92-e22

GLEED AGRICULTURAL CHEMICALS GROUND WATER QUALITY ASSESSMENT

by
Denis R. Erickson

Washington State Department of Ecology
Environmental Investigations and Laboratory Services
Toxics, Compliance and Ground Water Investigations Section
Olympia, Washington 98504-7710

Water Body No. WA-38-1010GW
(Segment No. 18-38-07GW)

December 1992

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS ii

ABSTRACT iii

INTRODUCTION 1
Objectives 1
Setting 1

METHODS 3
Target Analyte Selection 3
Well Locations 3
Sampling Procedures 8
Laboratory Support 8
Quality Assurance 8
Target Analytes 9
Non-Target Analytes 9

RESULTS 9
Hydrogeology 9
Target Analyte Detections 10
Non-Target Analytes and Field Parameters 13

CONCLUSIONS 14

REFERENCES 15

ACKNOWLEDGEMENTS

I thank the many people who contributed to the completion of this work. Especially, I want to thank the well owners whose cooperation was essential. Jon Bennett assisted with sampling. Dave Nash, Department of Health, wrote the Health Consults for well owners and provided peer review. Bill Yake, Art Larson and Will Kendra, Environmental Investigations, and Michael Hepp, Water Quality Program, provided peer review. Kelly Carruth typed and proofed the report.

ABSTRACT

Twenty-seven wells were sampled for 74 pesticides and pesticide residues near Gleed, Washington. Gleed is located about five miles northwest of Yakima, Washington. The study area is underlain by a shallow alluvial aquifer and the predominant land use is fruit orchards. Five wells showed low concentrations of total xylenes (estimated to range between 0.2 to 0.9 μg/L) and one well showed one detection of DCPAs (dacthal and metabolites) at a concentration of 0.88 μg/L. The xylene detections are not necessarily related to pesticide use. Arsenic was detected in 13 wells at concentrations that ranged from an estimated 1.5 to 5.4 μg/L. All arsenic detections exceeded the Washington State ground water quality standards criterion. None of the observed concentrations for target analytes exceeded drinking water standards for public systems. Nitrate+nitrite-N was detected in all of the wells at concentrations ranging from 0.7 to 4.2 mg/L and a mean concentration of 2.9 mg/L.

INTRODUCTION

This study was conducted as follow-up work to the Washington State Agricultural Chemicals Pilot Study. The Agricultural Chemicals Pilot Study was conducted jointly by Ecology, Department of Health, and the Department of Agriculture between 1988 and 1990 as an initial step toward defining the effects of agricultural chemicals on Washington State ground water. The Gleed area was identified by Ecology's Central Regional Office staff as a candidate study area for the Pilot Study because it had a high potential for ground water contamination by pesticide residues. However, the area was not selected for the Pilot Study because it was dominated by a single agricultural practice, fruit orchards. One of the Pilot Study conclusions was that ground water sampling should be continued statewide. As funding became available, the sampling in the Gleed area was conducted.

Objectives

The primary objective of the study is to provide information on the presence and concentration of pesticide residues in ground water resulting from normal (non-point agricultural) pesticide use in the Gleed area.

The two secondary objectives are:

- To evaluate the effectiveness of potential indicators (nitrate+nitrite-N and total phosphorus) for identifying wells to be tested for pesticides; and

- To correlate, where possible, site conditions and pesticide use with any observed ground water contamination.

Setting

The Gleed study area is about five miles northwest of Yakima in the Naches River valley. The study area occupies about 3½ square miles along the valley bottom north of the Naches River (Figure 1). It is bounded on the north and east by Selah Heights and on the west and south by the Naches River. The geology consists of alluvial deposits (Campbell, 1979). The area is underlain by a shallow alluvial aquifer designated as the East Naches Aquifer (Larson and Marti, in progress). The hydrogeologic characteristics of the study area are discussed in the results section of this report.

The soil textures are variable and primarily consist of silt loam, loam, sandy loam, and gravelly loam of the Weirman-Ashue soil series (Lenfesty and Reedy, 1985). These soils are relatively permeable and somewhat excessively drained to well drained.

