Report
2003 Annual Groundwater Monitoring
Gate J-28/Museum of Flight
Tukwila, Washington

July 24, 2003

Prepared for

The Boeing Company
Seattle, WA

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

This report summarizes the activities and results associated with four quarters of groundwater monitoring beginning in October 2002 and completed in July 2003 at the Museum of Flight (MOF) property formerly identified as Gate J-28 at The Boeing Company (Boeing) Developmental Center, 9725 East Marginal Way South, in Tukwila, Washington (Figure 1). The purpose of this and prior reports is to provide a basis for the Washington State Department of Ecology (Ecology) to determine that no further action (NFA) is necessary at a portion of the Developmental Center that has been donated to the MOF.

The groundwater monitoring was performed in accordance with Boeing's Developmental Center groundwater monitoring plan (Boeing 2001). Samples from three groundwater monitoring wells were collected during each of the four quarterly events. Background information and a description of the site are provided in the remainder of this section. A description of the field activities performed during this investigation is provided in Section 3.0. Section 4.0 presents the results of the groundwater monitoring for the past four quarters. Groundwater quality is evaluated in Section 5.0.

1.1 BACKGROUND

In 2001, GeoEngineers collected soil and groundwater samples from direct-push borings located at Gate J-28 of the Boeing Developmental Center as part of a phase II environmental site assessment for the MOF. No soil samples contained detectable concentrations of diesel-range petroleum hydrocarbons. Oil-range petroleum hydrocarbons were detected in only one soil sample from this area. The soil sample collected from boring B-9 at a depth of 12 ft contained 490 mg/kg oil-range petroleum hydrocarbons. Diesel-range petroleum hydrocarbons were measured at a concentration of 6.9 mg/L in a groundwater sample collected from boring B-10 (GeoEngineers 2001). No sources for this material have been identified.

Subsequently, a groundwater quality investigation including installation and sampling of two groundwater monitoring wells near the 9-04 building, DC-MW-7 and DC-MW-8, was conducted. The results from the initial sampling of these wells were summarized in a report submitted to Ecology (Landau Associates 2001a). Based on the results of this investigation, Ecology determined that the total petroleum hydrocarbons (TPH) in the soil no longer pose a threat to human health or the environment. In a letter to Boeing, Ecology issued a determination of NFA for the soil, but required additional groundwater monitoring (Ecology 2001). The groundwater monitoring requirements included installation of an additional well, DC-MW-9, at the location of former soil boring B-10 and quarterly groundwater monitoring for TPH for a minimum of 1 year at this well and wells DC-MW-7 and DC-MW-8. Monitoring well DC-MW-9 was installed in July 2001. The well installation and results from the initial

sampling of this well were documented in a report submitted to Ecology (Landau Associates 2001b). A report documenting groundwater monitoring for four quarters (beginning in June 2001) at all three wells (DC-MW-7, DC-MW-8, and DC-MW-9) was submitted to Ecology in May 2002 (Landau Associates 2002). After review of the report, Ecology required an additional year of quarterly monitoring (Boeing 2002). This report presents results for the additional four quarters of monitoring required by Ecology. Groundwater data from the initial four quarters is also presented to provide additional basis for a NFA determination at this former portion of the Developmental Center.

2.0 FIELD INVESTIGATION ACTIVITIES

This section describes water level measurements, groundwater sampling, and groundwater analyses conducted on a quarterly basis at wells DC-MW-7, DC-MW-8, and DC-MW-9. Quarterly events for the additional year of groundwater monitoring occurred in October 2002, January 2003, April 2003, and July 2003, respectively. Field activities were conducted in accordance with Boeing's Developmental Center groundwater monitoring plan (Boeing 2001) and the monitoring well installation work plan (Landau Associates 2001c). Monitoring well locations are shown on Figure 2.

