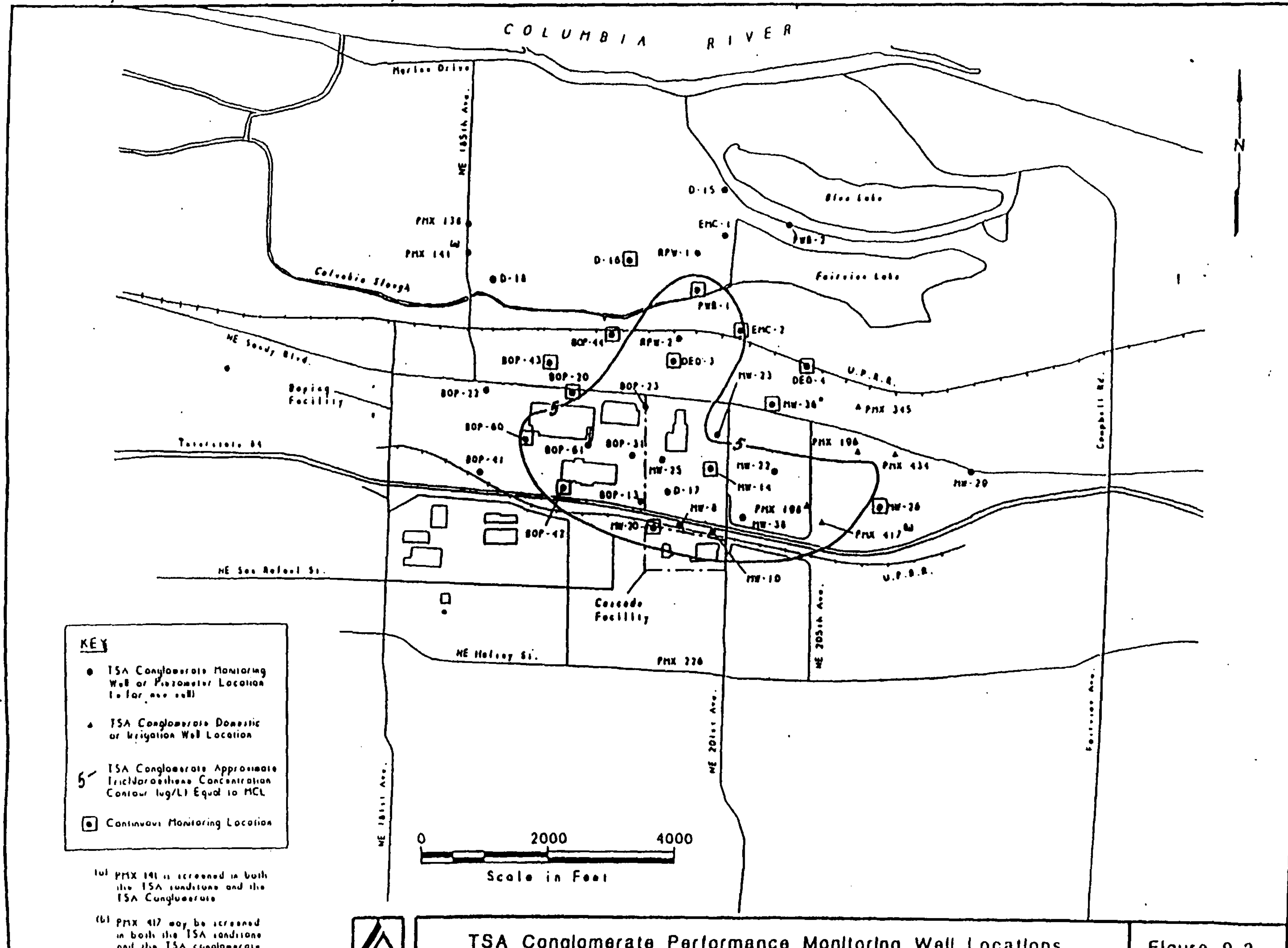
Figure 9-1





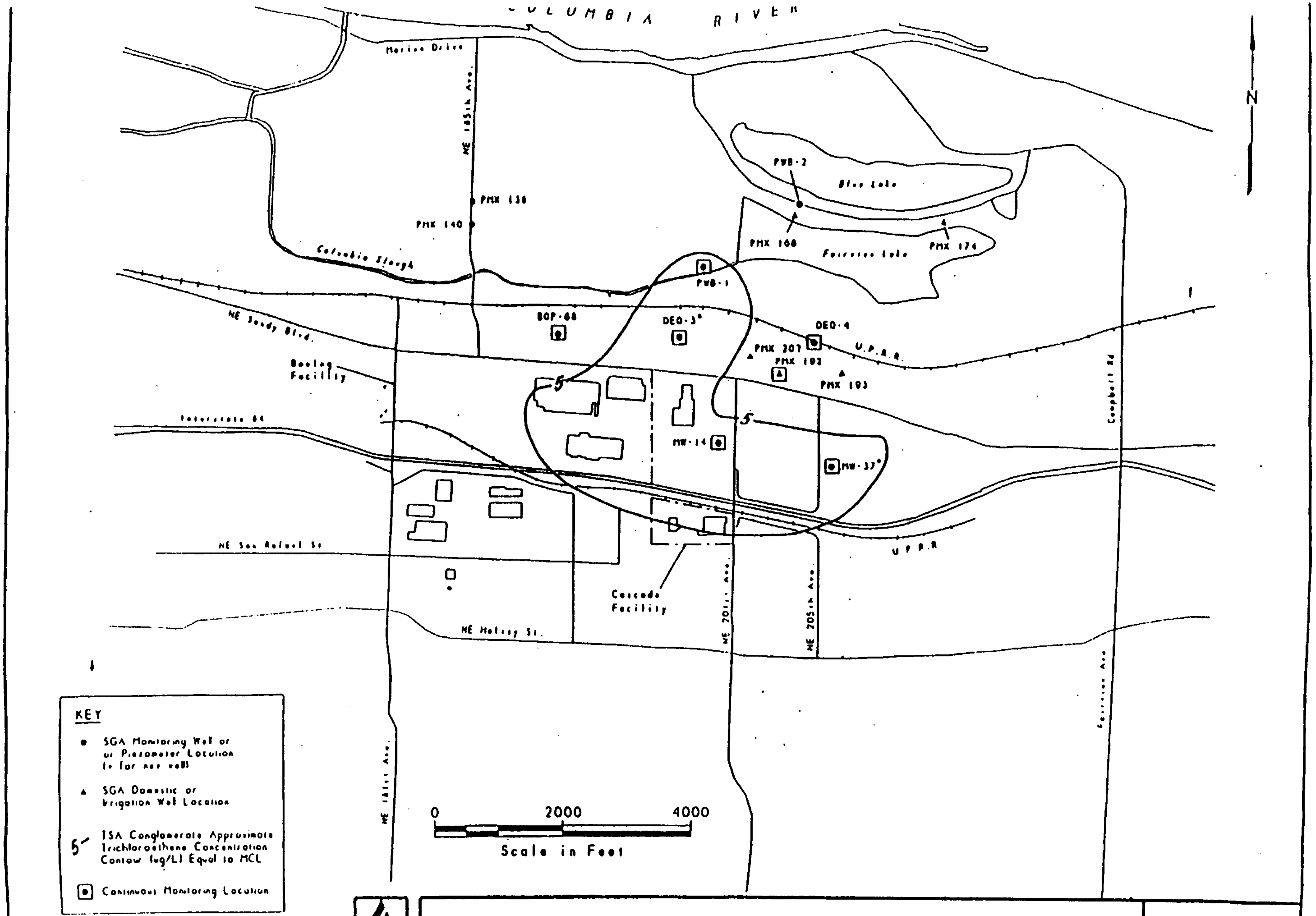
TSA Sandstone Performance Monitoring Well Locations

Figure 9-2



TSA Conglomerate Performance Monitoring Well Locations

Figure 9-3



SGA Performance Monitoring Well Locations

Figure 9-4

Appendix A
East Multnomah County Area Groundwater Contamination Site
ADMINISTRATIVE RECORD INDEX

1.0 SITE IDENTIFICATION

1.1 DEQ. *Preliminary Assessment.* Cascade Corporation Facility. DEQ Environmental Cleanup Division. February 3, 1989. (DEQ Site I.D. No. 635; CERCLIS No. ORD 009031378)

1.2 DEQ. *Preliminary Assessment.* Swift Adhesives. DEQ Environmental Cleanup Division. March 10, 1989. (DEQ Site I.D. No. 884; CERCLIS No. ORD 990751828)

