Hydrogeologic Susceptibility and Vulnerability Assessment for Girdwood Station Mall Public Drinking Water Well, Girdwood, Alaska

DRINKING WATER PROTECTION PROGRAM REPORT 3

August 2000

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By MICHAEL. J. CROTTEAU

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ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION: 2000

CONTENTS

TABLES

ILLUSTRATIONS

APPENDICES

Hydrogeologic Susceptibility and Vulnerability Assessment for Girdwood Station Mall Public Drinking Water Well, Girdwood, Alaska

By Michael J. Crotteau

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

Girdwood Station Mall Public Water System is a seasonal Class B (transient/non-community) water system consisting of one well. Identified potential and current sources of contaminants for Girdwood Station Mall include: domestic wastewater sewerlines, a railroad corridor, livestock stables, home heating fuel tanks, gravel and paved roads and right-of-ways, and a inactive contaminated site. These identified sources of contaminants are considered contaminant sources of bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals. Overall, Girdwood Station Mall's public water system received a vulnerability rating of **medium** for bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals.

INTRODUCTION

The purpose of the environmental assessment is to provide public water system owners/operators, communities, and local governments with information they can use to preserve the quality of this drinking water suply. This assessment was completed for the Girdwood Station Mall's source of public drinking water. This source consists of one well in the Glacier Creek Valley (see Figure 1). This assessment, known under the Alaska Drinking Water Protection Program as the *Source Water Assessment*, has combined a review of the natural hydrogeologic sensitivity with potential and existing contaminant risks to arrive at an overall vulnerability of the drinking water source to contamination. This assessment has been performed as a basis for voluntary local protection efforts and to assist agencies in their efforts to reduce risk to this public drinking water supply.

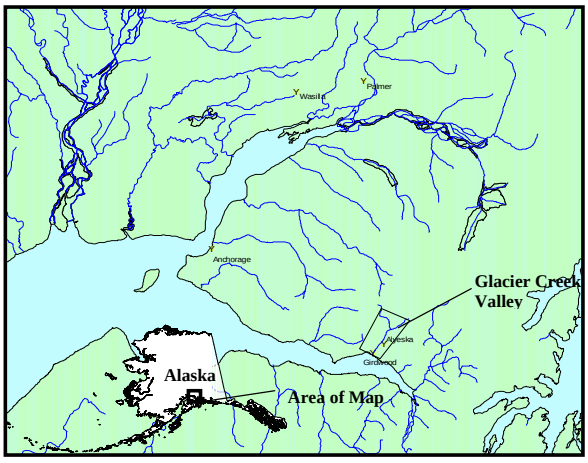

Figure 1. Index map showing the location of the Glacier Creek Valley, Alaska

PHYSIOGRAPHY OF THE GLACIER CREEK VALLEY, ALASKA

Glacier Creek Valley, drained primarily by Glacier Creek, is located near the head of Turnagain Arm of Cook Inlet, approximately 45 miles south of Anchorage, Alaska (see Figure 1). Widened by glaciers and surrounded by steep mountain slopes, the valley is approximately six miles in length and trends northeast-southwest. The valley floor is roughly four miles wide. Elevations within the valley increase inland, from sea level at Turnagain Arm to approximately 6500 feet at the head of the valley. Development comprising the community of Girdwood is present along the lower four miles of the valley.

The floor of the Girdwood Valley is covered primarily by coniferous forests. Bedrock is exposed at the surface and wetlands occur intermittently in the valley floor. Bedrock also crops out at elevation in the mountains. Glacier Creek originates in uplands at the head of the valley, drains an area of approximately 58.2 square miles and is roughly centrally located. A mean annual discharge of 265 cubic feet per second was recorded in Glacier Creek (USGS gaging station near the mouth) from 1965-78. California Creek and Alyeska Creek flow into Glacier Creek. California Creek drains an area of roughly 6.96 square miles. Virgin Creek flows directly into the Turnagain Arm and drains an area of about 3.5 square miles in the valley [*Glass and Brabets*, 1988].

Mean annual precipitation of roughly 40 inches per year was recorded near the mouth of the valley from 1955-66 and 1977-78. At the base of the Alyeska Ski Resort, annual precipitation in excess of 65 inches year has been recorded (1985-86) [*Glass and Brabets*, 1988]. Mean daily temperature ranges from 65.1^{o} F during cool rainy summers to 13.9^{o} F in snowy winters, with average total snow depths of 197.4 inches [*Western Regional Climate Center*, 2000].

GIRDWOOD STATION MALL PUBLIC WATER SYSTEM

Girdwood Station Mall Public Water System is a Class B (transient/non-community) water system, which is owned by Tesoro Northstore Company and operated by M-W Drilling. The system consists of one well, which is located near the corner of the Seward and Alyeska Highways, in the old Girdwood Townsite (see Figure 2). According to the well log, the well penetrates silty gravel and clay and is screened in clean sandy gravel from 113 to 118 feet below land surface. At the time of drilling (February 18, 1998), the well had a static water level of 12.4 feet below land surface. The land is drained properly away from the site and the well is grouted from land surface to approximately 18 feet below land surface where it comes in contact with a three foot layer of brown, silty clay. This water system operates year round and serves approximately 400 non-residents through a single connection to the mall.

ASSESSMENT AND PROTECTION AREA FOR GIRDWOOD STATION MALL'S DRINKING WATER SOURCE

The Drinking Water Protection and Assessment Area that has been established for Girdwood Station Mall's public drinking water well is the area that is most sensitive to contamination. This area has served as a basis for assessing the risk of the drinking water source to contamination. This zone around the drinking water source is the most critical area to the preservation of the quality of the drinking water. Therefore, this area will also serve as the area of focus for voluntary protection efforts.

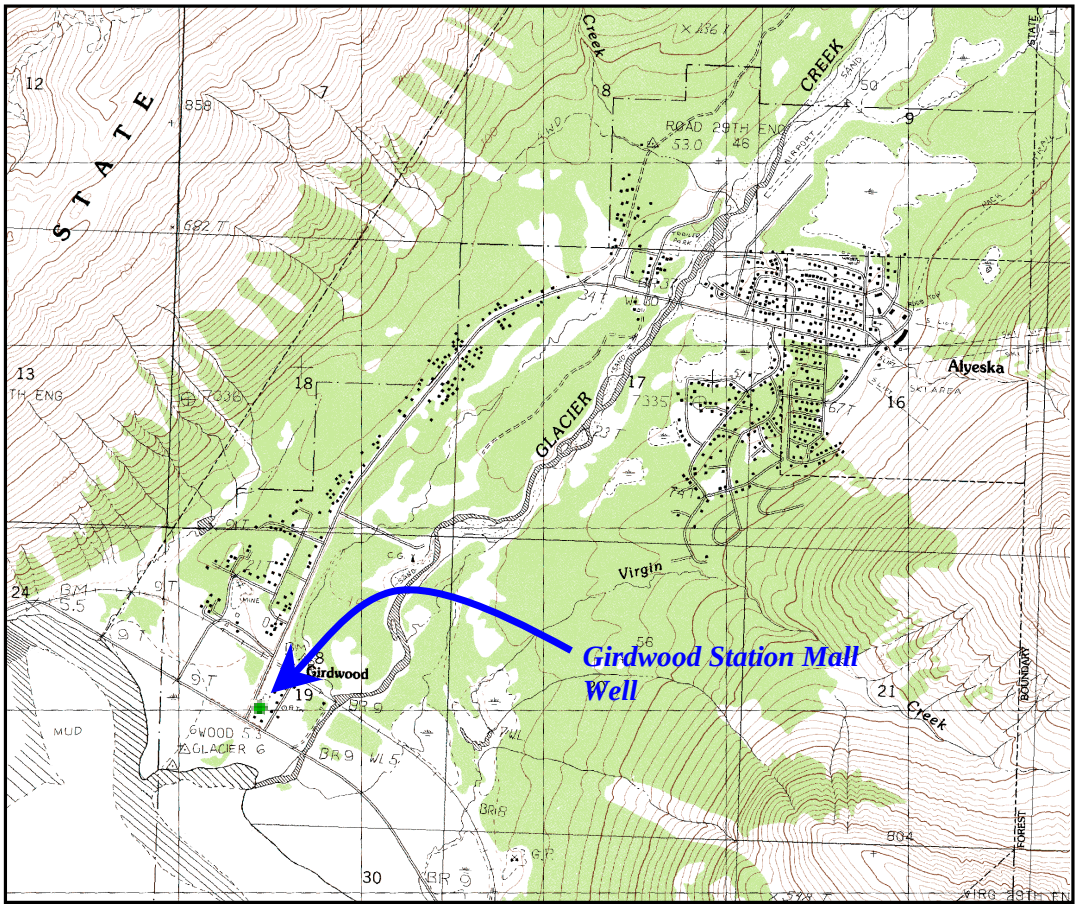

Figure 2. Map showing the location of the drinking water source for the Girdwood Station Mall.

Conceptually, surface water and groundwater flow is downgradient from steep bedrock slopes toward the unconsolidated stream and glacial deposits in the valley (see Figure 3). A 2-dimensional groundwater flow model was built to simulate groundwater flow in the saturated valley sediments (water table aquifer). This model was used as a guide in the first step in establishing the protection and assessment areas for the Girdwood Station Mall's source of public drinking water. Additional methods were further employed to take into account any uncertainties in groundwater flow and aquifer characteristics to arrive at meaningful and conservative protection and assessment areas with respect to public health (Please refer to the Guidance Manual for Class B Public Water Systems for additional information).

The Drinking Water Protection and Assessment Areas established for wells by the Alaska Department of Environmental Conservation are separated into zones. These zones correspond to a time-of-travel. Time-of-travel is the time required for water to move in the saturated zone of the ground from a specific point to the well. The Drinking Water Protection and Assessment Area for the Girdwood Station Mall contains two zones, Zone A and Zone B (See Map 1 - Map 3 in Appendix B). Zone A corresponds to ¼ of the distance to the 2-year time-of-travel isochron (a line on a map at which the time interval has the same value). Depending on where a contaminant source is located in Zone A, travel time for a contaminant to the well may be on the order of several days to several hours.

The Zone B protection and assessment area for the Girdwood Station Mall corresponds to a time-of-travel of less than two years. Zone B extends up-slope to the top of the watershed divide to take into account contaminants that may flow overland and enter valley sediments.

INVENTORY OF CONTAMINANT SOURCES

The Drinking Water Protection Program has completed an inventory of potential and existing sources of contamination within Girdwood Station Mall's Drinking Water Assessment and Protection Area. This survey was conducted through a search of agency records and other publicly available information. Potential sources of contamination to drinking water supplies cover a wide range of categories and types. Potential drinking water contaminants are found within agricultural, residential, commercial, and industrial areas, but can also occur within areas that have little or no development.

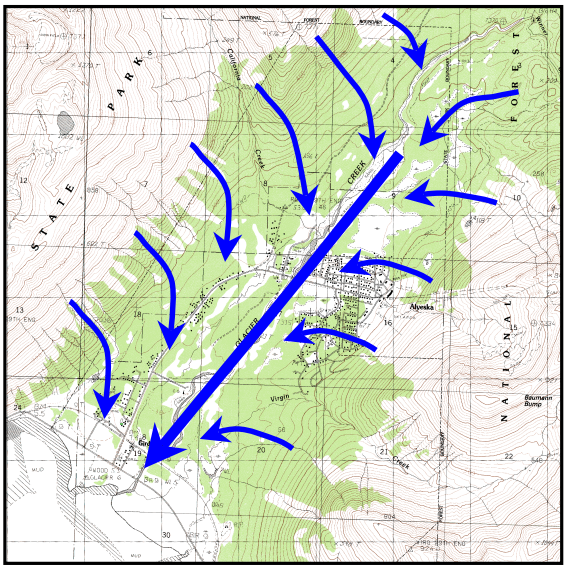

Figure 3. Map showing the conceptual groundwater flow in the Glacier Creek Valley.

For the basis of this assessment and all Class B public water system assessments, three categories of drinking water contaminants were inventoried. They include:

- Bacteria and viruses;
- Nitrates/nitrites; and
- Volatile organic chemicals.