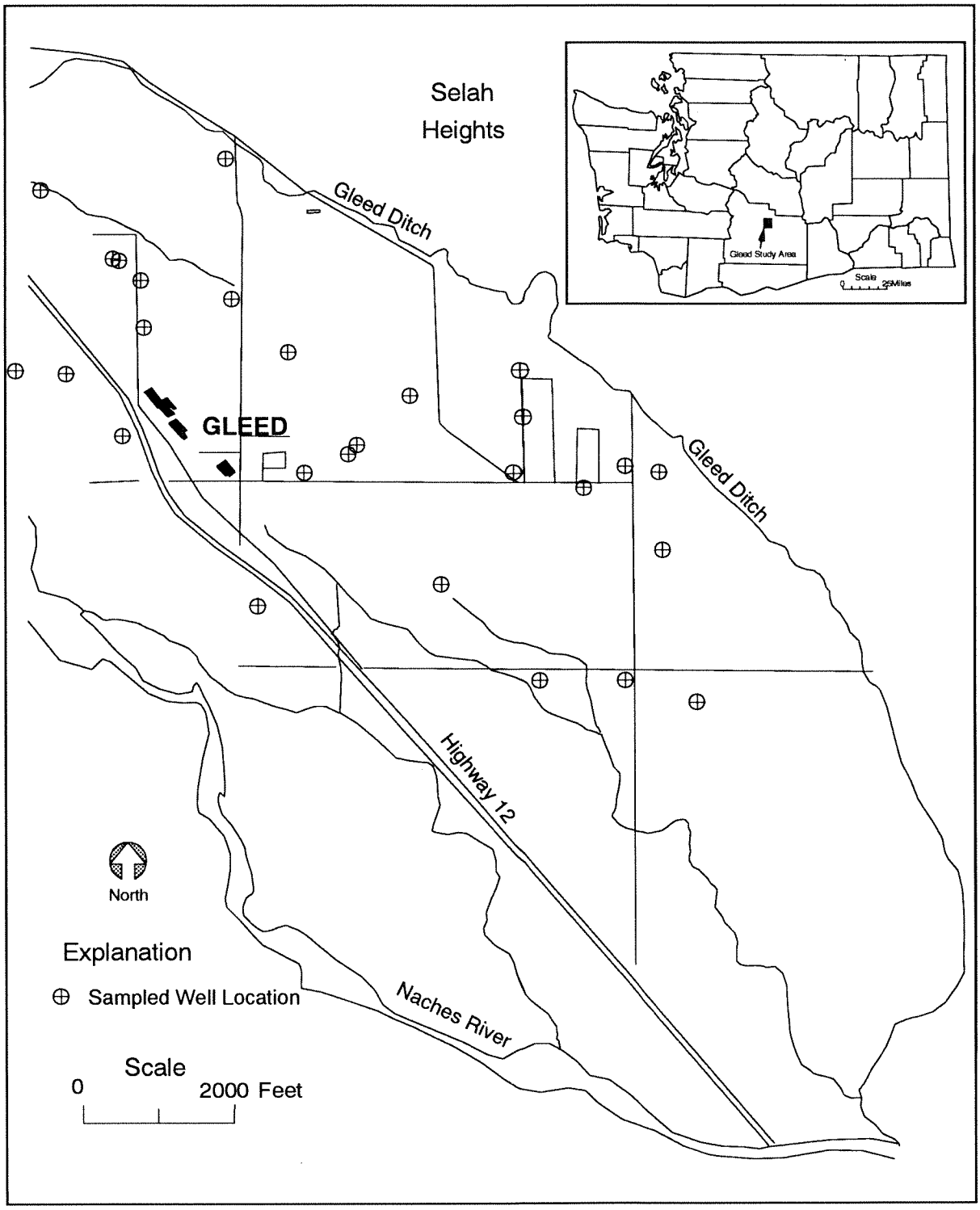

Figure 1. Gleed Study Area and Well Location Map

The primary crops grown are apples and pears with some cherries. Grapes are grown in the uplands along the north boundary of the study area. All crops in the area are irrigated, commonly with sprinklers.

METHODS

Target and non-target analytes, well selection criteria and construction, sampling procedures, laboratory support, and quality assurance are discussed below.

Target Analyte Selection

Table 1 lists the 74 target analytes, test methods, and reporting limits. Twenty-four target analytes were originally identified from EPA's list of leachable pesticides registered in Washington (US EPA, 1986) combined with the WSU Cooperative Extension Information Registration List (WSU Cooperative Extension, 1990a) and spray guide for apples and pears (WSU Cooperative Extension, 1990b). An additional 47 pesticides were added to the target list because they could be identified with little or no added cost using the National Pesticide Survey test methods NPS 1 and NPS 3. Arsenic, copper, and lead were also added because of their use as pesticides or their association with pesticides used on orchard crops.

In addition to the pesticides, all wells were tested for potential indicator parameters (nitrate+nitrite-N and total phosphorus). Also, five wells were tested for major cations and anions (sodium, potassium, calcium, magnesium, carbonate/bicarbonate, chloride, and sulfate). These non-target analytes, test methods and detection limits are listed in Table 2.

Well Locations

Twenty-seven wells were selected and sampled. The locations of the wells are shown in Figure 1. Twenty-five of the wells were private domestic wells and two were irrigation wells. The well depths ranged from 19 to 59 feet. The depths and construction information are described in Table 3. The criteria used to select wells are listed as follows:

- Proximity of fields where agricultural chemicals could have been applied,
- Access to well,
- Availability of well construction information and stratigraphic logs,
- Shallow well intake,
- Age of well: newer wells preferred because of improved well construction practices and less time for deterioration of casing and well seals, and
- Distribution of well locations: a spatial distribution that fairly represented shallow ground water quality.

Table 1. Target Analytes, Test Methods, and Reporting Limits for the Gleed Agricultural Chemical Ground Water Quality Assessment.

Target Analyte	Test Method*	Reporting Limit,ug/L
Acifluorfen	NPS 3	0.2
Alachlor	NPS 1	1.0
Ametryn	NPS 1	0.3
Arsenic, Total	EPA 206.2	1.5
Atraton	NPS 1	0.3
Atrazine	NPS 1	0.2
Bentazon	NPS 3	0.5
Bromacil	NPS 1	2.2
Butachlor	NPS 1	1.5
Butylate	NPS 1	1.0
Carbofuran	EPA 632	1.0
Carboxin	NPS 1 & EPA 632	1.0
Chloramben	NPS 3	0.5
Chlorpropham	NPS 1	0.7
Copper, Total	EPA 200.7	2.0
Cycloate	NPS 1	0.4
Dalapon	NPS 3	5.0
DCPAs(Dacthal and metabolites)	NPS 3	0.2
Diazinon	NPS 1	0.1
Dichlorvos	NPS 1	0.2
Dicamba	NPS 3	0.2
Dichloroprop	NPS 3	0.5
Dinoseb	NPS 3	2.5
Diphenamide	NPS 1 & EPA 632	0.4
Disulfoton	NPS 1	0.2
Disulfoton Sulfone	NPS 1	0.2
Disulfoton Sulfoxide	NPS 1	0.4
Diuron	EPA 632	0.5
EPTC	NPS 1	0.3
Ethoprop	NPS 1	0.1
Fenamiphos	NPS 1	0.3
Fenarimol	NPS 1	0.4
Fluridone	NPS 1	1.8
Hexazinone	NPS 1	0.3
Lead, Total	EPA 239.2	1.0
Merphos	NPS 1	0.4
Methyl Paraoxon	NPS 1	0.3
Methomyl	EPA 632	0.5
Metolachlor	NPS 1	1.5
Metribuzin	NPS 1	0.4
Mevinphos	NPS 1	0.3
MGK264	NPS 1	2.0
Molinate	NPS 1	0.4

Page 2. Table 1. Continued

Target Analyte	Test Method*	Reporting Limit,ug/L
Napropamide	NPS 1	0.5
Norflurazon	NPS 1	0.4
Oxamyl	EPA 632	0.6
Pebulate	NPS 1	0.4
Pentachlorophenol	NPS 3	0.2
Picloram	NPS 3	1.0
Prometon	NPS 1	0.3
Prometryn	NPS 1	0.2
Pronamide	EPA 632	0.5
Propazine	NPS 1	0.2
Propham	EPA 632	0.5
Silvex	NPS 3	0.2
Simazine	NPS 1	0.5
Simetryn	NPS 1	0.1
Stirofos	NPS 1	0.4
Tebuthiuron	NPS 1	0.4
Terbacil	NPS 1 & EPA 632	3.5
Terbutryn	NPS 1	0.3
Triademefon	NPS 1	0.3
Tricyclazole	NPS 1	1.2
Vernolate	NPS 1	0.4
Xylenes, Total	EPA 8010/8020	1.0
1,2-Dichloropropane	EPA 8010/8020	0.2
cis-1,3-Dichloropropene	EPA 8010/8020	0.2
trans-1,3-Dichloropropene	EPA 8010/8020	0.2
2,4,5-Trichlorophenoxyacetic Acid	NPS 3	0.2
2,4-D	NPS 3	0.5
2,4-DB	NPS 3	2.0
3,5-Dichlorobenzoic Acid	NPS 3	0.6
4-Nitrophenol	NPS 3	5.0
5-Hydroxy Dicamba	NPS 3	0.2

* NPS 1- Determination of N and P-containing pesticides by GC with N detector.
NPS 3- Determination of chlorinated acids by GC with electron capture detector.
NPS= National Pesticide Survey test method.
Sources:USEPA (1984), USEPA (1987a), and Montgomery Laboratories (1988)

Table 2. Non–Target Parameters, Test Methods, and Detection Limits for the Gleed Agricultural Chemicals Ground Water Quality Assessment.