1.3 DEQ. *Preliminary Assessment.* Boyd Coffee Facility. DEQ Environmental Cleanup Division. March 1989. (DEQ Site I.D. No 967; CERCLIS No ORD 009052218)

1.4 DEQ. *Preliminary Assessment.* Viking Industries Inc. DEQ Environmental Cleanup Division. March 6, 1989. (DEQ Site I.D. No. 885; CERCLIS No. ORD 009620113)

1.5 DEQ. *Preliminary Assessment.* Norwest Publishing Co.. DEQ Environmental Cleanup Division. August 1989. (DEQ Site I.D. No. 962; CERCLIS No. ORD 044108603)

1.6 DEQ. *Preliminary Assessment.* Dirt & Aggregate Interchange. DEQ Environmental Cleanup Division. March 6, 1989. (DEQ Site I.D. No. 874; CERCLIS No. ORD 060582236) 1989.

1.7 E&E 1991a. Final Report for East Multnomah County Vadose Zone Gas Survey, Portland, Oregon. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, Washington, by Ecology and Environment, Inc., Seattle, Washington. October.

1.8 E&E 1991b. East Multnomah County Groundwater Study, Gresham, Oregon. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, Washington, by Ecology & Environment, Inc., Seattle, Washington. October.

1.9 EPA 1992. *Preliminary Assessment & Site Investigation.* Libby, McNeil & Libby. (DEQ Site I.D. No. 1259; CERCLIS No. ORD 042484188)

1.10 DEQ. *Preliminary Assessment.* NW Retreaders. DEQ Environmental Cleanup Division. August 1993. (DEQ Site I.D. No. 1268; CERCLIS No. ORD 987197415).

1.11 EMS 1992. Level I Environmental Site Assessment of the Multnomah County Park Services Building located in Blue Lake Park, Gresham, Oregon. Prepared by Environmental Management Solutions for Multnomah County Parks Services Division. May 22.

1.12 TAG 1991. Phase I/Phase II Environmental Property Evaluation, Opti-Craft Facility; Prepared for Optical Radiation Corp. by Technical Action Group, Inc.; September 3.

2.0 REMOVAL RESPONSE

Boeing Portland

2.1 Landau Associates, Inc. Final Report - Initial Corrective Action Study, Boeing Portland (as Revised). December 15, 1988.

2.2 Landau Associates, Inc. 1990 Work Plan Rockwood Well Abandonment, Boeing Portland, Gresham, Oregon. July 17, 1990

2.3 Landau Associates, Inc. 1990 Final Report, Rockwood Well Abandonment, Rockwood Water District, Boeing Portland, Gresham, Oregon. November 16, 1990.

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2.5 Landau Associates, Inc. 1994. *Report, Status of Interim Measures*, Boeing, Portland. March 4.

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Cascade Corporation

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2.11 CWE 1991. Industrial Well Abandonment Report, Cascade Corporation, Troutdale, Oregon. Prepared for Cascade Corporation by Century West Engineering Corp., Portland, Oregon. November 8.

2.12 EMCON 1992. Interim Removal Action Measures Implementation Workplan, Cascade Corporation, Workplan Amendment. Prepared for Cascade Corporation by EMCON Northwest, Inc., Portland, Oregon March 23.

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2.14 EMCON 1995. Pilot Test for Troutdale Gravel Aquifer Control. Prepared for Cascade Corporation by EMCON Northwest, Inc., Portland, Oregon. May 23.

2.15 EMCON 1995. Revised Workplan, Expansion of Off-Site TGA Trench Recovery System. Prepared for Cascade Corporation by EMCON Northwest, Inc., Portland, Oregon. August 14

2.16 EMCON. 1996. *Evaluation of TGA/IRAM Control Trench Performance Technical Memorandum*. Prepared for Cascade Corporation. January 16.

Boeing & Cascade Corporation

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3.0 REMEDIAL INVESTIGATION (RI)

Department of Environmental Quality

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3.2 SSP&A. East Multnomah County Data Base and Model: Preliminary Groundwater Flow Model Report. Prepared for the Oregon Department of Environmental Quality by S.S. Papadopulos & Associates, Inc., Bethesda. October 1991.

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Boeing of Portland

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Cascade Corporation

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3.16 CWE. 1989b. Letter (re: results of north receiving ditch excavation and soil analysis, Cascade Corporation facility) to P. Burnet, DEQ Site Response Section, from J. Snell, Century West Engineering Corporation, Portland, Oregon. October 19.