Maps 4 in Appendix C depict the Contaminant Source Inventory for the Girdwood Station Mall. Inventoried potential sources of contamination within Zone A and Zone B were associated with residential and light industrial type activities (see Table 1 in Appendix A). Below is a summary of the sources inventoried within Girdwood Station Mall's protection and assessment areas:

- Domestic wastewater sewer lines;
- Gravel and paved roads and right-of-ways;
- Residential areas;
- An Inactive ADEC Contaminated Site;
- Above ground home heating fuel tanks;
- A Gravel pit;
- An Electric substation; and
- Livestock stables.

These potential contaminant sources present risk for all three categories of drinking water contaminants for Girdwood Station Mall's drinking water source.

In October 1989, the U.S.F.S. Glacier Ranger District reported a spill containing heating oil adjacent to the warehouse on that property. Twenty-five cubic yards of contaminated soil was removed from the site (ADEC Contaminated Site 74.04) in July 1990 and is currently inactive. This contaminated site is considered a low volatile organic chemical risk for the Girdwood Station Mall.

RANKING OF CONTAMINANT RISKS

Potential and existing sources of contamination have been identified, sorted, and ranked according to what type and level of risk they represent. Ranking of contaminant risks for a "potential" or "existing" source of contamination is a function of toxicity and volumes of specific contaminants associated with that source. Contaminant risks are further a function of the number and density of those types of contaminant sources as well as the proximity of those sources to the well.

VULNERABILITY OF GIRDWOOD STATION MALL'S DRIKING WATER SOURCE

Vulnerability of a drinking water source to contamination is a combination of two factors:

- natural susceptibility; and
- contaminant risks.

Appendix D contains four charts, which together form the 'Vulnerability Analysis' for a source water assessment for a public drinking water source. Chart 1 contains the 'Vulnerability Analysis for bacteria and viruses'. Chart 2 analyzes the 'Susceptibility of the Wellhead' to contamination by looking at the construction of the well and its surrounding area. Chart 3 analyzes the' Susceptibility of the Aquifer' to contamination by looking at the naturally occurring attributes of the water source and influences on the groundwater system that might lead to contamination. Lastly, Chart 4 analyzes 'Contaminant Risks' for the drinking water source with respect to bacteria and viruses. This portion of the analysis examines any existing or historical contamination that has been detected at the drinking water source through routine sampling. It also reviews contamination that has or may have occurred but has not arrived or been detected at the well. The 'Contaminant Risks' portion of the analysis also considers potential sources of contaminants. Chart 5 through 8 contains the Vulnerability Analysis for nitrates and/or nitrites and volatile organic chemicals, respectively.

Each of the three categories of drinking water-regulated contaminants has been analyzed and an overall vulnerability score of 0 to 100 is ultimately assigned:

Natural Susceptibility (0 – 50 points)

+

Contaminant Risks (0 – 50 points)

=

Vulnerability of the
Drinking Water Source to Contamination (0 – 100).

A score for the susceptibility of the aquifer and the well to contamination is achieved by analyzing the properties of the aquifer and the well. The Girdwood Station Mall well penetrates only minor clay rich layers of sediment, which may inhibit the movement of contaminants. The well appears to be properly grouted and sloped away from the site. Combining the susceptibility of the wellhead and the aquifer to contamination leads to a score (0 – 50 points) and rating of overall Susceptibility. Table 1 shows the overall Susceptibility score and rating for the Girdwood Station Mall.

Table 1. Susceptibility of the Wellhead and Aquifer to Contamination

	Score	**Rating**
Susceptibility	14	Medium

Contaminant Risks to a drinking water source depends on the type, number and/or density, and distribution of contaminant sources. Domestic wastewater sewer lines, a railroad corridor, livestock stables, home heating fuel tanks, gravel and paved roads and right-a-ways, residential areas, and a inactive contaminated site contribute the highest risk for potential contamination to the Girdwood Station Mall's source of public drinking water.

A score (0 – 50 points) and rating of Contaminant Risks is assigned based on the findings of the Contaminant Source Inventory (Appendix A - Table 1 – Table 4). Table 2 below summarizes the Contaminant Risks for the Girdwood Station Mall for each category of drinking regulated contaminants.

Table 2. Contaminant Risks

Contaminant Risks	Score	Rating
Bacteria & Viruses	30	High
Nitrates and/or Nitrites	36	High
Volatile Organic Chemicals	30	High

Vulnerability of the drinking water source to contamination is the combination of susceptibility of the aquifer and the well with contaminant risks. Table 3 contains the overall vulnerability scores (0 – 100) and ratings for each of the three categories of drinking water contaminants. The close proximity of wastewater sewer lines, roads, an electric substation, and a railroad corridor is reflected in the Contaminant Risks and, ultimately, the overall vulnerability of this public drinking water source to contamination. Note: scores are rounded off to the nearest five.

Table 3. Overall Vulnerability of Girdwood Station Mall Public Drinking Water System to Contamination by Category

Category	Score	Rating
Bacteria & Viruses	45	Medium
Nitrates and/or Nitrites	50	Medium
Volatile Organic Chemicals	45	Medium

SUMMARY

A *Source Water Assessment* has been completed for the Girdwood Station Mall's source of public drinking water. The overall vulnerability of this source to contamination is **medium** by bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals. This assessment of contaminant risks can be used as a foundation for local voluntary protection efforts as well as a basis for the continuous efforts on the part of agencies to protect public health. It is anticipated that *Source Water Assessments* will be updated every five years to reflect any changes in the vulnerability and/or susceptibility of this public drinking water source.

REFERENCES CITED

Glass, Roy L. and Brabets, Timothy P., 1988, Summary of water resources data for the Girdwood-Alyeska Area, Alaska: USGS Open-File Report 87-678.

Western Regional Climate Center, 2000, August 24, Web extension to the *Western Regional Climate Center* [WWW document]. URL http://www.wrcc.dri.edu/index.html

APPENDIX A

Contaminant Source Inventory and Risk Ranking for Girdwood Station Mall

Table 1

Contaminant Source Inventory for Girdwood Station Mall Public Water System

PWSID 214968

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Location	Map Number	Notes/Comments
Livestock stables/corrals	A9	A9-1	B	Corner of Toadstool and Jewell Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-1	A	Gold Street	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-2	A	West Street	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-3	B	Monarch Mine , Sproat , and Jewell Mine Roads	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-4	B	Gunnysack Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-5	B	Treasure Box Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-6	B	Hottentot Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-7	B	Agostino Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-1	A	Gold Street	Map 4	
Gravel pits/rock quarries	E10	E10-1	B	At DOT Maintenance Facility	Map 4	
Lawns and gardens	R1	R1-1	A	Gold Street	Map 4	
Lawns and gardens	R1	R1-2	B	Off Alyeska Highway and Monarch Mine Road	Map 4	
Lawns and gardens	R1	R1-3	B	Hottentot to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-4	B	Hottentot to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-5	B	Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-6	B	Treasure Box to Agostino Mine Road	Map 4	
Tanks, heating oil, residential (above ground)	R8	R8-1	B	Toadstool Tpke	Map 4	
Tanks, heating oil, residential (above ground)	R8	R8-2	B	End of Treasurebox Mine Road	Map 4	
Contaminated sites, DEC recognized, non-Superfund, non-RCRA	U4	U4-1	B	Glacier Ranger District	Map 4	1989 heating oil spill
Highways and roads, paved (cementor asphalt)	X20	X20-1	A	Alyeska Highway	Map 4	
Highways and roads, paved (cementor asphalt)	X20	X20-1	A	Alyeska Highway	Map 4	
Highways and roads, dirt/gravel	X24	X24-1	A	Gold Street	Map 4	
Highways and roads, dirt/gravel	X24	X24-2	A	West Street	Map 4	
Highways and roads, dirt/gravel	X24	X24-3	B	Monarch Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-4	B	Sproat Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-5	B	Jewell Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-6	B	Toadstool Tpke	Map 4	
Highways and roads, dirt/gravel	X24	X24-7	B	Gunnysack Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-8	B	Treasure Box Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-9	B	Hottentot Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-10	B	Agostino Mine Road	Map 4	
Rail corridors	X30	X30-1	A	Crosses Alyeska Highway	Map 4	
Electric Substation	X37	X37-1	A	Corner of West and Gold Ave	Map 4	

Table 2

Contaminant Source Inventory and Risk Ranking for Girdwood Station Mall Public Water System Sources of Bacteria and Viruses

PWSID 214968

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Anaysis	Location	Map Number	Notes/Comments
Domestic wastewater collection systems (sewer lines)	D1	D1-1	A	Medium	1	Gold Street	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-2	A	Medium	2	West Street	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-3	B	Medium	3	Monarch Mine , Sproat , and Jewell Mine Roads	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-4	B	Medium	4	Gunnysack Mine Road	Map 4	
Livestock stables/corrals	A9	A9-1	B	Medium	5	Corner of Toadstool and Jewell Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-5	B	Medium	6	Treasure Box Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-6	B	Medium	7	Hottentot Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-7	B	Medium	8	Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-1	A	Low	9	Gold Street	Map 4	
Lawns and gardens	R1	R1-2	B	Low	10	Off Alyeska Highway and Monarch Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-1	A	Low	11	Gold Street	Map 4	
Highways and roads, dirt/gravel	X24	X24-2	A	Low	12	West Street	Map 4	
Highways and roads, paved (cementor asphalt)	X20	X20-1	A	Low	13	Alyeska Highway	Map 4	
Highways and roads, dirt/gravel	X24	X24-3	B	Low	14	Monarch Mine Road	Map 4	
Lawns and gardens	R1	R1-3	B	Low	15	Hottentot to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-4	B	Low	16	Hottentot to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-5	B	Low	17	Agostino Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-4	B	Low	18	Sproat Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-5	B	Low	19	Jewell Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-6	B	Low	20	Toadstool Tpke	Map 4	
Highways and roads, dirt/gravel	X24	X24-7	B	Low	21	Gunnysack Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-8	B	Low	22	Treasure Box Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-9	B	Low	23	Hottentot Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-10	B	Low	24	Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-6	B	Low	25	Treasure Box to Agostino Mine Road	Map 4	

Table 3

Contaminant Source Inventory and Risk Ranking for Girdwood Station Mall Public Water System Sources of Nitrates/Nitrites

PWSID 214968

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Anaysis	Location	Map Number	Notes/Comments
Domestic wastewater collection systems (sewer lines)	D1	D1-1	A	Medium	1	Gold Street	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-2	A	Medium	2	West Street	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-3	B	Medium	3	Monarch Mine , Sproat , and Jewell Mine Roads	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-4	B	Medium	4	Gunnysack Mine Road	Map 4	
Livestock stables/corrals	A9	A9-1	B	Medium	5	Corner of Toadstool and Jewell Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-5	B	Medium	6	Treasure Box Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-6	B	Medium	7	Hottentot Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-7	B	Medium	8	Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-1	A	Low	9	Gold Street	Map 4	
Lawns and gardens	R1	R1-2	B	Low	10	Off Alyeska Highway and Monarch Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-1	A	Low	11	Gold Street	Map 4	
Highways and roads, dirt/gravel	X24	X24-2	A	Low	12	West Street	Map 4	
Highways and roads, paved (cementor asphalt)	X20	X20-1	A	Low	13	Alyeska Highway	Map 4	
Highways and roads, dirt/gravel	X24	X24-3	B	Low	14	Monarch Mine Road	Map 4	
Lawns and gardens	R1	R1-3	B	Low	15	Hottentot to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-4	B	Low	16	Hottentot to Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-5	B	Low	17	Agostino Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-4	B	Low	18	Sproat Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-5	B	Low	19	Jewell Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-6	B	Low	20	Toadstool Tpke	Map 4	
Highways and roads, dirt/gravel	X24	X24-7	B	Low	21	Gunnysack Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-8	B	Low	22	Treasure Box Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-9	B	Low	23	Hottentot Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-10	B	Low	24	Agostino Mine Road	Map 4	
Lawns and gardens	R1	R1-6	B	Low	25	Treasure Box to Agostino Mine Road	Map 4	

Table 4

Contaminant Source Inventory and Risk Ranking for Girdwood Station Mall Public Water System Sources of Volatile Organic Chemicals