Parameter	Method of Analysis*	Reference	Detection Limit
Field Parameters:			
Water Level	Slope Indicator Well Probe	NA	.03 feet
pH	Beckman pH Meter	NA	0.1 S.U.
Specific Conductance	Beckman RC–15C Conductivity Bridge	NA	10 umhos/cm
Temperature	Beckman Temperature Probe	NA	0.1°C
Indicator Parameters:			
Nitrate/Nitrite	EPA #353.2	US EPA(1983)	0.01 mg/L
Total Phosphorus	EPA #365.1	"	0.001 mg/L
Ammonia as N	EPA #350.1	"	0.01 mg/L
Major Cations:			
Sodium	EPA #200.7	US EPA(1983)	0.01 mg/L
Calcium	EPA #200.7	"	0.01 mg/L
Magnesium	EPA #200.7	"	0.01 mg/L
Potassium	EPA #200.7	"	0.01 mg/L
Major Anions:			
Chloride	Std Methods #4110 B	APHA(1989)	0.1 mg/L
Carbonate	Std Methods #2320	"	1 mg/L
Bicarbonate	Std Methods #2320	"	1 mg/L
Sulfate	Std Methods #4110 B	"	0.1 mg/L
Metals (Total Recoverable):			
Cadmium	EPA #200.7	US EPA(1983)	0.2 ug/L
Chromium	EPA #200.7	"	5 ug/L
Iron	EPA #200.7	"	10 ug/L
Manganese	EPA #200.7	"	10 ug/L
Mercury	EPA #245.1	"	0.06 ug/L
Nickel	EPA #200.7	"	10 ug/L
Selenium	EPA #270.2	"	1 ug/L
Zinc	EPA #200.7	"	5 ug/L

* Huntamer(1986) and Huntamer and Hyre(1991)

NA= Not Applicable

Table 3. Construction of Sampled Wells, Gleed Study Area.

Well ID	Borehole Depth (feet)	Open Interval (feet)	Static Depth to Water[1] (feet)	Date	Well Diameter (inches)	Water Use
30K01	28	28				Domestic
30J01	60	59	40	4/23/85	6	Domestic
31A02	60	60			6	Domestic
32D01	33	31.5	12	4/8/74	5	Domestic
30Q01	32	32	19	3/28/80	5	Domestic
30Q02	19	19			2	Irrigation
30R01	50	50	17	3/4/86	6	Domestic
31A01	16	16			6	Domestic
32E01	42	39	11	9/30/85	6	Domestic
32F01	20	20	8	7/17/79	2	Irrigation
32F02	40-45	40-45				Domestic
32F03	65	59	15	10/4/85	6	Domestic
32G01	33	30			6	Domestic
32G02	53	50	19	5/86	6	Domestic
32B01	80	55			6	Domestic
32J01	42	40	22	3/86	6	Domestic
32H01	45	40	8	8/12/77	6	Domestic
33E01	55	49	28	3/15/87	6	Domestic
33M01	52	52	15		6	Domestic
05A01	36	34.5	10	4/17/74	5	Domestic
05B01	46	36	5	5/84	6	Domestic
32Q01	38	37	10	11/81	6	Domestic
04D01	32	32	9	9/26/78	5	Domestic
31C01	45	45	18	9/25/78	6	Domestic
31B01	40	40	18	9/78	6	Domestic
31G01	43	39	5	9/19/84	6	Domestic
32N01	43	40	12	7/11/86	6	Domestic

Source: Department of Ecology Well Log Files.

[1] Water level measurements obtained during sampling are shown in Table B-1, Appendix B.

Sampling Procedures

Sampling consisted of two sampling events: initial sampling on June 4 through 7, 1990, and verification sampling on February 5, 1992. Verification sampling consisted of sampling only those wells where non-metal target analytes were found in the initial sampling round. Pumps had been removed from two of the wells at the time of verification sampling and could not be resampled.

Wells were sampled using existing pumps and piping. Sampling procedures are listed as follows:

1. Water levels were measured in wells prior to and during sampling. Measurements were recorded to 0.01 feet. Measuring point elevations were estimated from 7½ minute quadrangle topographic maps.

2. Wells were purged until field parameters (temperature, specific conductance, and pH) stabilized. A minimum of three casing volumes were purged from the well prior to sampling.

3. Samples were obtained as close to the wellhead as possible, before water entered pressure tanks or underwent treatment. No samples were obtained that had been treated.

4. Samples were stored in coolers at 4°C. All pesticide samples were shipped or transported to the testing laboratory within 48 hours of collection.

5. A unique sample number was assigned to each sample and sample integrity was maintained.

Laboratory Support

For the initial sampling, Montgomery Laboratory, Pasadena, California conducted NPS 1 (nitrogen phosphorus pesticides) and NPS 3 (chlorinated acids) tests; Analytical Technologies, Inc., Seattle, Washington conducted volatile organics and carbamates tests; and the Ecology/EPA Region 10 Laboratory in Manchester, Washington conducted tests for metals, general chemistry, and indicator parameters. The Ecology/EPA Region 10 Laboratory conducted all tests for the verification sampling.

Quality Assurance

In general, the quality of the analytical data is good. Quality assurance results for target and non-target analytes are discussed below.

Target Analytes

All data are acceptable for use. The qualitative and quantitative accuracy, validity and usefulness of the data from contract laboratories were independently reviewed by Stuart Magoon of the Manchester Laboratory. The quality assurance (QA) packages consisted of copies of the extraction log, analytical run log, surrogate recovery forms, laboratory control sample (LCS) recovery forms, calibration curves, data worksheets, and chromatograms. All samples were extracted and analyzed within holding times. Method blanks, matrix spike recoveries and surrogate recoveries were within quality control (QC) limits. All xylene detections were below the quantitation limit (1 μg/L) and are considered to be estimated concentrations. Most (12 of 13) arsenic detections were below the quantitation limit (5 μg/L) and are considered to be estimated concentrations.