2.1 WATER LEVEL MEASUREMENTS

Static water levels in the three wells (DC-MW-7, DC-MW-8, and DC-MW-9) were measured during each quarterly monitoring event prior to well purging and sampling. The static water level in nearby well DC-MW-2 (shown on Figure 2) was also measured during the April and June 2003 quarterly monitoring events. At each well, the depth to groundwater was measured to the nearest 0.01 ft using a battery-operated water level indicator. Elevations at the top of PVC casing were surveyed by Boeing at monitoring wells DC-MW-7 and DC-MW-8 and by Landau Associates at DC-MW-9 for use in converting depth of groundwater measurements to groundwater elevations. Well elevations were surveyed to the nearest 0.01 ft.

2.2 GROUNDWATER SAMPLING

Four quarterly groundwater sampling events were conducted (October 14, 2002; January 6, 2003; April 1, 2003; and June 30, 2003). Prior to sample collection, each well was purged until the pH, conductivity, and dissolved oxygen parameters had stabilized. Purging and sample collection were conducted using dedicated bladder pumps installed by Boeing and low-flow sampling techniques, as described in Boeing's groundwater monitoring plan.

The samples were collected in appropriate containers, labeled, logged on a chain-of-custody (COC) document, and kept on ice until delivered to the laboratory. Sample containers, preservatives, and holding times were appropriate for the types of samples collected and the specified analytical methods.

2.3 GROUNDWATER ANALYSIS

The groundwater samples were submitted to Analytical Resources, Inc. (ARI) laboratory located in Tukwila, Washington. During each quarterly monitoring event, the samples were analyzed for

gasoline-range petroleum hydrocarbons using the NWTPH-Gx method; and diesel-range and motor oil-range petroleum hydrocarbons using the NWTPH-Dx method.

3.0 GROUNDWATER MONITORING RESULTS

This section presents the results for water level measurements and analytical testing performed during the past four quarterly monitoring events.

3.1 GROUNDWATER ELEVATIONS AND FLOW DIRECTION

Groundwater elevation results from groundwater monitoring were used to evaluate groundwater flow direction. Groundwater elevation contours were plotted using data from wells DC-MW-7, DC-MW-8, DC-MW-9, and DC-MW-2 for the April 2003 and June 2003 monitoring events. The contours are shown on Figures 3 and 4, respectively. As shown on these figures, the groundwater continues to have a southwesterly flow direction in this portion of the MOF property.

3.2 GROUNDWATER ANALYTICAL RESULTS

This section presents the groundwater analytical results for the past four quarterly monitoring events. These results are summarized in tabular format in Table 1. Petroleum hydrocarbon and benzene, toluene, ethylbenzene, and xylenes (BTEX) results for previous sampling events are also included in Table 1. A data quality evaluation of analytical data for each of the past four quarterly sampling events was performed by Landau Associates. The evaluation was performed in accordance with the procedures and requirements specified in Section 3.0 of Landau Associates' work plan (Landau Associates 2001c). Based on the data quality evaluation, no data were qualified or rejected, and the data were determined acceptable for use.

3.2.1 MONITORING WELL DC-MW-7

Gasoline-range petroleum hydrocarbons were detected in groundwater from well DC-MW-7 during only one of the four sampling events (October 2002). Gasoline-range petroleum hydrocarbons have only been detected one other time at this well, in March 2001. Both detected concentrations (0.27 mg/L and 0.44 mg/L, respectively) were less than the MTCA Method A cleanup level (0.8 mg/L) for gasoline-range organics in groundwater.

Gasoline-related compounds were not analyzed for during the past four sampling events, but were analyzed for during earlier sampling events. Ethylbenzene and m,p-xylene were detected at well DC-MW-7 during the initial April 2001 and the fourth quarterly monitoring events. Ethylbenzene was detected at concentrations of 1.7 µg/L and 11 µg/L, which are significantly below the MTCA Method A cleanup level for groundwater (700 µg/L) and MTCA Method B cleanup level protective of surface water

(6,910 µg/L). m,p-Xylene was detected at concentrations of 1.9 µg/L and 3.1 µg/L, which are also significantly below the MTCA Method A cleanup level for groundwater (1,000 µg/L).