PWSID 214968

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Anaysis	Location	Map Number	Notes/Comments
Rail corridors	X30	X30-1	A	Medium	1	Crosses Alyeska Highway	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-1	A	Low	2	Gold Street	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-2	A	Low	3	West Street	Map 4	
Contaminated sites, DEC recognized, non-Superfund, non-RCRA	U4	U4-1	B	Low	4	Glacier Ranger District	Map 4	1989 heating oil spill
Tanks, heating oil, residential (above ground)	R8	R8-1	B	Medium	5	Toadstool Tpke	Map 4	
Tanks, heating oil, residential (above ground)	R8	R8-2	B	Medium	6	End of Treasurebox Mine Road	Map 4	
Electric Substation	X37	X37-1	A	Low	7	Corner of West and Gold Ave	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-3	B	Low	8	Monarch Mine , Sproat , and Jewell Mine Roads	Map 4	
Highways and roads, paved (cementor asphalt)	X20	X20-1	A	Low	9	Alyeska Highway	Map 4	
Highways and roads, dirt/gravel	X24	X24-1	A	Low	10	Gold Street	Map 4	
Highways and roads, dirt/gravel	X24	X24-2	A	Low	11	West Street	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-4	B	Low	12	Gunnysack Mine Road	Map 4	
Gravel pits/rock quarries	E10	E10-1	B	Low	13	At DOT Maintenance Facility	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-5	B	Low	14	Treasure Box Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-6	B	Low	15	Hottentot Mine Road	Map 4	
Domestic wastewater collection systems (sewer lines)	D1	D1-7	B	Low	16	Agostino Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-3	B	Low	17	Monarch Mine Road	Map 4	
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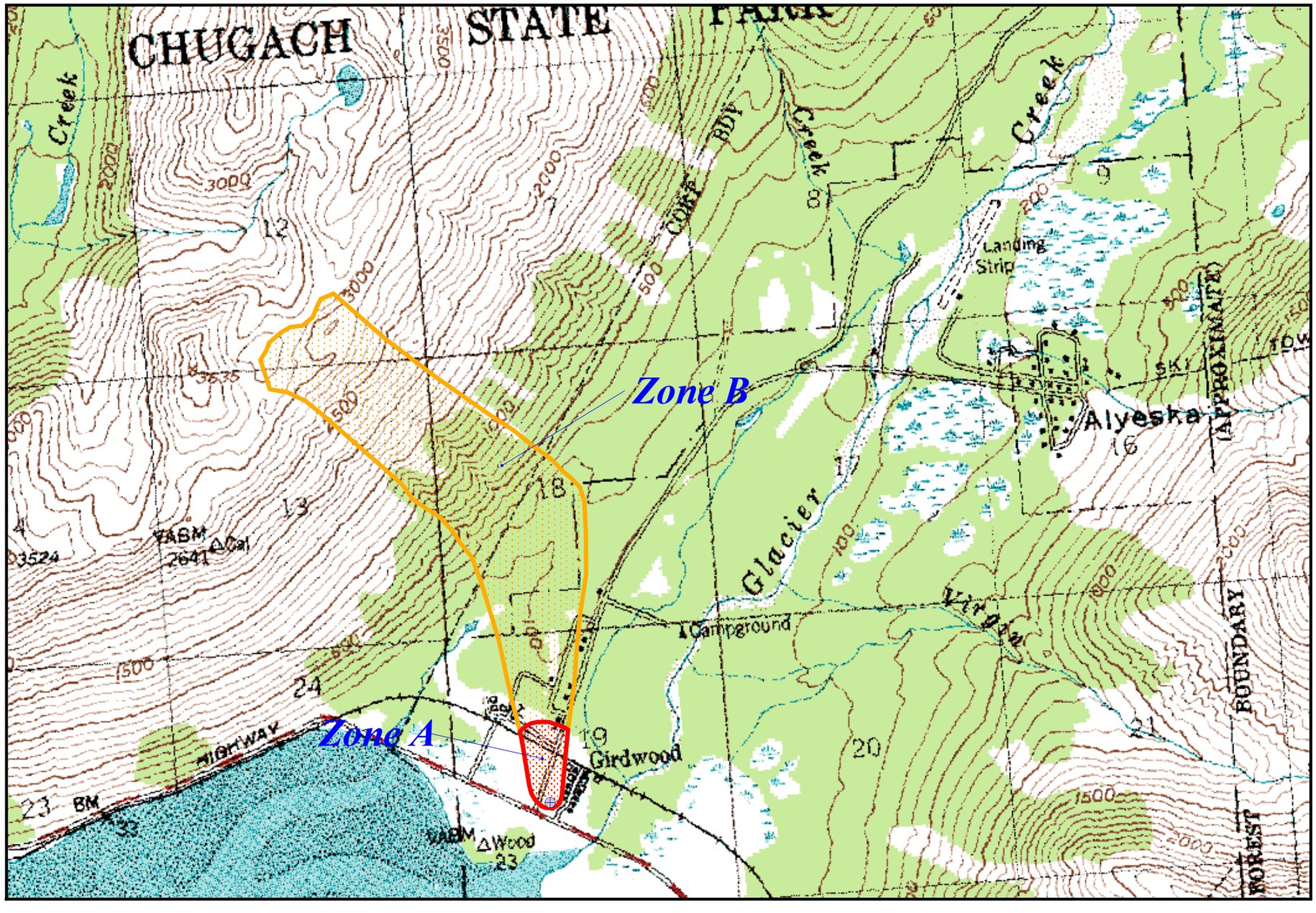
Highways and roads, dirt/gravel	X24	X24-8	B	Low	22	Treasure Box Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-9	B	Low	23	Hottentot Mine Road	Map 4	
Highways and roads, dirt/gravel	X24	X24-10	B	Low	24	Agostino Mine Road	Map 4	

APPENDIX B

Girdwood Station Mall's
Drinking Water Protection Area

Girdwood Station Mall (PWSID 214968)
Drinking Water Protection Areas



⊕ Girdwood Station Mall Well

Zone A Protection Area
Several Months Travel Time

Zone B Protection Area
Less Than 2 Years Travel Time

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W E
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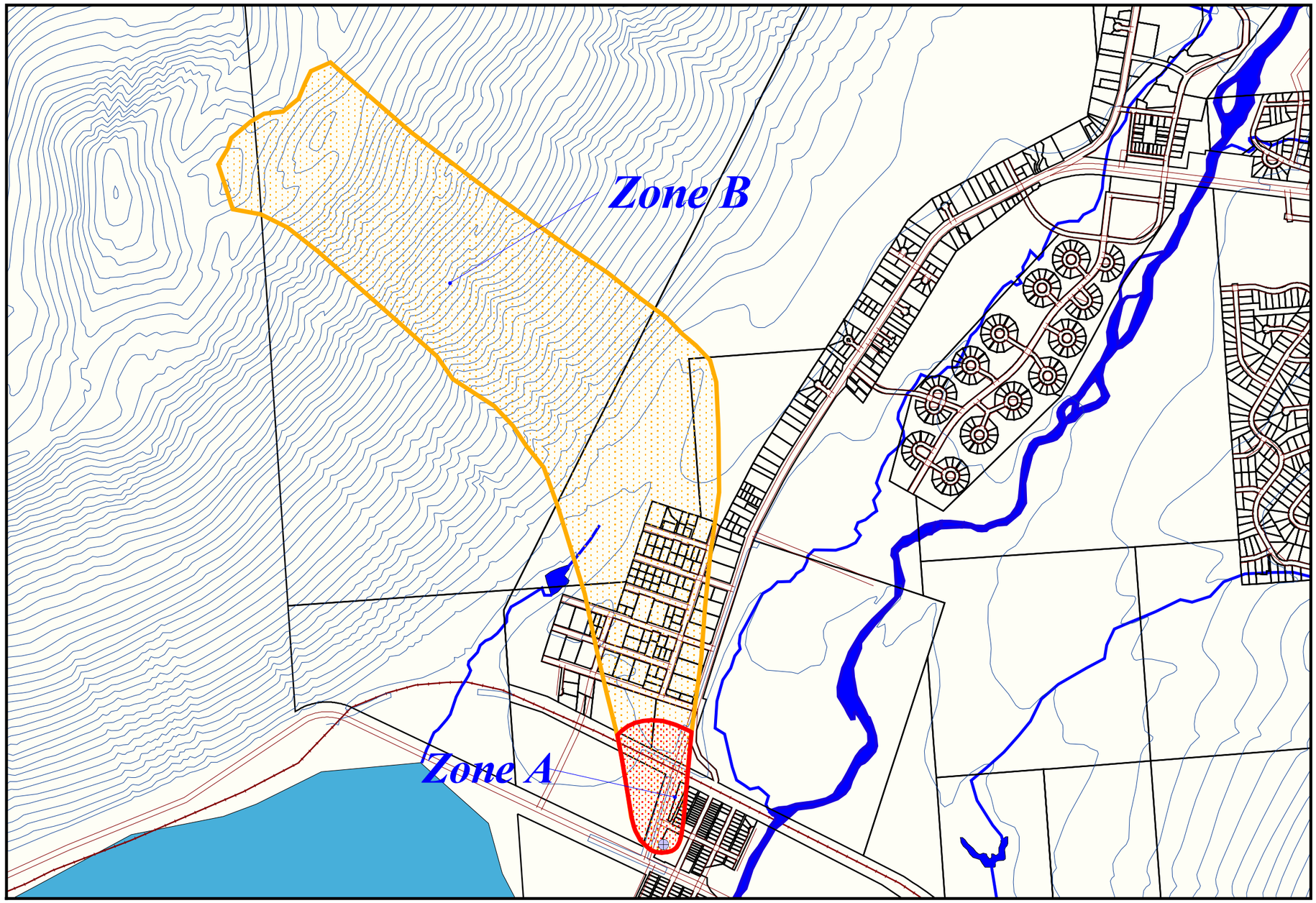
Map 1

Girdwood Station Mall (PWSID 214968)
Drinking Water Protection Areas



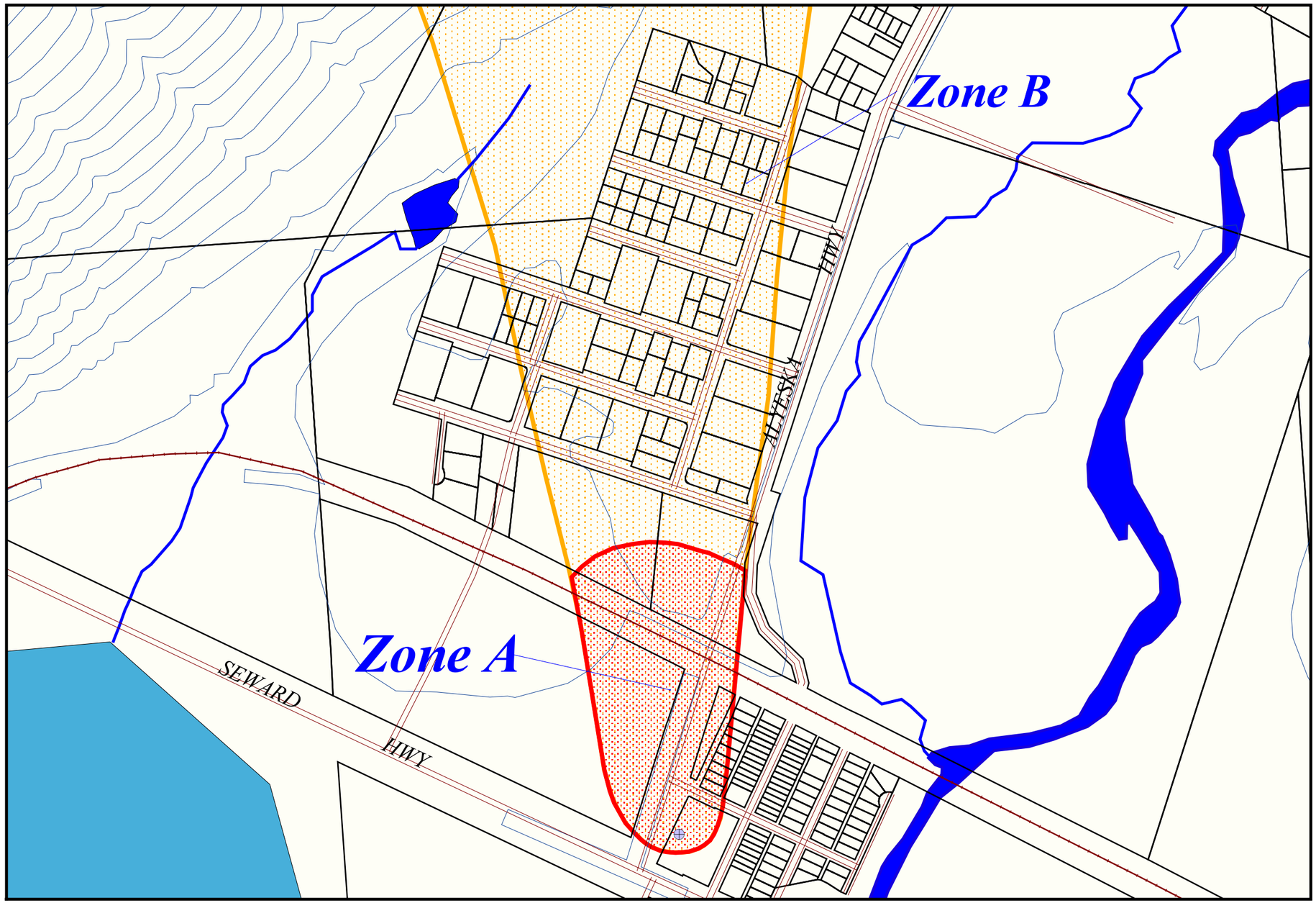
Girdwood Station Mall Well
Zone A Protection Area
Several Months Travel Time
Zone B Protection Area
Less Than 2 Years Travel Time
MOA Roads
Elevation Contours
MOA Land Parcels
2nd order streams
3rd order streams
4th order streams
Lakes and Ponds
Glacier Creek
Railroads
Turnagain Arm of Cook Inlet