In addition to laboratory QA samples, field quality assurance samples consisted of transport blanks, duplicate, and replicate samples. Field quality assurance results for target analytes are shown in Table A-1, Appendix A. No analytes were detected in the transport blanks. Two target analytes were detected in one duplicate set: DCPAs and total xylenes. Relative percent differences (RPDs) of duplicate sample results are used to estimate analytical precision. An RPD is the ratio of the difference and the mean of duplicate results expressed as a percentage. The RPDs for DCPAs and total xylenes were 6 and 33 percent, respectively. The total xylene concentrations (0.2J and 0.4J μg/L) were below the quantitation limit therefore the RPD probably underestimates analytical precision for higher concentrations.

Non-Target Analytes

The results of field quality assurance samples for major cations and anions and indicator parameters are shown in Table A-2, Appendix A. RPDs for duplicate samples are generally less than 5 percent. Two exceptions are total phosphorus (25 percent) and iron (13 percent). Matrix spike recoveries for metals ranged between 88 and 118 percent and were within QC limits. Iron results are qualified with a "B" because the analyte was detected in method blanks.

RESULTS

The study area hydrogeology and water quality results for target and non-target analytes are discussed below.

Hydrogeology

The target aquifer, a portion of the East Naches Aquifer, consists of shallow unconfined saturated alluvial deposits. The alluvial deposits consist primarily of sand and gravel and

some layers of silt and clay or mixtures of silt, sand and gravel. Boulder sized gravel is common. The aquifer thickness based on water well logs is estimated to range from about 55 to 95 feet. The depth to the water table ranges from about 10 to 40 feet. The depth of most wells is less than 50 feet. All drinking water in the study area is supplied by ground water. Water level measurements and estimated well elevations for sampled wells are shown in Table B-1, Appendix B. A Water-Table Contour Map based on the elevation of water levels obtained at sampled wells is shown in Figure 2. Ground water flows from high to low potential (*i.e.* high to low water table elevation). Based on Figure 2 the ground water flow direction in the Gleed area is toward the south and southeast as indicated by the arrows.

Target Analyte Detections

Of the 74 target analytes tested five were detected. The detected target analytes were total xylene, DCPAs, arsenic, copper and lead. The detections are summarized in Table 4. Concentrations for each well are shown in Table B-2, Appendix B.

Total xylenes were detected in five wells at concentrations ranging between 0.2J and 0.9J μg/L. All detections are considered to be estimated concentrations and are assigned a "J" qualifier. Xylene is used for weed control in canals, ponds, and

Table 4. Target Analyte Results Summary

Target Analyte	Number of Wells Tested	Number of Detections	Detection Frequency (%)	Concen-tration Range (μg/L)
DCPAs (Dacthal and metabolites)	27	1	3.7	0.88
Total Xylenes	27	5	18	0.2J-0.9J
Arsenic	27	13	48	1.5J-5.4
Copper	27	23	85	2.6-129
Lead	27	11	41	1.0J-2.8J

J= Estimated value.

irrigation water (Thomson, 1986). It is also commonly used as a solvent for paints, inks and adhesives and as a component of detergents and other industrial and household products. Xylene occurs naturally as a component of petroleum oil and is present in gasoline in concentrations as high as several percent. The xylene detections in the initial sampling round were not confirmed in the verification sampling round. Two of the wells could not be resampled because the pumps were not operating at the time of the verification sampling. Also, the analytical reporting limit for total xylenes (2 μg/L) for the verification round exceeded the concentrations observed during the initial sampling (0.2 to 0.9 μg/L).