Diesel-range petroleum hydrocarbons were detected at well DC-MW-7 during three of the past four sampling events. One of the detected concentrations (0.36 mg/L) is less than the MTCA Method A cleanup level of 0.5 mg/L. Two of the detected concentrations (0.53 mg/L and 0.54 mg/L) slightly exceed the MTCA Method A cleanup level of 0.5 mg/L. During earlier sampling events, diesel-range petroleum hydrocarbons had only been detected one other time at this well at a concentration less than the MTCA Method A cleanup level. The overall concentration range of detected diesel-range petroleum hydrocarbons at well DC-MW-7, based on the results for nine sampling events, is 0.26 to 0.54 mg/L.

Diesel-related compounds were analyzed for at well DC-MW-7 during the April 2001 monitoring event. Napthalene, 1-methylnapthalene, and acenaphthylene were detected at concentrations of 1.0 µg/L, 1.0 µg /L, and 0.12 µg /L, respectively. These concentrations are significantly below MTCA Method A cleanup levels for groundwater and MTCA Method B cleanup levels protective of surface water.

3.2.2 MONITORING WELL DC-MW-8

Diesel-range petroleum hydrocarbons are present in groundwater samples from well DC-MW-8 at levels slightly above the MTCA Method A cleanup level of 0.5 mg/L for diesel-range organics. Concentrations for diesel-range petroleum hydrocarbons at this well during the past year ranged from 0.36 to 0.69 mg/L, which are similar to the concentration range (0.50 to 0.68 mg/L) observed during the previous five sampling events. Diesel-related compounds [e.g., polycyclic aromatic hydrocarbons (PAHs)] were analyzed for at this well during the April 2001 monitoring event. No PAHs were detected.

No motor oil-range petroleum hydrocarbons, gasoline-range petroleum hydrocarbons, or gasoline-related compounds have been detected at well DC-MW-8 during the past nine sampling events.

3.2.3 MONITORING WELL DC-MW-9

Diesel-range petroleum hydrocarbons and gasoline-range petroleum were detected at well DC-MW-9 during each of the past four quarterly monitoring events at concentrations similar to concentrations detected at well DC-MW-9 during previous groundwater sampling events. Gasoline-range petroleum hydrocarbon concentrations ranged from 2.6 to 3.6 mg/L during the past year as compared to a concentration range of 1.8 to 3.5 mg/L observed during the previous year. Diesel-range petroleum hydrocarbon concentrations ranged from 1.8 to 3.1 mg/L during the past year as compared to a concentration range of 1.1 to 4.1 mg/L observed during the previous year. These gasoline-range and

diesel-range petroleum hydrocarbon concentrations exceed the MTCA Method A cleanup levels of 0.8 mg/L and 0.5 mg/L, respectively.

Gasoline-related compounds (e.g., BETX) were analyzed for during the previous year at this well. None of the concentrations exceeded the MTCA Method A cleanup levels for groundwater or the MTCA Method B cleanup levels protective of surface water.

4.0 EVALUATION

As shown on Figures 3 and 4 , the groundwater flow direction in the vicinity of wells DC-MW-7, DC-MW-8, and DC-MW-9 is to the southwest. Consequently, well DC-MW-9 is upgradient of well DC-MW-7. Well DC-MW-8 is crossgradient from the other two wells. The analytical results for well DC-MW-9 indicate that concentrations of both gasoline-range and diesel-range petroleum hydrocarbons are present above regulatory criteria. The analytical results at DC-MW-7 show that the concentrations rapidly decrease to concentrations below the regulatory criteria (or below the laboratory reporting limit) in the downgradient direction.

Gasoline-range petroleum hydrocarbons have never been detected at well DC-MW-8 and, although diesel-range petroleum hydrocarbons have been detected at this well, these concentrations have been only slightly above regulatory criteria. No well exists immediately downgradient of well DC-MW-8; however, based on the results for wells DC-MW-7 and DC-MW-9, it is likely that the diesel-range hydrocarbon concentrations at well DC-MW-8 decrease to concentrations below the regulatory criteria within a short distance downgradient of the well.