N
W
E
S

3000 0 3000 Feet

Map 2

Girdwood Station Mall (PWSID 214968)
Drinking Water Protection Areas



Girdwood Station Mall Well
Railroads
MOA Roads
Elevation Contours
MOA Land Parcels
2nd order streams
3rd order streams
4th order streams
Lakes and Ponds
Glacier Creek
Zone A Protection Area
Several Months Travel Time
Zone B Protection Area
Less Than 2 Years Travel Time
Turnagain Arm of Cook Inlet

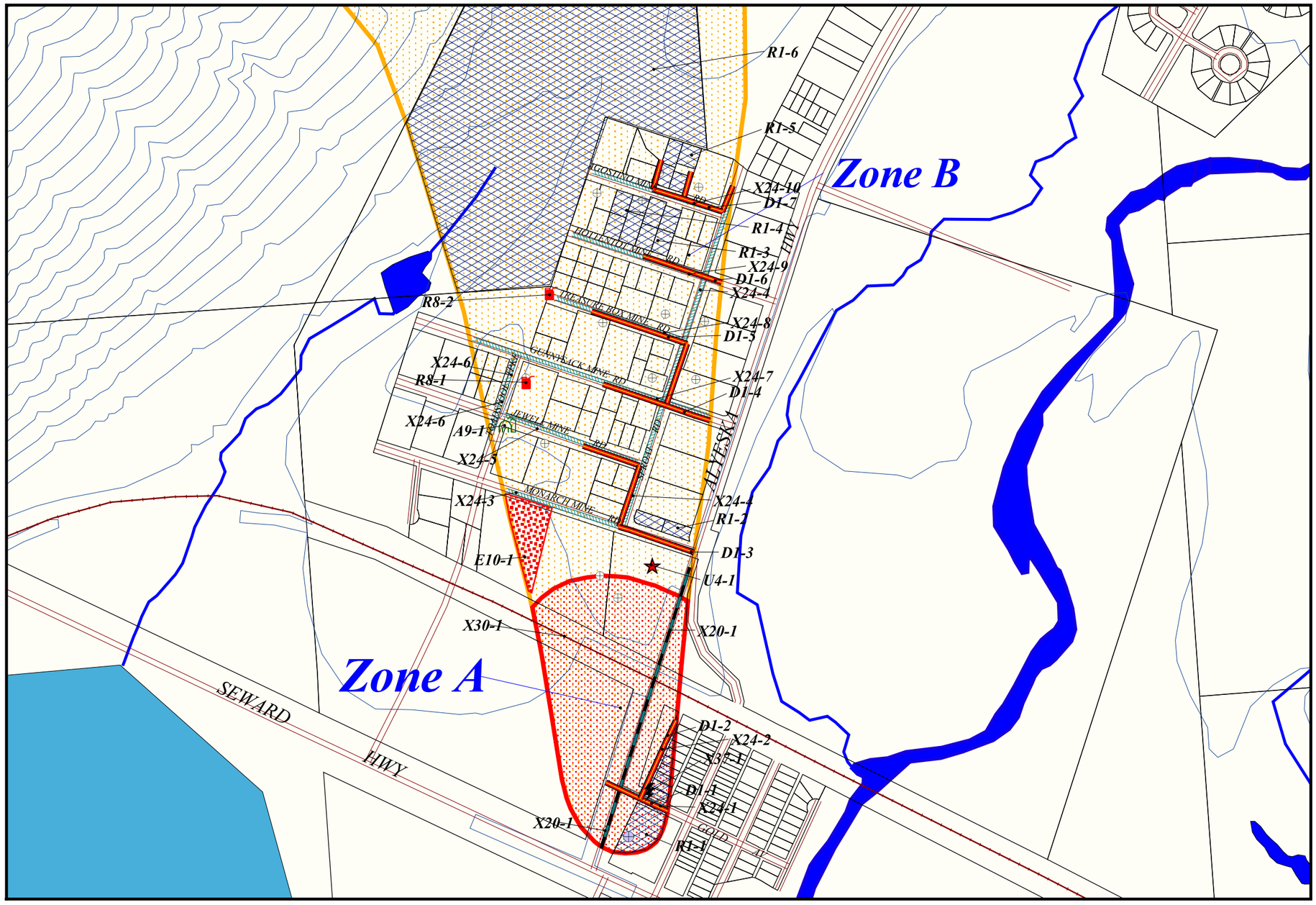
N
W
E
S

Map 3

APPENDIX C

Girdwood Station Mall's Drinking Water Protection Area and Potential & Existing Contaminant Sources

Girdwood Station Mall (PWSID 214968) Drinking Water Protection Areas and Potential and Existing Sources of Contamination



Potential and Existing Sources of Contamination

- Contaminated sites, ADEC recognized
- Electric Substation
- Livestock stables/corrals
- Tanks, heating oil, residential (above ground)
- Girdwood station mall sewer lines.shp
- Paved Roads
- Gravel Roads
- Gravel Pits
- Girdwood Station Mall Well
- Residential Areas
- Private and Public Drinking Water Wells
- Railroads
- MOA Roads
- Elevation Contours
- MOA Land Parcels
- 2nd order streams
- 3rd order streams
- 4th order streams
- Lakes and Ponds
- Glacier Creek

Zone A Protection Area

- Several Months Travel Time

Zone B Protection Area

- Less Than 2 Years Travel Time
- Turnagain Arm of Cook Inlet

Map 4

APPENDIX D

Vulnerability Analysis for Girdwood Station Mall Public Drinking Water System

Chart 1. Vulnerability analysis for Bacteria & Viruses – Girdwood Station Mall

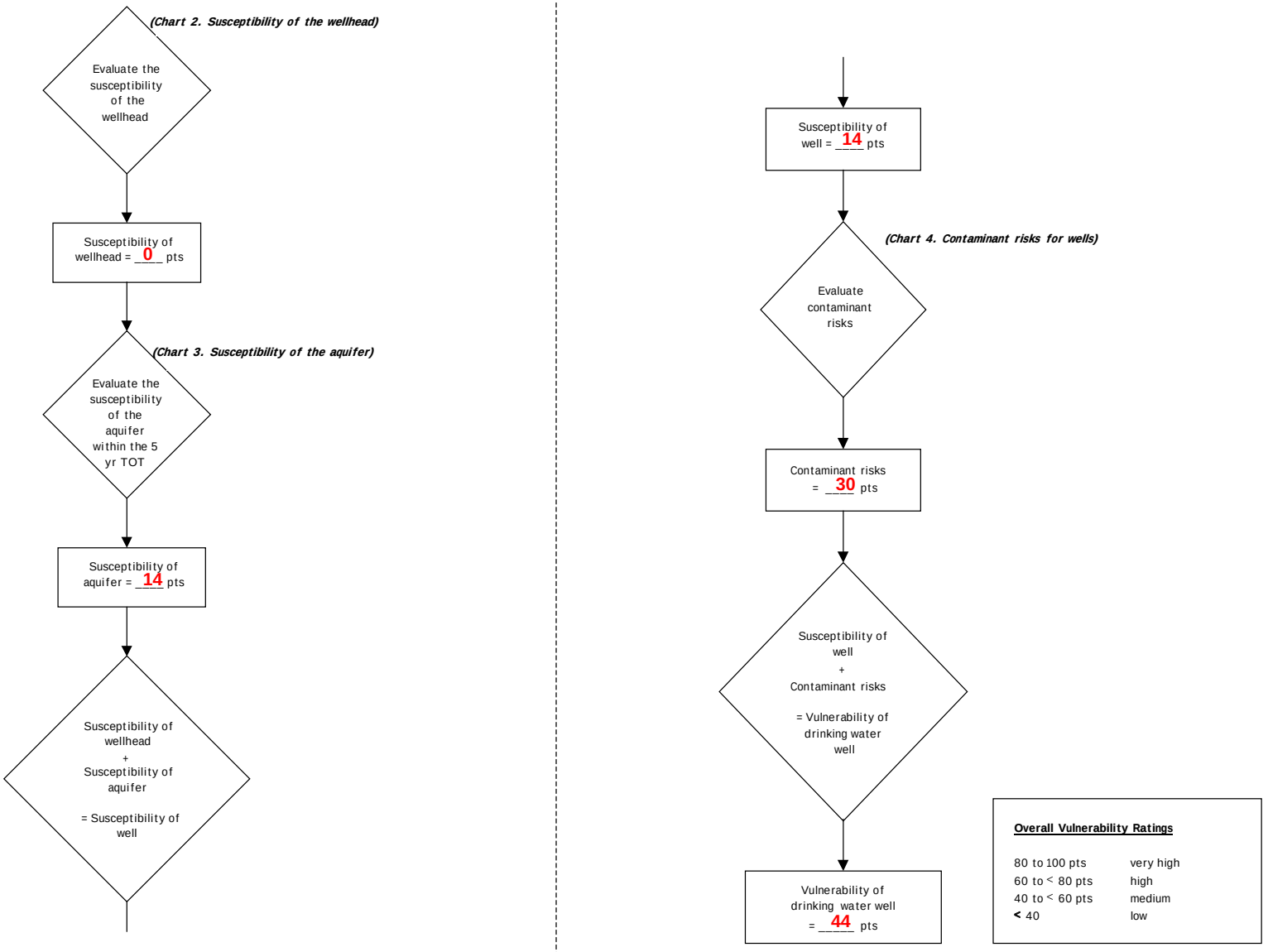
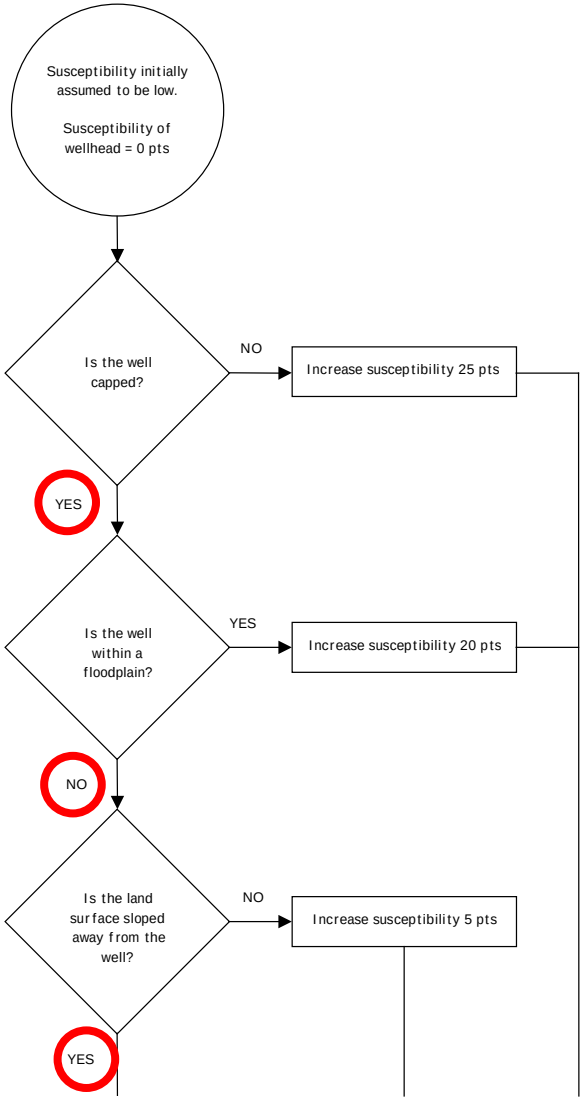
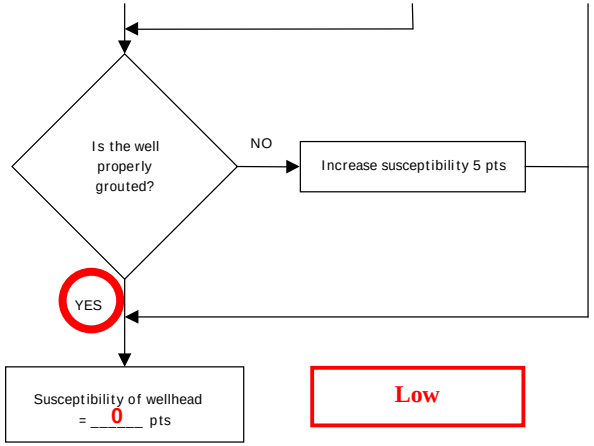