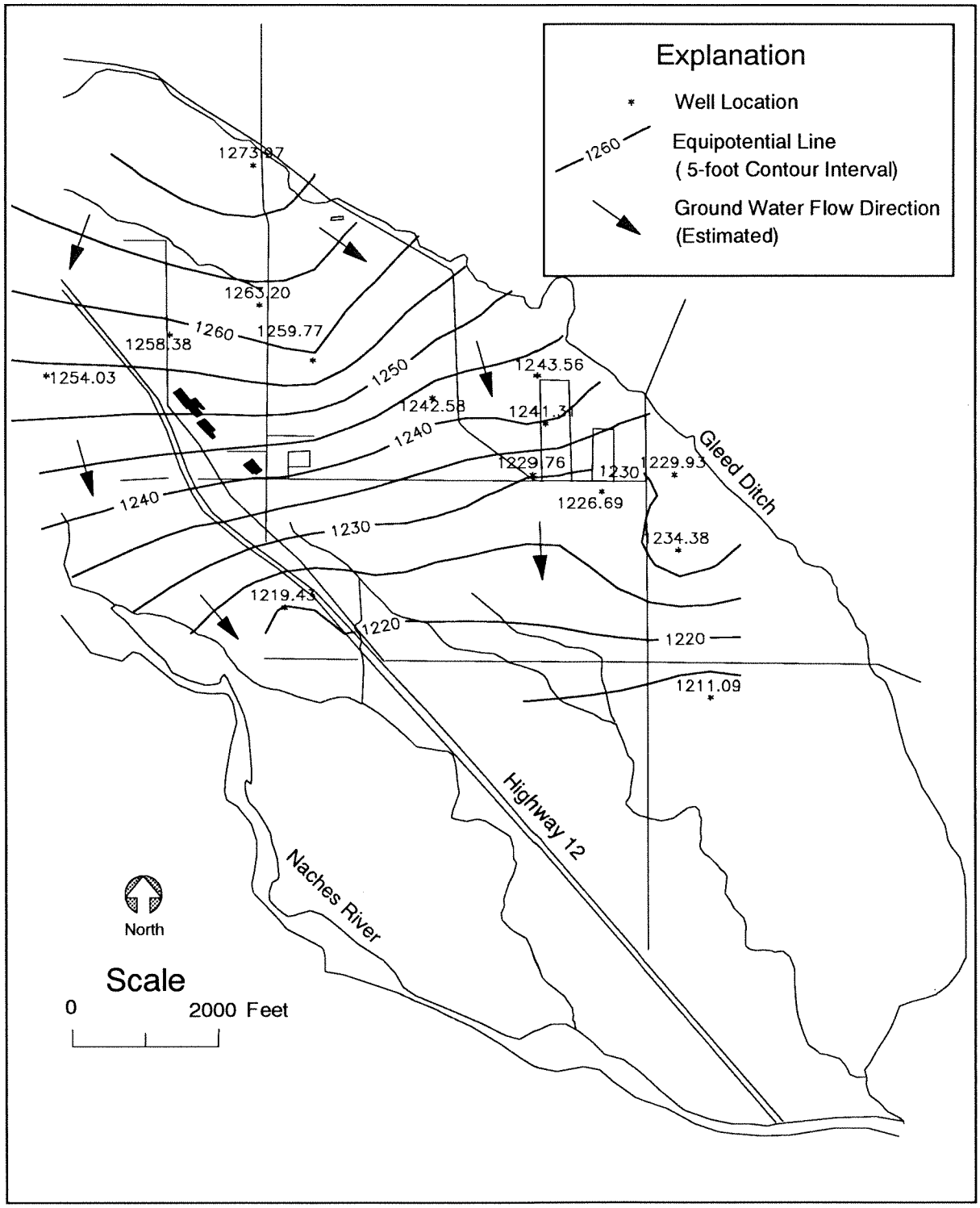

Figure 2. Gleed Study Area Water-Table Contour Map, June 1990

DCPAs (dacthal and metabolites of dacthal) were detected in one well at a concentration of 0.88 μg/L. With the test method used, it was not possible to distinguish dacthal from its degradation products (monomethyl tetrachloroterephthalate and tetrachloroterephthalic acid). Dacthal is a preemergence selective herbicide commonly used to control annual grasses and broadleaf weeds. It is a widely used crabgrass killer on turf (Thomson, 1986). The DCPAs detection was not confirmed in the verification sampling round. This may have been the result of seasonal or long-term variability of DCPAs concentrations in ground water as the initial sampling was conducted in June 1990 and the verification sampling was conducted in February 1992.

The wells with xylene and DCPAs detections occur in a 0.15 square-mile area in the western part of the study area north and east of Highway 12. The source of these contaminants was not identified.

Arsenic, copper and lead were detected in 13, 23, and 11 wells respectively. The concentrations for arsenic (1.5J to 5.4 μg/L), copper (2.6J to 129 μg/L), and lead (1.0J to 2.8J μg/L) were low. The individual concentrations for each well are shown in Table B-2, Appendix B.

The presence of arsenic, copper and lead in ground water is not necessarily due to pesticide use. These metals occur naturally in soils and in trace amounts in ground water. In addition, trace metals samples obtained from water supply wells may not accurately portray ground water quality. Factors that may affect trace metals results from water supply wells include:

1. Water supply wells are constructed to maximize water yield rather than to define ground water quality. Often water supply wells are screened deeper than comparable monitoring wells for water quality sampling. As a result, samples from water supply wells potentially could underestimate contaminant concentrations.

2. Copper and lead commonly are present in plumbing materials. Even though the well and plumbing is well flushed prior to sampling, contamination of samples may still occur.

3. Samples were obtained using existing submersible (without variable-rate motor control), centrifugal, or jet pumps. These pumps are not well suited for sampling trace metals because the pumped water is aerated and severely agitated which may substantially affect metals concentrations in samples.

Drinking water standards for the target analytes are shown in Table 5. None of the parameters tested exceeded the drinking water standards or EPA Lifetime Health Advisories. All detections of arsenic exceeded the ground water quality standards criterion of 0.05 μg/L. This criterion is based on an incremental human cancer risk of less than 1 in 1,000,000. Reportedly, US EPA is considering lowering the drinking water standard for arsenic from 50 to 20 μg/L or lower (Inside EPA, 1992).

Table 5. Standards and Criteria for Detected Target Analytes.

Target Analyte	Drinking Water Standard[1] (μg/L)	Ground Water Criteria[2] (μg/L)	EPA Lifetime Health Advisory[3] (μg/L)	Concen-tration Range (μg/L)
DCPAs (Dacthal and metabolites)	None	None	3500	0.88
Total Xylenes	10000[4]	None	10000[4]	0.2J-0.9J
Arsenic	50	0.05	50	1.5J-5.4
Copper	1000	1000	None	2.6-129
Lead	50	50	None	1.0J-2.8J

None= No criterion established.
J= Estimated value.
[1]Washington State Department of Health, 1992
[2]Water Quality Standards for Ground Waters of the State of Washington, Chapter 173-200 WAC
[3]US EPA, 1987b
[4]US EPA, 1991.

Non-Target Analytes and Field Parameters

The results for potential indicator parameters, nitrate+nitrite-N and total phosphorus, are shown in Table B-3, Appendix B. Nitrate+nitrite-N was detected in all of the wells at concentrations ranging from 0.7 to 4.2 mg/L. The mean concentration was 2.9 mg/L. The drinking water standard for nitrate as N is 10 mg/L (Washington State Department of Health, 1992). None of the wells sampled exceeded 10 mg/L. Total phosphorus concentrations ranged from 0.02 to 0.38 with a mean of 0.13 mg/L. Ammonia was not detected in any of the samples.

Because of the small number of organic target analyte detections and the uncertainty of target metals concentrations, no correlation with indicator parameters was attempted. However, the low mean nitrate+nitrite-N concentrations for the study area and the low pesticide detection frequency agrees with previous findings of the Pilot Study (Erickson and Norton, 1990). For the three Pilot Study study areas, the lowest mean nitrate+nitrite-N concentration corresponded to the area with the lowest pesticide detection frequency.

The general chemistry results for the five wells tested are shown in Table B-4, Appendix B. The dominant anion is bicarbonate and the most abundant cations are calcium, sodium, and magnesium. Iron and manganese occurred at low concentrations.

Specific conductance, temperature and pH were measured at each of the wells during sampling. Specific conductance measurements ranged from 135 to 650 micromhos/cm, pH ranged from 6.6 to 7.5, and temperature ranged from 11.5 to 13.7°C The results are shown in Table B-5, Appendix B.

CONCLUSIONS

1. Of 27 wells sampled in the Gleed Study area five wells showed detections of total xylene and one well showed a detection for DCPAs (dacthal and metabolites of dacthal). Total xylene concentrations were below the quantitation limit and were estimated to range from 0.2 to 0.9 μg/L. The concentration of DCPAs was 0.88 μg/L.

2. The xylene detections occurred in wells within a 0.15 square-mile area in the western part of the study area. Xylene is used as a herbicide but also as an industrial solvent and is a major component of gasoline. The presence of the xylene in the ground water is not necessarily related to pesticide use.

3. Arsenic, copper, and lead, were detected in 13, 23, and 11 wells, respectively. In general, concentrations were low ranging from an estimated 1.5 μg/L to 5.4 μg/L for arsenic, 2.6 to 129 μg/L for copper, and an estimated 1.0 to 2.8 μg/L for lead. Most (12 of 13) of the arsenic detections were below the quantitation limit (5 μg/L) and are considered estimated concentrations. With the available information it is not possible to determine if the detections are related to pesticide use.

4. None of the concentrations for target analytes exceeded drinking water standards for public water-supply systems. All 13 arsenic detections exceeded the criterion (0.05 μg/L) for the ground water quality standards.