Because wells DC-MW-8 and DC-MW-9 are located at the upgradient edge of the property (Figures 3 and 4) and because diesel-range petroleum hydrocarbons were not in the soil sample collected from previous boring B10 (located near well DC-MW-9), the source of contaminants detected in groundwater at the upgradient edge of the property appears to be located off property.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the evaluation of the analytical results presented above, the source of the petroleum hydrocarbons and associated constituents appears to be upgradient of this portion of this property. In addition, the extent of petroleum hydrocarbon contamination at levels above regulatory criteria is very limited. These conclusions are adequately demonstrated by the initial and eight quarterly monitoring events with similar results during each event. For these reasons, we recommend no further groundwater monitoring at these wells and no other remedial actions at the property.

6.0 USE OF THIS REPORT

This report has been prepared for the exclusive use of The Boeing Company for specific application to the Gate J-28/MOF area. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff.

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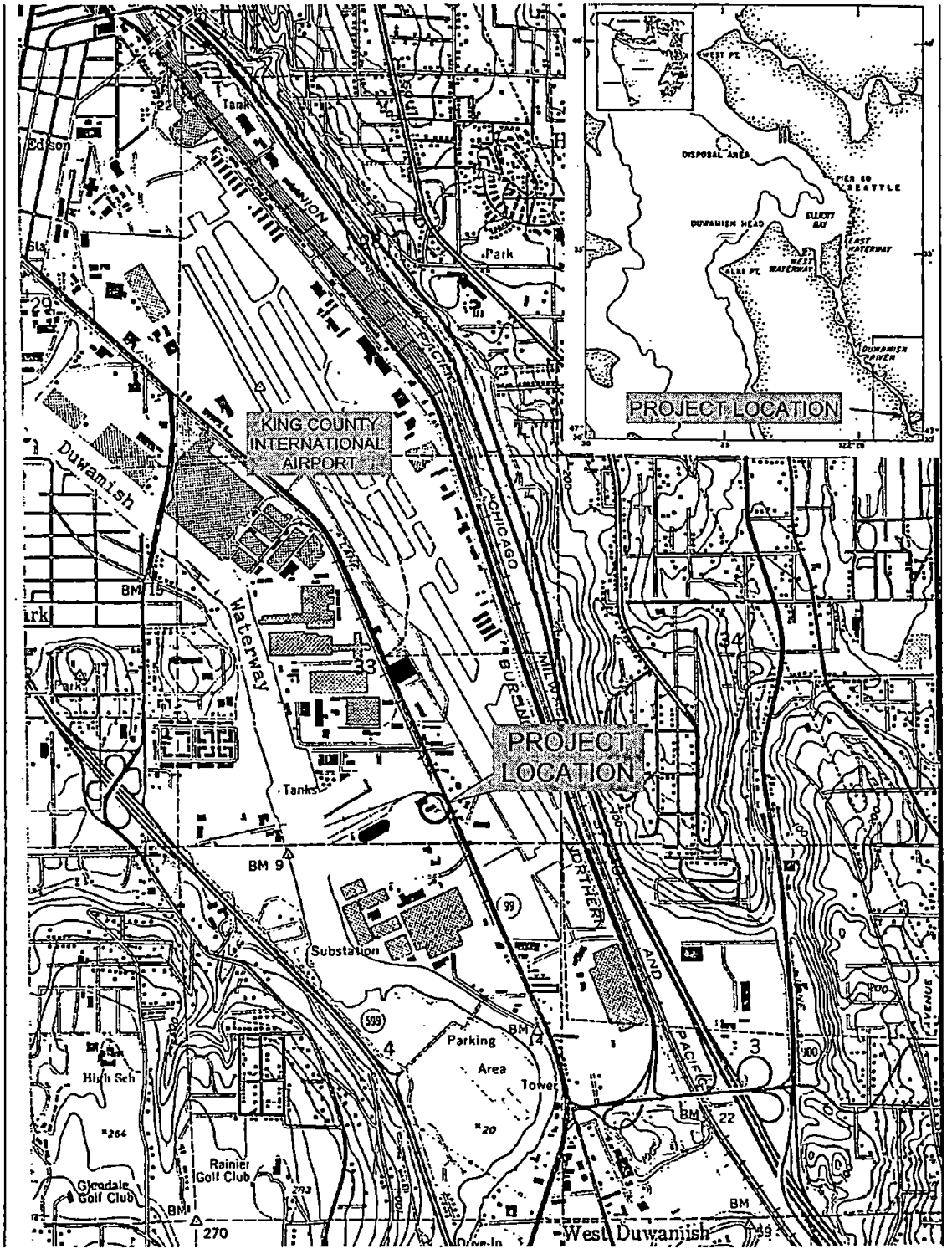