Chart 2. Susceptibility of the wellhead

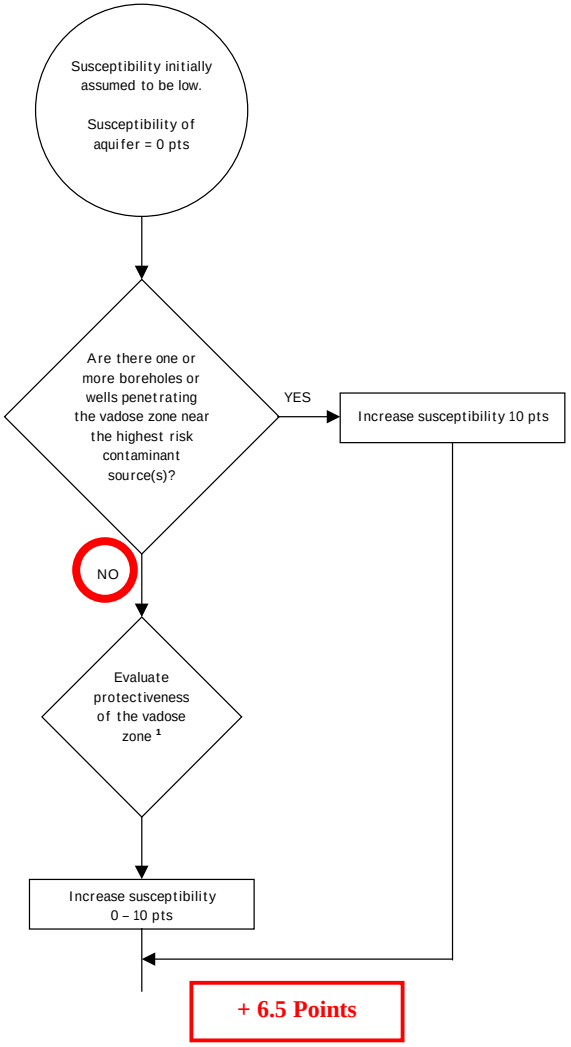


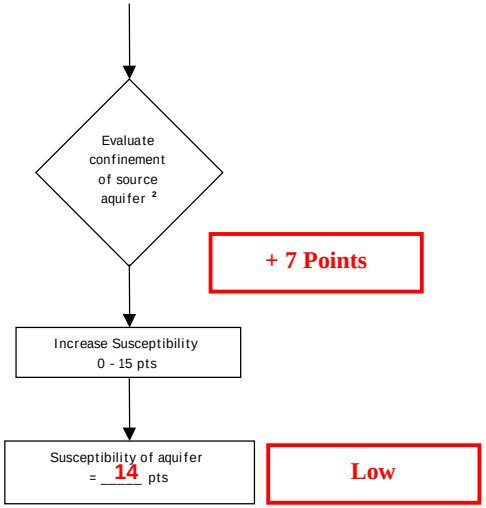


Wellhead Susceptibility Ratings

20 to 25 pts	very high
15 to < 20 pts	high
10 to < 15 pts	medium
< 10	low

Chart 3. Susceptibility of the aquifer





1. Protectiveness of the Vadose Zone

- net recharge (function of precipitation, slope of land surface, & permeability of soils)
  [0 – 10 pts; 50% weight]
- depth to water table (unconfined aquifer) or top of confining layer (confined aquifer)
  [interpolate linearly: 100' – 20', 0 – 5 pts; 20' – 0', 5 – 10 pts; 50% weight]

Net Recharge
7*0.5 = 3.5

Depth to Water Table
6*0.5 = 3

Total = 6.5

2. Degree of Confinement

- confined verses unconfined aquifer
  [confined: K ≤ 10^{-6} cm/s, minimum thickness of at least one layer = 20 ft, interpolate linearly 100' – 20', 0 – 10 pts; unconfined = 15 pts; 65% weight]
- density of boreholes and wells penetrating the confining layer (confined aquifer) or the water table (unconfined aquifer)
  [confined: 0 – 15 pts; unconfined = 15 pts; 35% weight]

Confinement?
3 feet of clay, 22 feet of silty clayey gravel:
10/15*0.65 = 6.5

Boreholes
Many in Zone B
10/15*0.35 = 3.5

Total = 7

Aquifer Susceptibility Ratings

20 to 25 pts	very high
15 to < 20 pts	high
10 to < 15 pts	medium
< 10	low

Medium

Chart 4. Contaminant risks for Girdwood Station Mall – Bacteria & Viruses

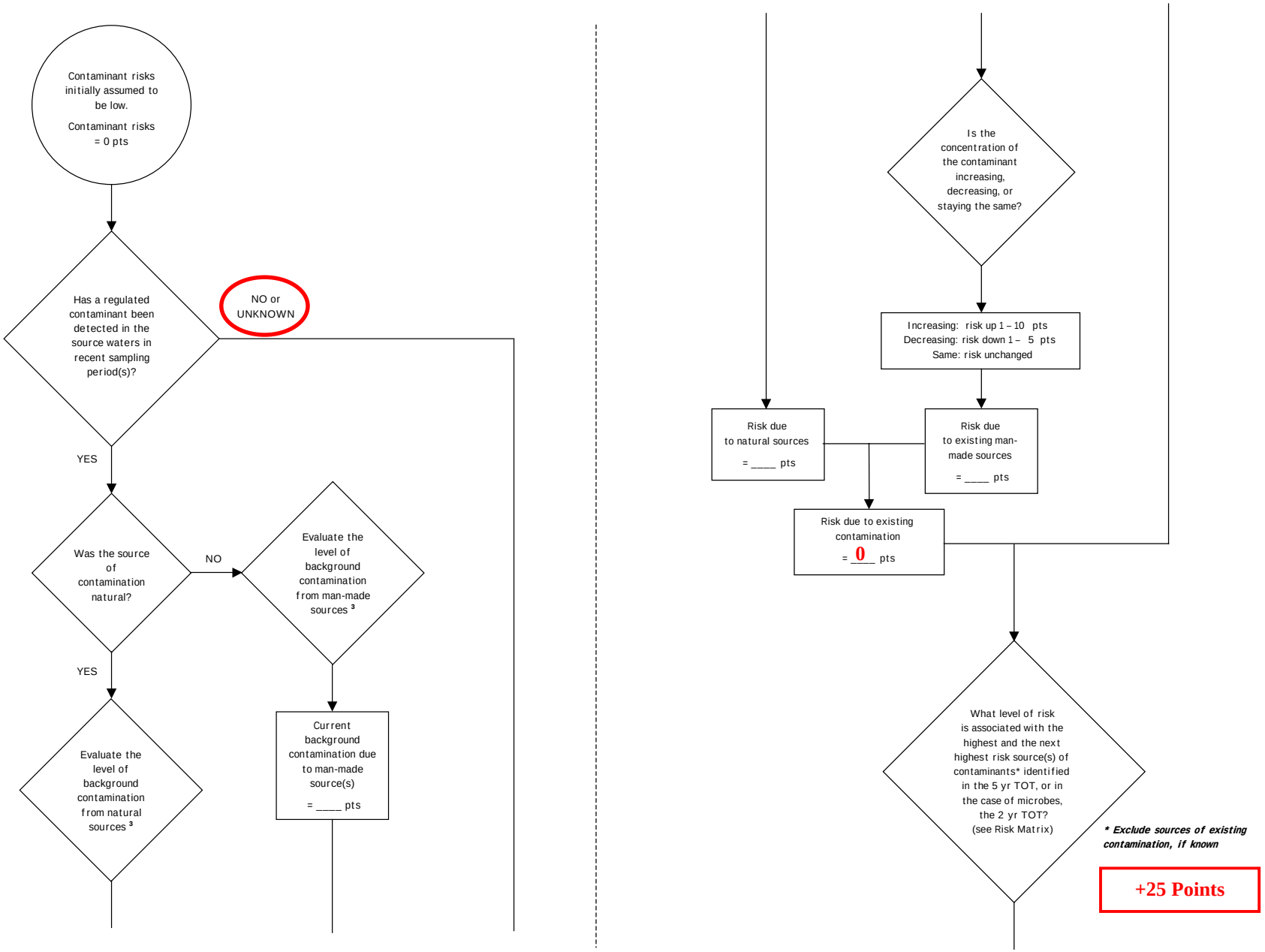
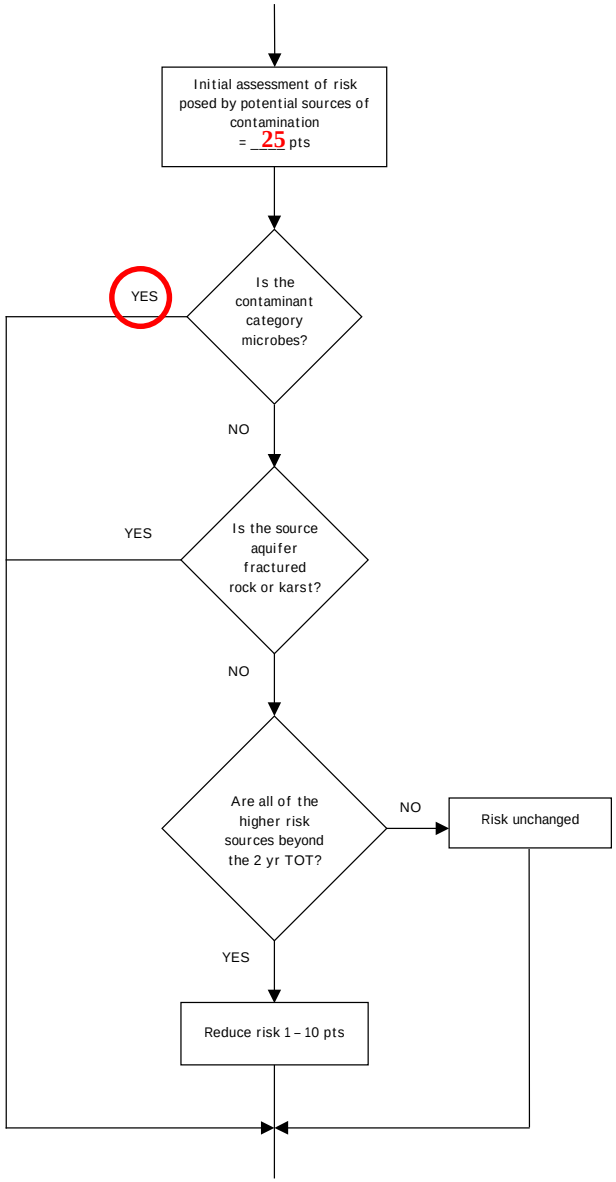