5. With the available information it is not possible to identify the source of the arsenic. To investigate the arsenic concentrations at Gleed a more intensive sampling program would need to be developed and implemented. The program would need to include: (1) installation and sampling of monitoring wells specifically designed to define ground water quality, (2) definition of background arsenic concentrations in ground water upgradient of the study area in non-orchard areas, (3) multiple sampling events to define the seasonal variation of arsenic concentrations, and (4) an assessment of the actual use of lead-arsenate pesticides in the study area.

6. Nitrate+nitrite-N was detected in all wells with a mean concentration of 2.9 mg/L. None of the concentrations exceeded 10 mg/L, the drinking water standard for public water-supply systems. The combination of a low mean nitrate+nitrite-N concentration and a low pesticide detection frequency agrees with previous findings of the Agricultural Chemicals Pilot Study.

REFERENCES

APHA *et al.* (American Public Health Association, American Water Works Association, and Water Pollution Control Federation), 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition, Washington D.C.

Campbell, N., 1979. Surficial Geologic Map of the Yakima Quadrangle, Washington Department of Natural Resources, Division of Geology and Earth Resources Open File Report OF79-15.

Erickson, D.R. and D. Norton, 1990. Washington State Agricultural Chemicals Pilot Study, Final Report. Department of Ecology Report 90-46. 76 pgs.

Huntamer, D., 1988. Washington State Department of Ecology Laboratory User's Manual. Revised August 1988.

Huntamer, D. and J. Hyre, 1991. Manchester Environmental Laboratory, Laboratory User's Manual. Third Edition, July 1991. 342 pgs.

Inside EPA, 1992. New Cancer Risk Findings May Lead to Stricter EPA Arsenic Regs, page 8, June 19, 1992.

Larson, A.G. and P.B. Marti, in progress. Surficial Aquifers of Washington State.

Lenfesty, C.D. and T.E. Reedy, 1985. Soil Survey of Yakima County. Soil Conservation Service, 345 pgs.

Montgomery Laboratories, 1988. Proposal for Analyses for Ground Water Samples for the Washington State Agricultural Chemicals Pilot Study, 17 pgs. (unpublished).

Thomson, W.T. 1986. Agricultural Chemicals, Book II Herbicides. Thomson Publications, Fresno, Califonia. 301 pgs.

US EPA, 1983. Methods for Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory. EPA-600/4-79-020, March 1983.

US EPA, 1984. Guidelines for Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act. Federal Register, October 26, 1984.

US EPA, 1986. Use of Pesticides in Vulnerable Groundwaters of Washington State. EPA Region X, Pesticides Section. 15 pgs.

REFERENCES (Continued)

US EPA, 1987a. Quality Assurance Project Plan for the National Pesticide Survey of Pesticides Drinking Water Wells Pilot Study. Office of Pesticides and Office of Drinking Water.

US EPA, 1987b. Health Advisories. Office of Drinking Water.

US EPA, 1991. National Primary Drinking Water Regulations; Final Rule. Federal Register Vol. 56, No. 20, January 30, 1991.

WSU Cooperative Extension, 1990a. Pesticide Registration List Database, 1990. Pesticide Information Center, April 13, 1990, Eleanor King, Manager.

WSU Cooperative Extension, 1990b. 1990 Spray Guide for Tree Fruits in Eastern Washington.

Washington State Department of Health, 1992. Drinking Water Regulations, Chapter 246-290 WAC. 65 pgs.

APPENDIX A

Quality Assurance Results

Table A-1. Quality Assurance Results for Target Analytes, Gleed Study Area (Units in ug/L).

		<----------INITIAL SAMPLING---------->							<-------- VERIFICATION SAMPLING--------->			
		23-8230	23-8234	23-8235	23-8240	23-8241	23-8246	23-8247	06-8130	06-8133	06-8134	06-8135
Analyte	Test Method	Transport	Dup	Dup	Dup	Dup	Matrix Spikes	Matrix Spikes	Transport	Dup	Dup	Rep
Alachlor	NPS-1	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U						
Ametryn	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U						
Atraton	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U						
Atrazine	NPS-1	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U						
Bromacil	NPS-1	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	84	85				
Butachlor	NPS-1	1.5 U	1.5 U	1.5 U	1.5 U	1.5 U						
Butylate	NPS-1	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U						
Carboxin	NPS-1	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	78	82				
Chlorpropham	NPS-1	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	85	88				
Cycloate	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	87	89				
Diazinon	NPS-1	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U						
Dichlorvos	NPS-1	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	100	100				
Diphenamide	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	85	86				
Disulfoton	NPS-1	NT	NT	NT	NT	NT	87	91				
Disulfoton Sulfone	NPS-1	NT	NT	NT	NT	NT	90	92				
Disulfoton Sulfoxide	NPS-1	NT	NT	NT	NT	NT	99	100				
EPTC	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	90	92				
Ethoprop	NPS-1	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U						
Fenamiphos	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U						
Fenarimol	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	82	85				
Fluridone	NPS-1	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	69	74				
Hexazinone	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	79	82				
Merphos	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	75	79				
Methyl paraoxon	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U						
Metolachlor	NPS-1	1.5 U	1.5 U	1.5 U	1.5 U	1.5 U						
Metribuzin	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	87	88				
Mevinphos	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	95	96				
MGK264	NPS-1	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U						
Molinate	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	90	91				

Table A-1, Con't, Page 2

		<----------INITIAL SAMPLING---------->							<-------- VERIFICATION SAMPLING--------->			
		23-8230	23-8234	23-8235	23-8240	23-8241	23-8246	23-8247	06-8130	06-8133	06-8134	06-8135
Analyte	Test Method	Transport	Dup	Dup	Dup	Dup	Matrix Spikes	Matrix Spikes	Transport	Dup	Dup	Rep
Napropamide	NPS-1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U						
Norflurazon	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	80	83				
Pebulate	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	86	89				
Prometon	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	87	88				
Prometryn	NPS-1	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	86	87				
Propazine	NPS-1	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U						
Simazine	NPS-1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U						
Simetryn	NPS-1	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	87	87				
Stirofos	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U						
Tebuthiuron	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	89	90				
Terbacil	NPS-1	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U						
Terbutryn	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U						
Triademefon	NPS-1	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	87	87				
Tricyclazole	NPS-1	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	80	86				
Vernolate	NPS-1	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	86	88				
Acifluorfen	NPS-3	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	106	96				
Bentazon	NPS-3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	114	109				
Chloramben	NPS-3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U						
2,4-D	NPS-3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	120	111				
2,4-DB	NPS-3	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	108	109				
DCPAs	NPS-3	0.2 U	0.2 U	0.2 U	0.86	0.91	117	111	0.015 U	0.016 U	0.015 U	0.023 U
Dalapon	NPS-3	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	226	262				
Dicamba	NPS-3	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	112	105				
3,5-Dichlorobenzoic Acid	NPS-3	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	94	107				
Dichloroprop	NPS-3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	110	106				
Dinoseb	NPS-3	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U						
5-Hydroxy Dicamba	NPS-3	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	110	99				
4-Nitrophenol	NPS-3	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U						
Pentachlorophenol	NPS-3	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	97	95				