Source: U.S.G.S. 7.5 Minute Series (Topographic) Map: Seattle South Quadrangle.

The Boeing Company Tukwila, Washington	**Vicinity Map**	Figure 1

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Legend

DC-MW-7 — Approximate Monitoring Well Location and Identification

9-05
9-403 COMPLEX
WATER TANK
9-07
DC-MW-2
EAST MARGINAL WAY SOUTH
DC-MW-8
DC-MW-9
DC-MW-7
9-04
RED BARN
MUSEUM OF FLIGHT
GREAT GALLERY
9-77
9-51
9-08
9-78
DC-9-52-3
DC-9-52-2
DC-9-52-1
9-52
9-35
DC-MW-5
9-43
9-49
9-48
9-54
9-43 COMPLEX

0 150 300
Approximate Scale in Feet

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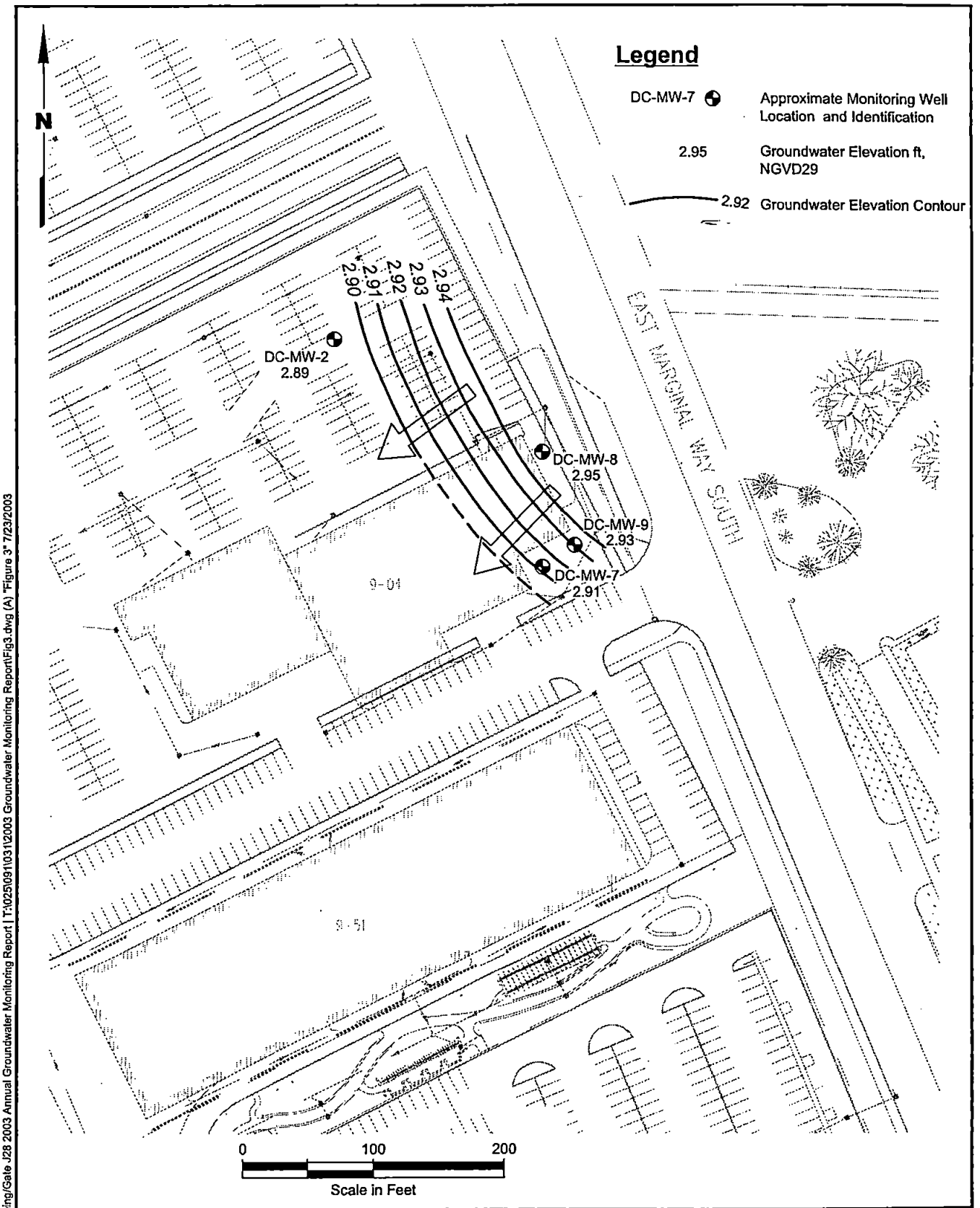
Monitoring Well Locations