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3.21 Century West. 1991. *Phase 2 Troutdale Gravel Aquifer Plume Characterization Report, Remedial Investigation and Feasibility Study, Cascade Corporation Facility.* August 7.

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<u>**Boeing and Cascade Corporation**</u>

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3.28 EMCON and Landau Associates. 1995. *Sand and Gravel Aquifer Pumping Test Evaluation.* Prepared for Cascade Corporation and The Boeing Company. May 4.

3.29 EMCON and Landau Associates. 1995. *Remedial Investigation/Feasibility Study, Troutdale Sandstone Aquifer. Part 1: Remedial Investigation, Part 2: Endangerment Assessment.* Prepared for Cascade Corporation and The Boeing Company. October 6.

3.30 EMCON. 1996. *Draft TSA-SGA Data Gap Investigation and SGA Interim Removal Measure Report.* Prepared for Cascade Corporation by EMCON, Portland, Oregon. January 31.

4.0 FEASIBILITY STUDY (FS)

<u>Boeing Portland</u>

4.1 Landau Associates, Inc. 1995 Phase I Corrective Measures Study, Boeing Portland Gresham, Oregon. July 17.

4.2 Landau Associates, Inc. 1995 Phase II Corrective Measures Study Work Plan, Boeing Portland Gresham, Oregon. August 14.

<u>Cascade Corporation</u>

4.3 EMCON. 1996b. *Phase 3 Remedial Investigation/Feasibility Study, Troutdale Gravel Aquifer. Part 3: Feasibility Study. Final Report.* Prepared for Cascade Corporation by EMCON, Portland, Oregon. January 15.

<u>Boeing and Cascade Corporation</u>

4.4 EMCON and Landau Associates. 1995. *Remedial Investigation/Feasibility Study, Troutdale Sandstone Aquifer, Feasibility Study Scoping Technical Memorandum.* Prepared for Cascade Corporation and The Boeing Company. August 1.

4.5 EMCON and Landau Associates. 1996. *Troutdale Sandstone Aquifer, Feasibility Study Report.* Prepared for Cascade Corporation and The Boeing Company. March 4.

4.6 EMCON and Landau Associates. *Technical Memorandum - Response Memorandum to DEQ Comments on TSA FS Report.*. Prepared for Cascade Corporation and The Boeing Company. June 17.

Department of Environmental Quality

4.7 SSPA. Memorandum from DEQ contractor Charles Andrews, S.S. Papadopulos & Associates, to Bruce Gilles, DEQ Project Manager. *Additional Remedial Options for TSA*. June 12, 1996

4.8 SSPA. Memorandum from DEQ contractor Charles Andrews, S.S. Papadopulos & Associates, to Bruce Gilles, DEQ Project Manager. *TCE Contamination in TSA - Areal Extent and Mass*. June 18, 1996

4.9 SSPA. Memorandum from DEQ contractor Charles Andrews, S.S. Papadopulos & Associates, to Bruce Gilles, DEQ Project Manager. *TSA ROD*. July 26, 1996

5.0 RECORD OF DECISION (ROD)

5.1 Record of Decision for Swift Adhesives; May 10, 1994. Prepared by Oregon Department of Environmental Quality.

5.2 DEQ *Staff Report DEQ Recommended Remedial Action for the Cascade Corporation Site*. Department of Environmental Quality, Waste Management and Cleanup Division. August 1996.

5.3 DEQ *Staff Report DEQ Recommended Remedial Action for the East Multnomah County Groundwater Contamination Site, Troutdale Sandstone Aquifer*. Department of Environmental Quality, Waste Management and Cleanup Division. August 1996.

5.4 Memorandum to Project File from Bruce Gilles, DEQ Project Manager, dated November 1996; Summarizes two public hearings held on the DEQ Recommended Remedial Action for the Troutdale Sandstone Aquifer and Cascade Corporation (TGA).

5.5 Public Comment Letters on DEQ Recommended Remedial Action:

- Letter from Lorraine McCurdy, owner of Terrand Mobile Terrace, to Bruce Gilles, dated October 11, 1996. Written transcript of verbal testamony given at DEQ Public Hearing on October 10, 1996.

- Letter from Doug Morgan, Portland Utilities Review Board, to Bruce Gilles, DEQ, dated October 14, 1996.