Chart 4. Contaminant risks for Girdwood Station Mall – Bacteria & Viruses (Continued)



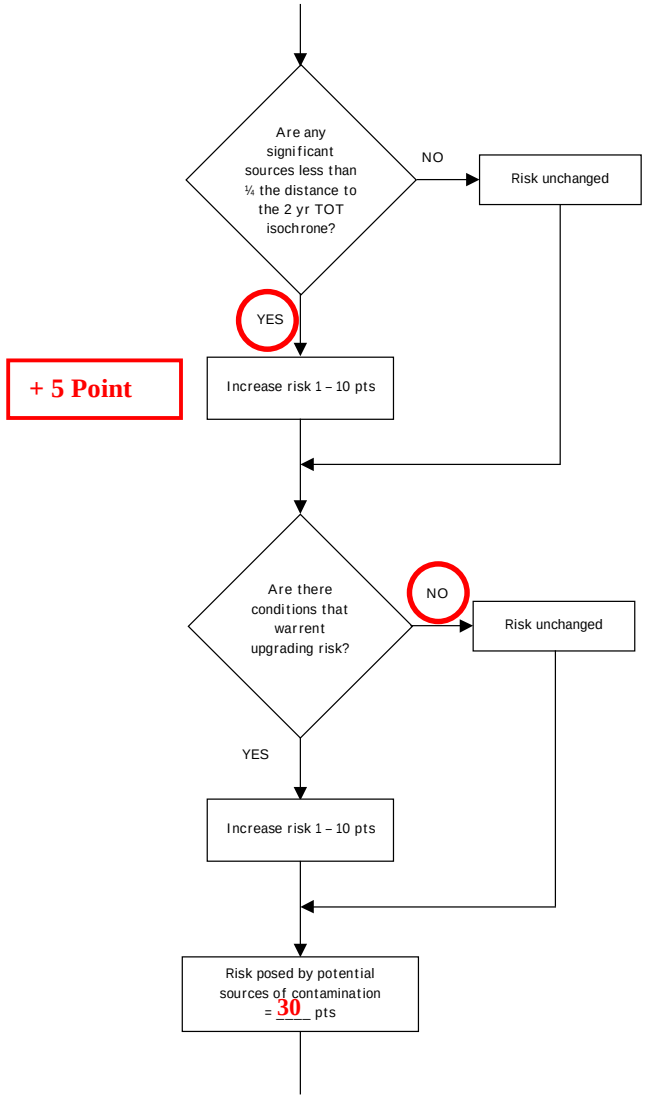
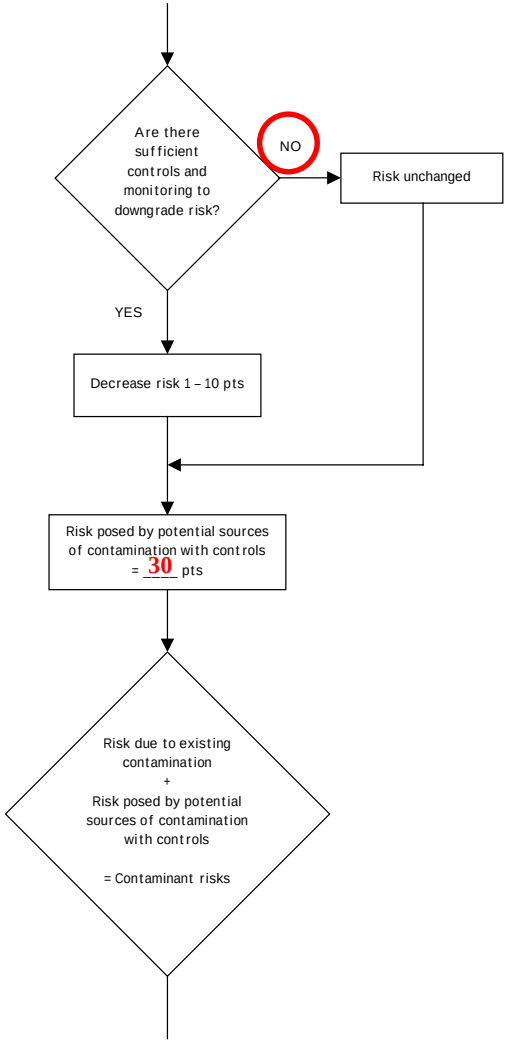
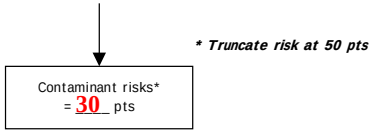


Chart 4. Contaminant risks for Girdwood Station Mall – Bacteria & Viruses (Continued)





3. Level of Background Contamination

> MCL	50 pts
0.5 MCL to < MCL	20 pts
0.2 MCL to < 0.5 MCL	10 pts
'detect' to < 0.2 MCL	5 pts

Contaminant Risk Ratings

40 to 50 pts	very high
30 to < 40 pts	high
20 to < 30 pts	medium
< 20	low

Table 5. Risk Matrix for Contaminant Sources for Bacteria & Viruses – Girdwood Station Mall

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	**LOW 10 pts**	**MEDIUM 20 pts**	**HIGH 30 pts**	**VERY HIGH 40 pts**
Low	≥ 10 sources + 10 pts	≥ 10 sources + 5 pts	≥ 20 sources + 5 pts	—
Medium	—	≥ 2 sources + 5 pts	≥ 5 sources + 5 pts	≥ 10 sources + 5 pts
High	—	—	1 source + 10 pts	≥ 2 sources + 10 pts
Very High	—	—	—	1 source + 10 pts