Figure
2

Boeing/Gate J28 2003 Annual Groundwater Monitoring Report | T:\025\09\103\12\2003 Groundwater Monitoring Report\Fig2.dwg (A) "Figure 2" 7/23/2003



Boeing/Gate J28 2003 Annual Groundwater Monitoring Report | T:\025\09\10311\2003 Groundwater Monitoring Report\Fig3.dwg (A) "Figure 3" 7/23/2003

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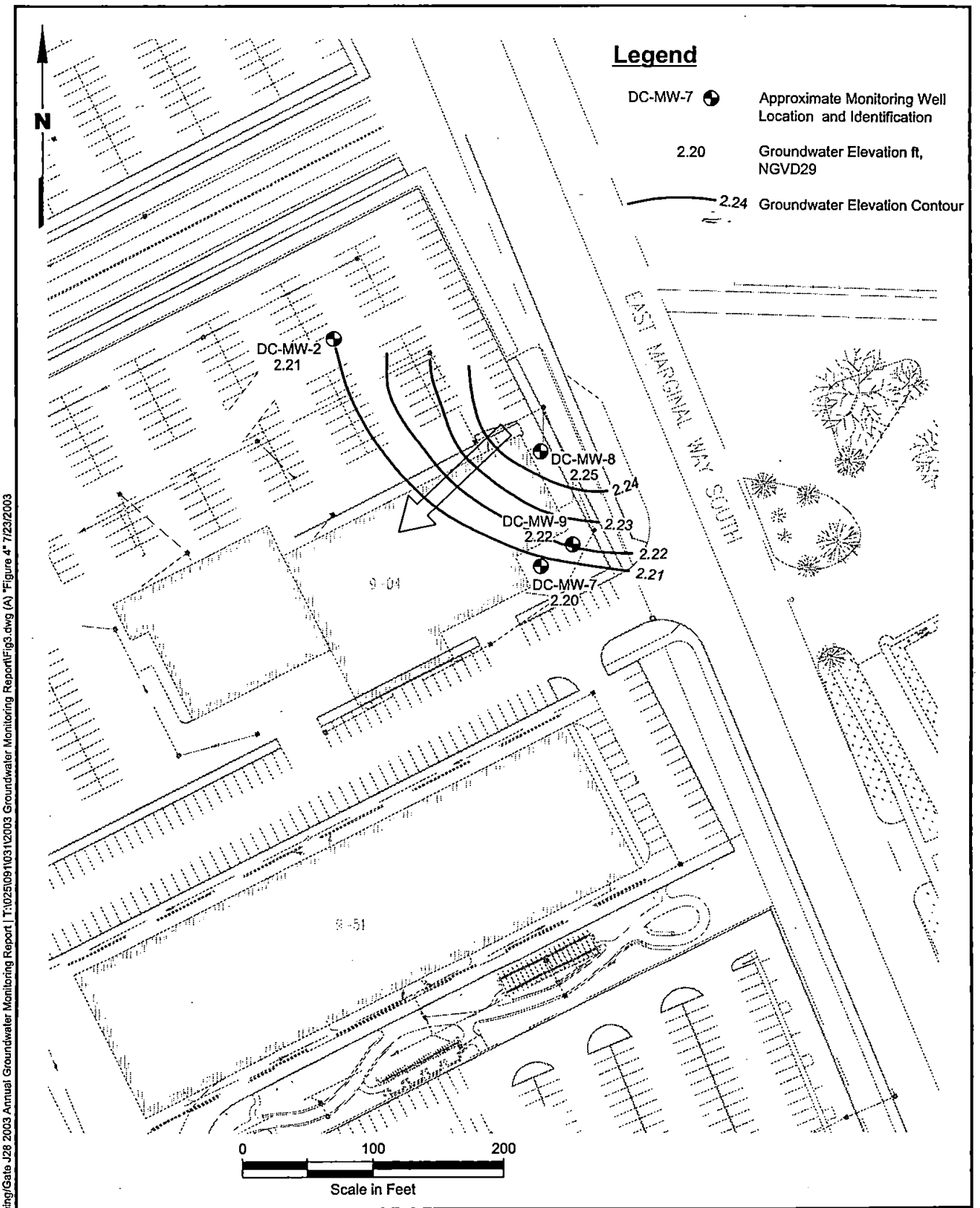
The Boeing Company Tukwila, Washington	**Groundwater Elevation Contours - April 2003**	Figure 3