- Letter from Paulette Rossi, member of Portland Utilities Review Board, to Bruce Gilles, DEQ, dated October 24, 1996.

- Letter from Dale Anderson, Chair of Water Managers Advisory Board of Bull Run Water Users, to Bruce Gilles, DEQ, dated October 21, 1996.

- Letter and attached report from Ann Nickel, Executive Director of Columbia Corridor Association, to Bruce Gilles, DEQ, dated October 25, 1996

- Letter and report from Scott A. Wells, Portland State University, to Bruce Gilles, DEQ Project Manager, dated October 28, 1996. Prepared in behalf of Freinds of Blue and Fairview Lake under support of the U.S. EPA Technical Assistance Grant.

- Letter from Taryn McCain, The Boeing Company, to Bruce Gilles, DEQ, dated October 29, 1996.

- Letter from Gayle Killam, Water Program Director for Oregon Environmental Council, to Bruce Gilles, DEQ, dated October 29, 1996.

- Letter and enclosed Resolution No. 35559 from Mike Lindberg, Commissioner City of Portland Office of Public Utilities, to Langdon Marsh, Director Department of Environmental Quality, dated October 29, 1996.

- Letter from Gregory E. DiLoreto, Director City of Gresham Environmental Services, to Bruce Gilles, DEQ, dated October 30, 1996.

- Letter and enclosure from David Blount, Copeland, Landye, Bennett and Wolf, to Bruce Gilles, DEQ, dated October 30, 1996.

6.0 INTERAGENCY COORDINATION

6.1 Memorandum of Agreement between the U.S. Environmental Protection Agency Region 10 and the Oregon Department of Environmental Quality for the East Multnomah County Groundwater Contamination Site. August 1994.

7.0 ENFORCEMENT

7.1 DEQ. Order on Consent between the Oregon Department of Environmental Quality and Cascade Corporation. DEQ No. ECSR-NWR-88-01. July 1988.

7.2 DEQ. Order on Consent between the Oregon Department of Environmental Quality and Cascade Corporation. DEQ No. ECSR-NWR-89-11. August 1989.

7.3 DEQ Order on Consent and Addendums between the Oregon Department of Environmental Quality and Reichhold Chemicals. DEQ No. ECSR-NWR-89-07.

7.4 DEQ. Order on Consent between the Oregon Department of Environmental Quality, the Boeing Company and Cascade Corporation. DEQ No. ECSR-NWR-93-07. July 1993.

7.5 DEQ. Addendum to Order on Consent between the Oregon Department of Environmental Quality, the Boeing Company and Cascade Corporation. DEQ No. ECSR-NWR-93-07. July 1994.

7.6 DEQ. Second Addendum to Order on Consent between the Oregon Department of Environmental Quality, the Boeing Company and Cascade Corporation. DEQ No. ECSR-NWR-93-07. January 1996.

7.7 DEQ. Prospective Purchaser Agreement between the Oregon Department of Environmental Quality and Silent Creek Joint Venture. DEQ No. 95-01. October 31, 1995

8.0 HEALTH ASSESSMENTS

8.1 ATSDR. Public Health Assessment for East Multnomah County Groundwater Contamination, Gresham, Multnomah County, Oregon. CERCLIS No. ORD987185030. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. July 14, 1995.

8.2 ATSDR. Toxicological Profile for 1,1-dichloroethene. Atlanta: U.S. Department of Health and Human Services, Public Health Service, May 1994

8.3 ATSDR. Toxicological Profile for cis-1,2-dichloroethene. Atlanta: U.S. Department of Health and Human Services, Public Health Service, August 1994.

8.4 Toxicological Profile for trichlororoethylene. Atlanta: U.S. Department of Health and Human Services, Public Health Service, August 1995.

8.5 Toxicological Profile for tetrachlororoethylene. Atlanta: U.S. Department of Health and Human Services, Public Health Service, 1992.

9.0 NATURAL RESOURCE TRUSTEE NOTIFICATIONS

9.1 Letter from Bruce Gilles, Oregon DEQ to Mr. Charles Polityka, U.S. Department of Interior Federal Natural Resource Trustee Notification East Multnomah County Groundwater Contamination Site, September 6, 1994.

9.2 Letter from Bruce Gilles, Oregon DEQ to Mr. Chris Mebane, NOAA Coastal Resource Coordinator, Federal Natural Resource Trustee Notification for the East Multnomah County Groundwater Contamination Site, September 6, 1994.