Table A-1, Con't, Page 3

		<----------INITIAL SAMPLING---------->							<-------- VERIFICATION SAMPLING--------->			
		23-8230	23-8234	23-8235	23-8240	23-8241	23-8246	23-8247	06-8130	06-8133	06-8134	06-8135
Analyte	Test Method	Transport	Dup	Dup	Dup	Dup	Matrix Spikes	Matrix Spikes	Transport	Dup	Dup	Rep
Picloram	NPS-3	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	85	84				
Silvex	NPS-3	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	113	107				
2,4,5-Trichlorophenoxy-acetic Acid	NPS-3	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	116	110				
							23-8238	23-8238				
1,2-Dichlorpropane	EPA 801	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	NT	NT				
cis-1,3-Dichlorpropene	EPA 801	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	NT	NT				
trans-1,3-Dichlorpropene	EPA 801	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	NT	NT				
Total Xylenes	EPA 801	0.5 U	0.5 U	0.5 U	0.4 J	0.2 J	78	69	2 U	2 U	2 U	2 U
							23-8240	23-8237				
Carbofuran	EPA 632	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U						
Carboxin	EPA 632	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U						
Diphenamide	EPA 632	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	82,83	77,80				
Diuron	EPA 632	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	89,90	85,88				
Methomyl	EPA 632	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	54,60	79,80				
Oxamyl	EPA 632	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U						
Pronamide	EPA 632	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	76,73	87,90				
Propham	EPA 632	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	79,76	86,74				
Terbacil	EPA 632	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	87,86	82,85				
							23-8233	23-8250				
Arsenic, Total	EPA 206.	NT	1.5 U	1.5 U	1.5 U	1.5 U	100,97	103,102				
Copper, Total	EPA 200.	NT	2.0 U	2.0 U	3.9 J	3.3 J	101,100	99,99				
Lead, Total	EPA 239.	NT	2.8 J	1.0 U	1.0 U	1.0 U	89,97	101				

NPS= National Pesticide Survey Test Method

NT= Not Tested

U= Analyte not detected above the reported concentration.

J= Estimated concentration.

Table A-2. Quality Assurance Results for Non-Target Analytes, Gleed Study Area (Units in mg/L).

Analyte	Test Method	Dup 23-8234	Dup 23-8235	RPD(%)	Dup 23-8240	Dup 23-8241	RPD(%)	Matrix Spikes (% Recovery) 23-8233	Matrix Spikes (% Recovery) 23-8250
Calcium	EPA 200.7	NT	NT	--	20.6	20.4	1	97,106	105,109
Iron	EPA 200.7	NT	NT	--	0.032 J	0.037 J	14	106,106	98,95
Magnesium	EPA 200.7	NT	NT	--	5.65	5.6	1	115, 117	104,104
Manganese	EPA 200.7	NT	NT	--	0.0012 J	0.0012 J	0	88,88	95,95
Potassium	EPA 200.7	NT	NT	--	3.04	2.9 B	5	93,101	103,105
Sodium	EPA 200.7	NT	NT	--	11.6	11.4	2	102,104	118,116
Bicarbonate	Std Methods 406C	NT	NT	--	76	78	3	NT	NT
Carbonate	Std Methods 406C	NT	NT	--	1 U	1 U	--	NT	NT
Chloride	Std Methods 429	NT	NT	--	3.03	3.07	1	NT	NT
Sulfate	Std Methods 429	NT	NT	--	8.02	8.1	1	NT	NT
Nitrate+Nitrite-N	EPA 353.2	3.11	3.13	1	2.06	2.02	2	NT	NT
Ammonia-N	EPA 350.1	0.01 U	0.01 U	--	0.01 U	0.01 U	--	NT	NT
Total Phosphorus	EPA 365.1	0.07	0.09	25	0.14	0.14	0	NT	NT

NT= Not tested.

U= Analyte not detected above reported concentration.

B= Analyte detected in laboratory blank.

APPENDIX B

Water-Level Data

Water Quality Results

Table B–1. Water Level Measurements and Elevations, Gleed Study Area.

Well ID	Date	Top of Casing (feet, MSL)	State Plane, South Zone (feet) X	Y	Depth to Water (feet)	Water Elevation (feet, MSL)
30J01	06/04/90	1311	1971323	487834	37.03	1273.97
31A02	06/04/90	1279	1971397	485804	15.80	1263.20
32D01	06/04/90	1271	1972143	484986	11.23	1259.77
31A01	06/05/90	1268	1970169	485360	9.62	1258.38
32F03	06/05/90	1262.5	1973787	484438	19.92	1242.58
32G01	06/06/90	1250.7	1975157	483312	20.94	1229.76
32G02	06/06/90	1261.5	1975319	484060	20.19	1241.31
32B01	06/06/90	1270.3	1975211	484762	26.74	1243.56
32J01	06/06/90	1246.4	1976081	483068	19.71	1226.69
33E01	06/06/90	1256.5	1977091	483312	26.57	1229.93
33M01	06/06/90	1250.65	1977137	482214	16.27	1234.38
04D01	06/06/90	1223	1977589	480050	11.91	1211.09
31C01	06/07/90	1268	1968479	484762	13.97	1254.03
32N01	06/07/90	1230.5	1971747	481380	11.07	1219.43

MSL= Mean Sea Level.

Table B–2. Detected Target Analytes, Gleed Study Area.