Boeing/Gate J28 2003 Annual Groundwater Monitoring Report | T:\025\09\10311\2003 Groundwater Monitoring Report\Fig3.dwg (A) "Figure 4" 7/23/2003

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The Boeing Company Tukwila, Washington	**Groundwater Elevation Contours - June 2003**	Figure 4

TABLE 1
GROUNDWATER ANALYTICAL RESULTS
GATE J-28, MUSEUM OF FLIGHT

Well Identification	Data Package No.	Sampling Event	Sample Collection Date	PETROLEUM HYDROCARBONS (mg/L)			BTEX (µg/L)				
				Gasoline Range	Diesel Range	Motor Oil Range	Benzene	Toluene	Ethyl-benzene	m,p-Xylene	o-Xylene
MW-7	DA16B	--	4/23/2001	0.25 U	0.25 U	0.50 U	1.0 U	1.0 U	**1.7**	**1.9**	1.0 U
MW-7	DF50A	1st Quarter	6/12/2001	0.25 U	0.25 U	0.50 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
MW-7	DO10A	2nd Quarter	9/4/2001	0.25 U	0.25 U	0.50 U	NA	NA	NA	NA	NA
MW-7	DW60A	3rd Quarter	12/3/2001	0.25 U	0.25 U	0.50 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
MW-7	EE21C	4th Quarter	3/13/2002	**0.44**	**0.26**	0.50 U	1.0 U	1.0 U	**11**	**3.1**	1.0 U
MW-7	EW75A	5th Quarter	10/14/2002	**0.27**	**0.54**	0.50 U	NA	NA	NA	NA	NA
MW-7	FD05A	6th Quarter	1/6/2003	0.25 U	**0.36**	0.50 U	NA	NA	NA	NA	NA
MW-7	FJ14A	7th Quarter	4/1/2003	0.25 U	0.25 U	0.50 U	NA	NA	NA	NA	NA
MW-7	FP83AA	8th Quarter	6/30/2003	0.25 U	**0.53**	0.50 U	NA	NA	NA	NA	NA
MW-8	DA16A	--	4/23/2001	0.25 U	**0.66**	0.50 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
MW-8	DF50B	1st Quarter	6/12/2001	0.25 U	**0.60**	0.50 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
MW-8	DO10C	2nd Quarter	9/4/2001	0.25 U	**0.68**	0.50 U	NA	NA	NA	NA	NA
MW-8	DW60C	3rd Quarter	12/3/2001	0.25 U	**0.50**	0.50 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
MW-8	EE21A	4th Quarter	3/13/2002	0.25 U	**0.56**	0.50 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
MW-8	EW75C	5th Quarter	10/14/2002	0.25 U	**0.36**	0.50 U	NA	NA	NA	NA	NA