Chart 5. Vulnerability analysis for Nitrates/Nitrites – Girdwood Station Mall

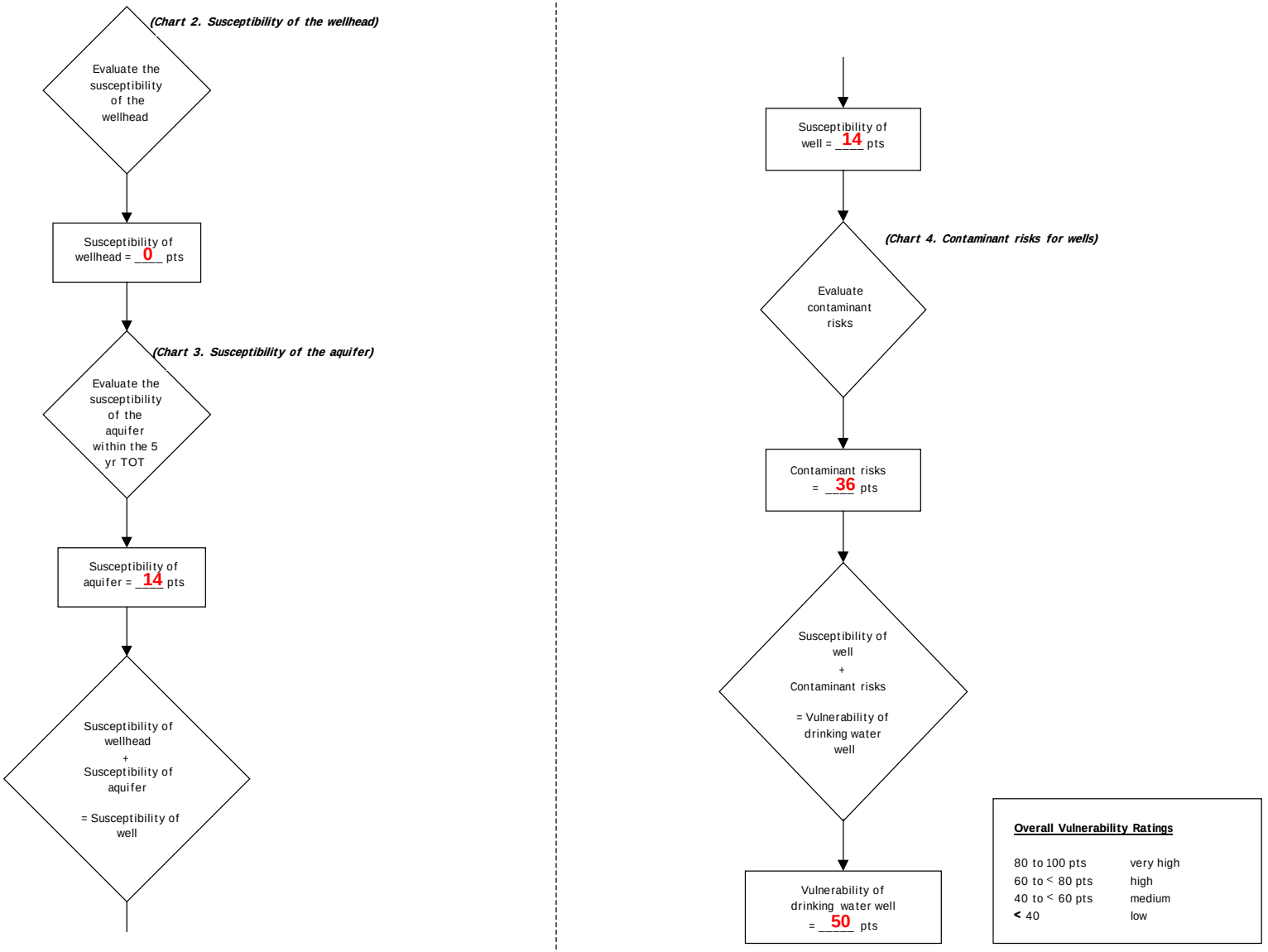


Chart 6. Contaminant risks for Girdwood Station Mall – Nitrates/Nitrites

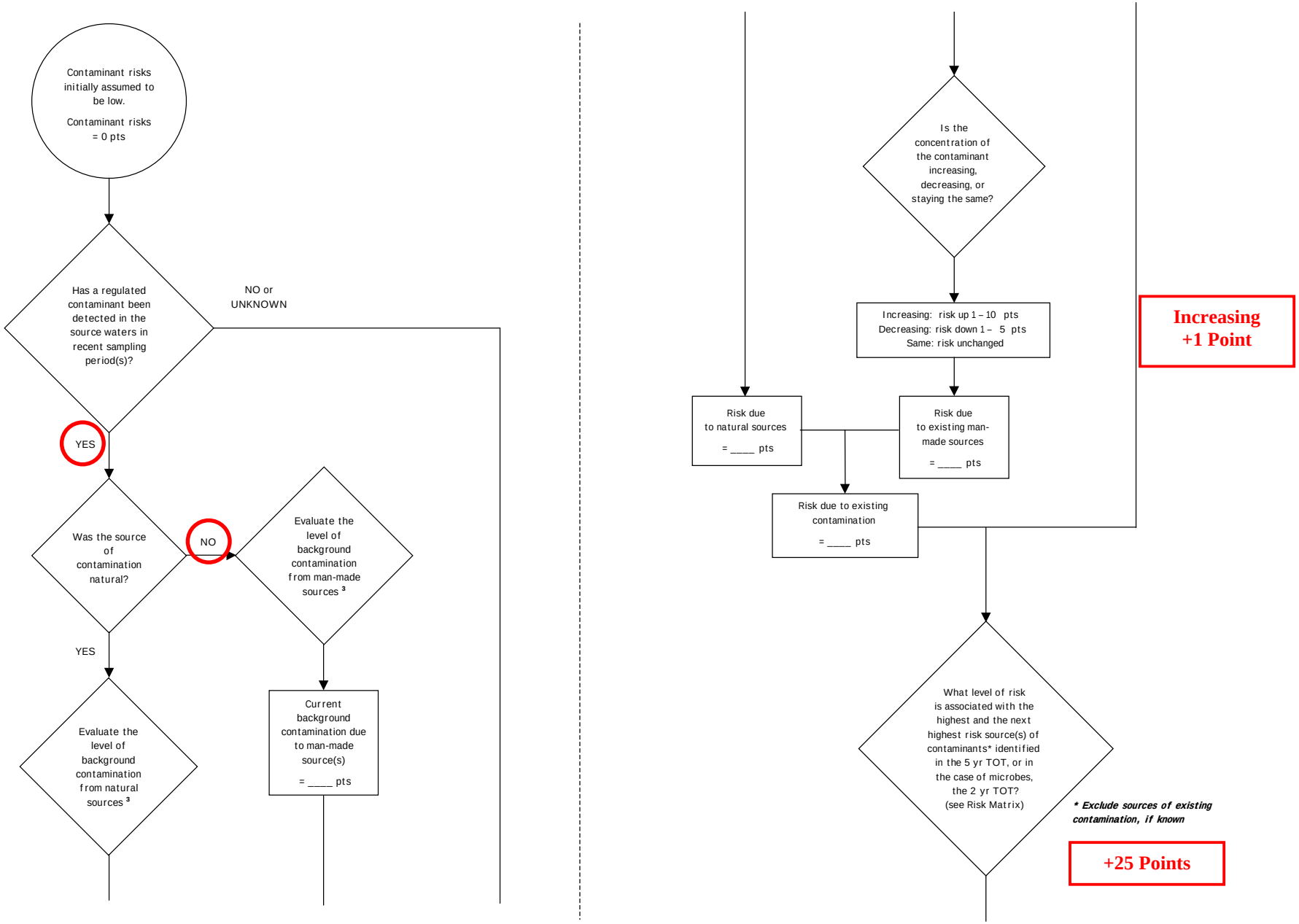
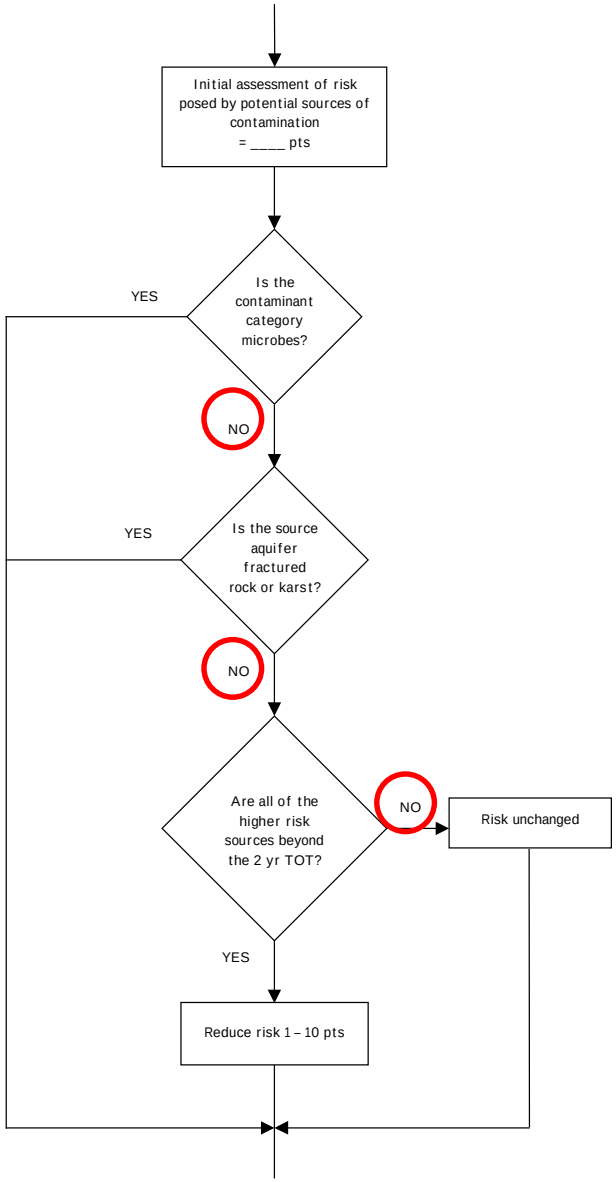


Chart 6. Contaminant risks for Girdwood Station Mall – Nitrates/Nitrites (Continued)



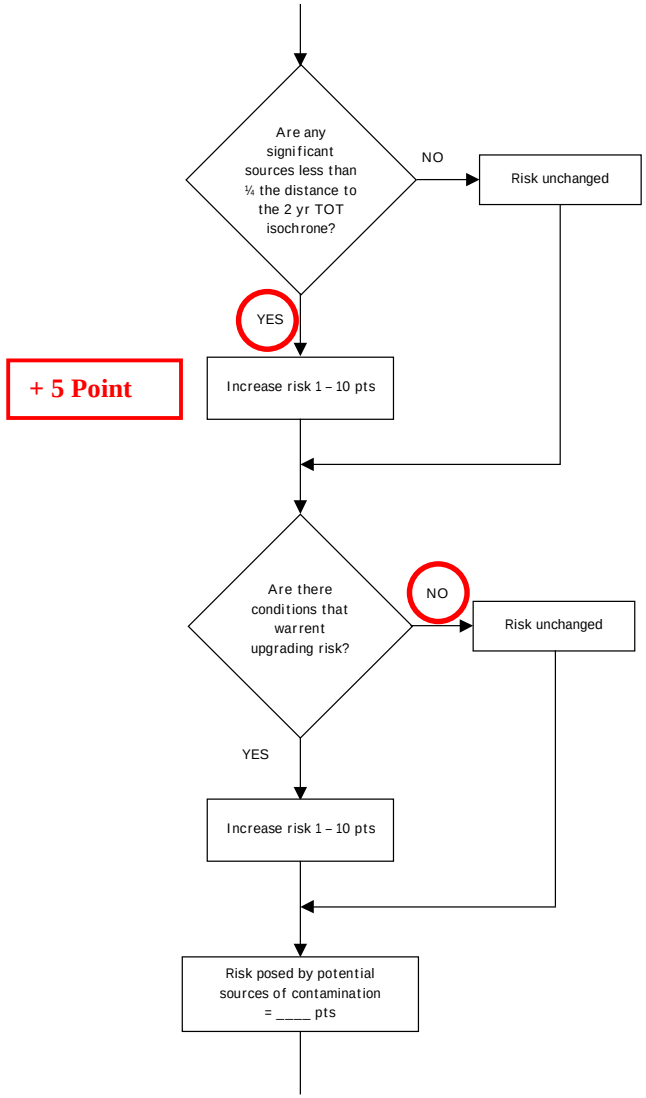
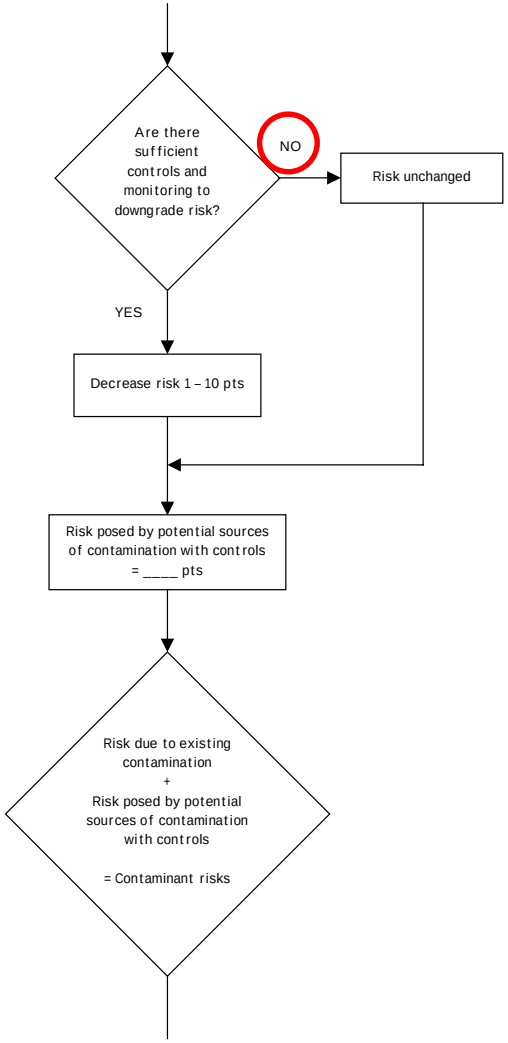


Chart 6. Contaminant risks for Girdwood Station Mall – Nitrates/Nitrites (Continued)



Contaminant risks* = ____ pts

**** Truncate risk at 50 pts***

3. Level of Background Contamination

> MCL	50 pts
0.5 MCL to < MCL	20 pts
0.2 MCL to < 0.5 MCL	10 pts
'detect' to < 0.2 MCL	5 pts

Contaminant Risk Ratings

40 to 50 pts	very high
30 to < 40 pts	high
20 to < 30 pts	medium
< 20	low

Level	Date
352	7/8/97
290	5/7/97
270	6/13/96
230	2/15/96

352/10000 = 0.03

High

Table 6. Risk Matrix for Contaminant Sources for Nitrates/Nitrites – Girdwood Station Mall

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	LOW 10 pts	MEDIUM 20 pts	HIGH 30 pts	VERY HIGH 40 pts
Low	≥ 10 sources + 10 pts	≥ 10 sources + 5 pts	≥ 20 sources + 5 pts	—
Medium	—	≥ 2 sources + 5 pts	≥ 5 sources + 5 pts	≥ 10 sources + 5 pts
High	—	—	1 source + 10 pts	≥ 2 sources + 10 pts
Very High	—	—	—	1 source + 10 pts

Chart 7. Vulnerability analysis for Volatile Organic Chemicals – Girdwood Station Mall

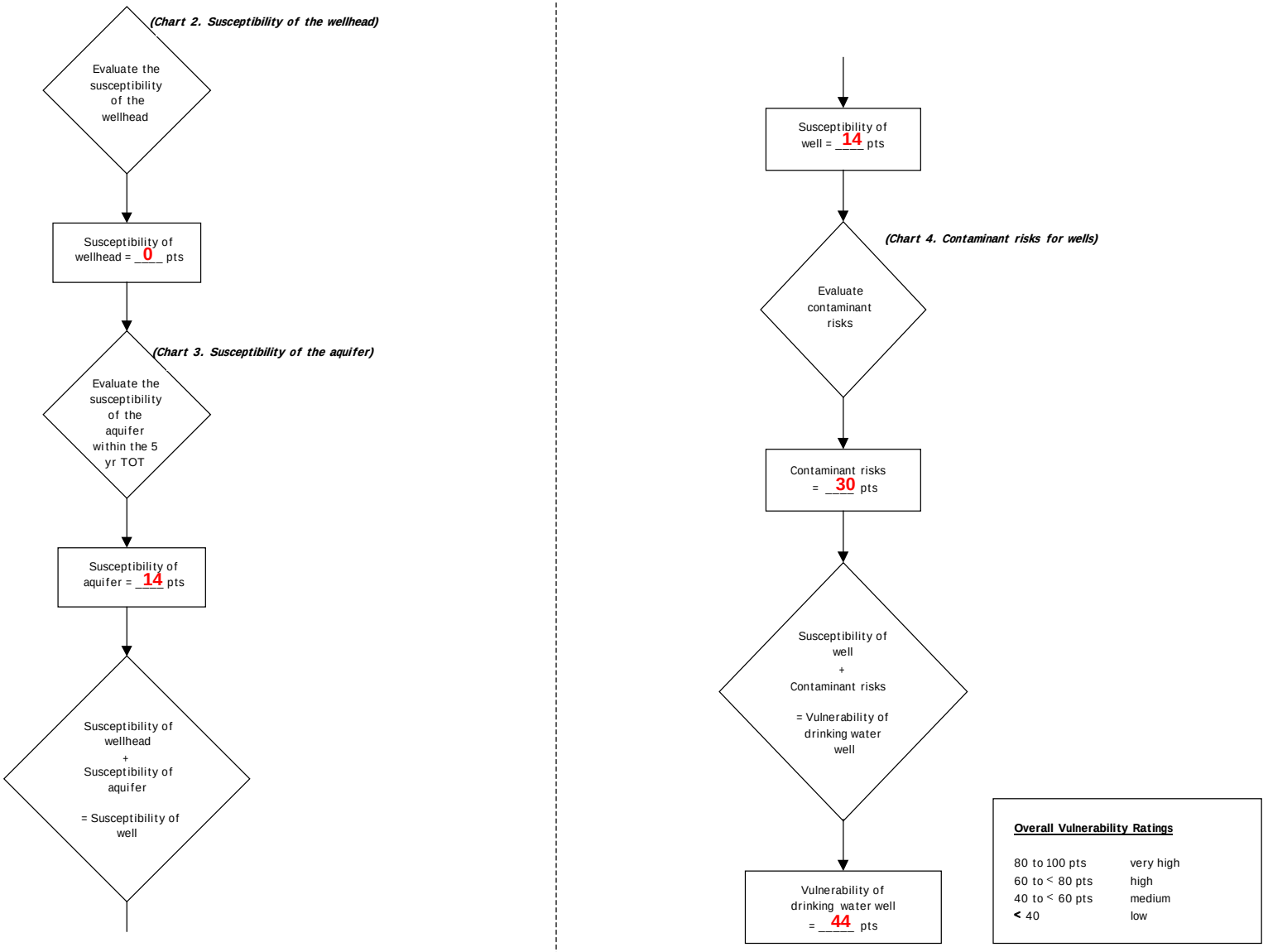


Chart 8. Contaminant risks for Girdwood Station Mall – Volatile Organic Chemicals