Well ID	Date	Xylenes, Total	DCPAs	Arsenic, Total	Copper, Total	Lead, Total
30K01	06/04/90	0.5 U	0.2 U	1.5 J	5.3 J	1 U
30J01	06/04/90	0.5 U	NT	4.7 J	78.9	1 U
30J01	07/02/90	NT	0.2 U	NT	NT	NT
31A02	06/04/90	0.5 U	0.2 U	1.5 U	11	2 J
32D01	06/04/90	0.5 U	0.2 U	1.5 U	2 U	2.8 J
30Q01	06/04/90	0.5 U	0.2 U	1.5 U	47.3	1 U
30Q02	06/04/90	0.9 J	0.2 U	1.7 J	4 J	1 U
30R01	06/05/90	0.2 J	0.2 U	1.5 U	7.2 J	1 U
30R01	02/05/92	2 U	NT	NT	NT	NT
31A01	06/05/90	0.3 J	0.2 U	1.5 U	40.1	1 U
31A01	02/05/92	2 U	NT	NT	NT	NT
32E01	06/05/90	0.4 J	0.88	1.5 U	3.9 J	1 U
32E01	02/05/92	2 U	0.016 U	NT	NT	NT
32F01	06/05/90	0.2 J	0.2 U	1.5 U	2 U	1.2 J
32F02	06/05/90	0.5 U	0.2 U	1.5 U	3.3 J	1 U
32F03	06/05/90	0.5 U	0.2 U	1.6 J	2.6 J	1.2 J
32G01	06/06/90	0.5 U	0.2 U	1.7 J	11	2.3 J
32G02	06/06/90	0.5 U	0.2 U	2.8 J	4.6 J	2.4 J
32B01	06/06/90	0.5 U	0.2 U	3.3 J	3.3 J	1 U
32J01	06/06/90	0.5 U	0.2 U	4.9 J	2.6 J	1 U
32H01	06/06/90	0.5 U	0.2 U	4.9 J	25.7	1.1 J
33E01	06/06/90	0.5 U	0.2 U	4.7 J	3.9 J	1.6 J
33M01	06/06/90	0.5 U	0.2 U	5.4	39.5	1 J
05A01	06/06/90	0.5 U	0.2 U	2.5 J	33.5	1 U
05B01	06/06/90	0.5 U	0.2 U	1.5 U	129	1 U
32Q01	06/06/90	0.5 U	0.2 U	1.5 U	53.3	1 U
04D01	06/06/90	0.5 U	0.2 U	2.5 J	2 U	1 U
31C01	06/07/90	0.5 U	0.2 U	1.5 U	28.9	2.7 J
31B01	06/07/90	0.5 U	0.2 U	1.5 U	3.9 J	1.8 J
31G01	06/07/90	0.5 U	0.2 U	1.5 U	128	1 U
32N01	06/07/90	0.5 U	0.2 U	1.5 U	2 U	1 U

= Analyte detected.

J= Estimated value.

U= Analyte not detected above listed value.

NT= Not tested.

Table B–3. Nitrate+Nitrite–N, Total Phosphorus, and Ammonia–N Results (mg/L).

Well ID	Date	Nitrate+ Nitrite–N	Total Phosphorus	Ammonia–N	
30K01	06/04/90	2.08	0.10	0.01	U
30J01	06/04/90	3.40	0.13	0.01	U
31A02	06/04/90	1.50	0.12	0.01	U
32D01	06/04/90	3.11	0.07	0.01	U
30Q01	06/04/90	3.37	0.08	0.01	U
30Q02	06/04/90	2.50	0.19	0.01	U
30R01	06/05/90	2.80	0.10	0.01	U
31A01	06/05/90	0.74	0.05	0.01	U
32E01	06/05/90	2.06	0.14	0.01	U
32F01	06/05/90	3.46	0.07	0.01	U
32F02	06/05/90	3.55	0.08	0.01	U
32F03	06/05/90	3.58	0.16	0.01	U
32G01	06/06/90	2.54	0.14	0.01	U
32G02	06/06/90	3.29	0.20	0.01	U
32B01	06/06/90	4.12	0.20	0.01	U
32J01	06/06/90	3.85	0.34	0.01	U
32H01	06/06/90	4.14	0.24	0.01	U
33E01	06/06/90	3.14	0.18	0.01	U
33M01	06/06/90	3.94	0.38	0.01	U
05A01	06/06/90	4.24	0.13	0.01	U
05B01	06/06/90	2.09	0.05	0.01	U
32Q01	06/06/90	3.28	0.07	0.01	U
04D01	06/06/90	3.63	0.15	0.01	U
31C01	06/07/90	2.79	0.02	0.01	U
31B01	06/07/90	2.30	0.02	0.01	U
31G01	06/07/90	1.59	0.03	0.01	U
32N01	06/07/90	0.87	0.04	0.01	U
	MEAN=	2.89	0.13	--	
	MIN=	0.74	0.02	--	
	MAX=	4.24	0.38	--	

U= Analyte not detected above reported limit.

Table B–4. Gleed Major Cations and Anions (mg/L).

Well ID=========>	31A02	32E01	32B01	32J01	05B01
Sodium, Total	15.0	11.6	41.1	39.9	48.4
Potassium, Total	3.8	3.0	5.8	6.0	1.6
Calcium, Total	29.6	20.6	59.5	58.4	0.0854
Magnesium, Total	8.3	5.7	22.3	19.7	0.0228
Iron, Total	0.062 B	0.032 JB	0.0044 JB	0.043 JB	0.026 B
Manganese, Total	0.0037 J	0.0012 J	0.001 U	0.001 U	0.0037 J
Carbonate as CaCO3	1 U	1 U	1 U	1 U	1 U
Bicarbonate as CaCO3	122	76	268	242	78
Sulfate	8.65	8.02	18.6	19.2	10.2
Chloride	2.21	3.03	6.81	17.4	6.22

U= Analyte not detected.

J= Estimated concentration.

B= Analyte detected in laboratory blank.

Table B–5. Gleed Field Parameter Results.

Well ID	Date	pH (Std Units)	Temperature (°C)	Specific Conductance (micromhos/cm)
30K01	06/04/90	7.0	11.7	235
30J01	06/04/90	7.4	13.7	550
31A02	06/04/90	7.0	12.8	282
32D01	06/04/90	7.0	13.4	328
30Q01	06/04/90	7.0	13.3	323
30Q02	06/04/90	6.9	12.4	263
30R01	06/05/90	7.0	12.5	275
30R01	02/05/92	7.5	13.3	255
31A01	06/05/90	6.9	12.6	135
31A01	02/05/92	7.4	12.8	175
32E01	06/05/90	7.0	12.5	162
32E01	02/05/92	7.5	13.1	220
32F01	06/05/90	6.9	12.3	300
32F02	06/05/90	6.9	12.1	285
32F03	06/05/90	7.2	13.4	475
32G01	06/06/90	6.9	11.5	350
32G02	06/06/90	7.2	13.1	540
32B01	06/06/90	7.3	13.4	600
32J01	06/06/90	7.1	12.9	590
32H01	06/06/90	7.2	13.3	610
33E01	06/06/90	7.4	13.2	650
33M01	06/06/90	7.0	13.6	535
05A01	06/06/90	7.0	12.4	460
05B01	06/06/90	6.6	12.3	220
32Q01	06/06/90	6.7	12.4	270
04D01	06/06/90	7.1	12.8	500
31C01	06/07/90	6.8	12.7	225
31B01	06/07/90	6.9	13.3	250
31G01	06/07/90	6.6	12.7	170
32N01	06/07/90	7.3	12.1	165
	Mean=	7.1	12.8	347
	Minimum=	6.6	11.5	135
	Maximum=	7.5	13.7	650