MW-8	FD05C	6th Quarter	1/6/2003	0.25 U	**0.48**	0.50 U	NA	NA	NA	NA	NA
MW-8	FJ14C	7th Quarter	4/1/2003	0.25 U	**0.69**	0.50 U	NA	NA	NA	NA	NA
MW-8	FP83C	8th Quarter	6/30/2003	0.25 U	**0.67**	0.50 U	NA	NA	NA	NA	NA
MW-9	DK52A	1st Quarter	7/30/2001	**3.1**	**1.1**	0.50 U	1.0 U	**1.0**	**100**	**20**	1.0 U
MW-9	DO10B	2nd Quarter	9/4/2001	**3.5**	**1.8**	0.50 U	NA	NA	NA	NA	NA
MW-9	DW60B	3rd Quarter	12/3/2001	**1.8**	**1.3**	0.50 U	**1.1**	**1.2**	**24**	**13**	1.0 U
MW-9	EE21B	4th Quarter	3/13/2002	**3.0**	**4.1**	0.50 U	4.0 U	3.0 U	**58**	**18**	2.0 U
MW-9	EW75B	5th Quarter	10/14/2002	**3.6**	**2.0**	0.50 U	NA	NA	NA	NA	NA
MW-9	FD05B	6th Quarter	1/6/2003	**3.6**	**1.8**	0.50 U	NA	NA	NA	NA	NA
MW-9	FJ14B	7th Quarter	4/1/2003	**2.7**	**3.1**	0.50 U	NA	NA	NA	NA	NA
MW-9	FP83B	8th Quarter	6/30/2003	**2.6**	**2.3**	0.50 U	NA	NA	NA	NA	NA

NA = Not analyzed.
U = Indicates compound was analyzed for, but not detected at the given reporting limit.

TABLE 2
GROUNDWATER ELEVATIONS
GATE J-28, MUSEUM OF FLIGHT

Well Identification	Date	Reference Elevation (a,b) (ft)	Groundwater Elevation (a) (ft)
DC-MW-2	10/14/2002	12.67	NM
	1/6/2003	12.67	NM
	4/1/2003	12.67	2.89
	6/30/2003	12.67	2.21
DC-MW-7	4/23/2001	13.69	2.75
	6/12/2001	13.69	2.62
	7/30/2001	13.69	NM
	9/9/2001	13.69	2.37
	12/3/2001	13.69	3.73
	3/13/2002	13.69	3.66
	10/14/2002	13.69	2.15
	1/6/2003	13.69	3.60
	4/1/2003	13.69	2.91
	6/30/2003	13.69	2.20
DC-MW-8	4/23/2001	13.92	2.81
	6/12/2001	13.92	2.69
	7/30/2001	13.92	NM
	9/9/2001	13.92	2.43
	12/3/2001	13.92	3.84
	3/13/2002	13.92	3.80
	10/14/2002	13.92	2.14
	1/6/2003	13.92	3.69
	4/1/2003	13.92	2.95
	6/30/2003	13.92	2.25
DC-MW-9	4/23/2001	13.85	NM
	6/12/2001	13.85	NM
	7/30/2001	13.85	2.49
	9/9/2001	13.85	2.39
	12/3/2001	13.85	3.85
	3/13/2002	13.85	3.78
	10/14/2002	13.85	2.15
	1/6/2003	13.85	3.64
	4/1/2003	13.85	2.93
	6/30/2003	13.85	2.22

(a) Vertical Datum - NVGD 29
(b) Reference elevation = top of PVC well casing

NM = Not Measured