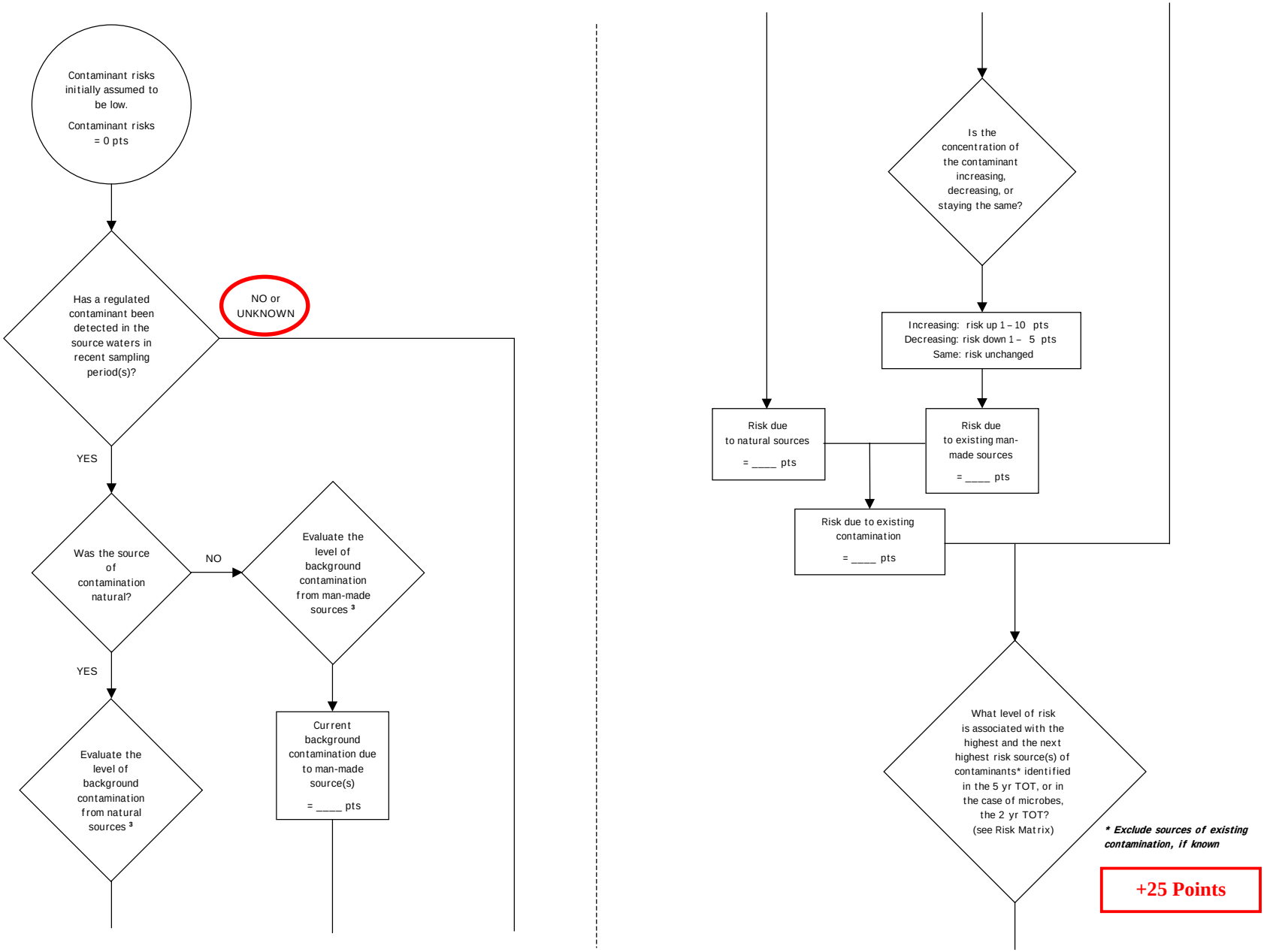
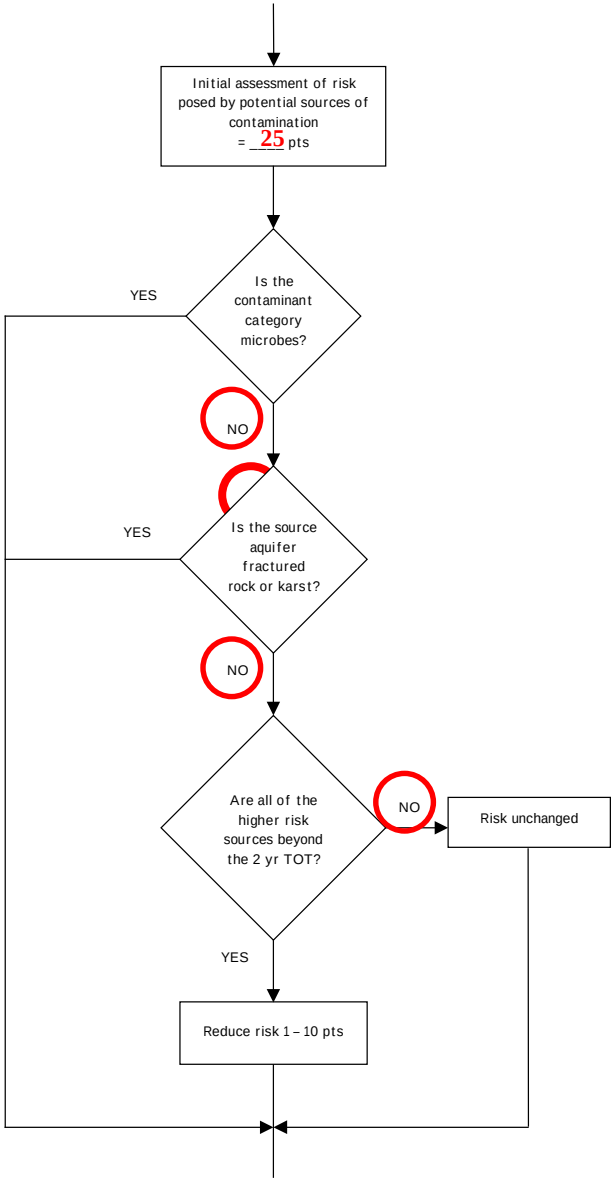


Chart 3. Susceptibility of the aquifer

Chart 8. Contaminant risks for Girdwood Station Mall – Volatile Organic Chemicals (Continued)



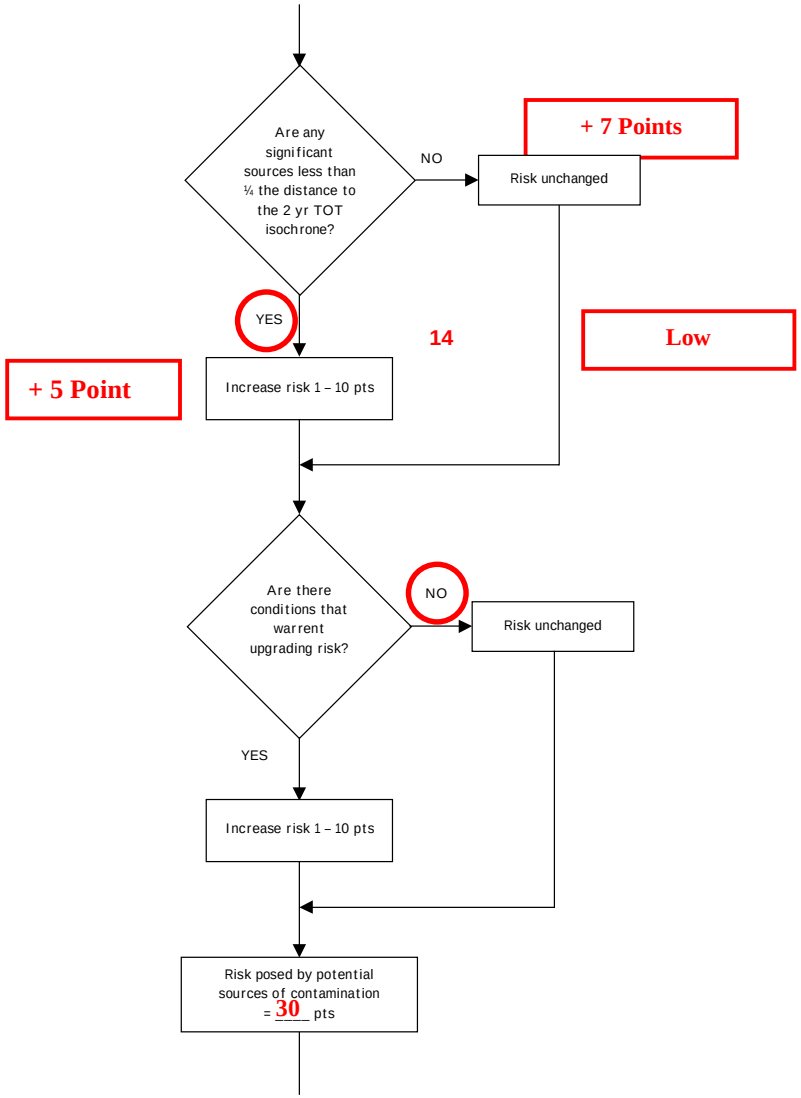
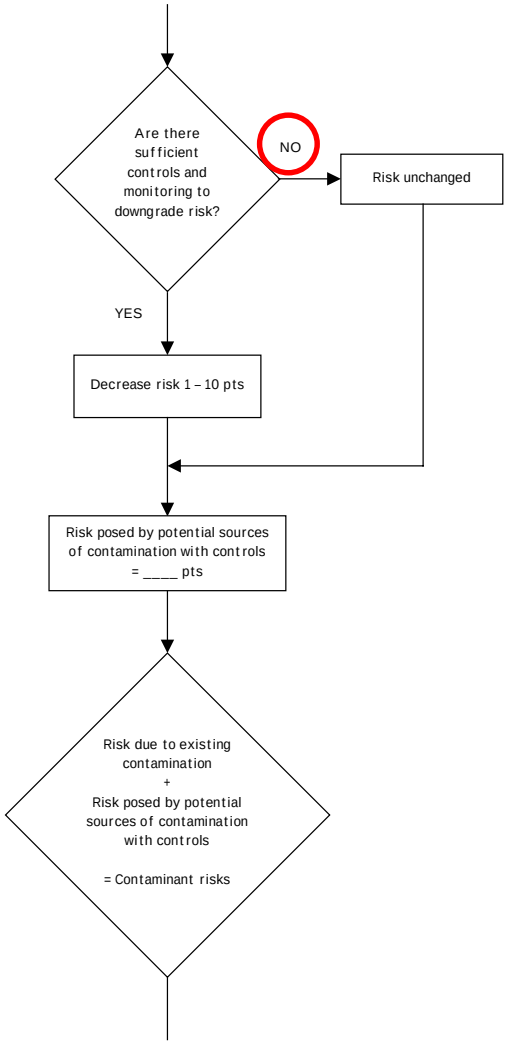
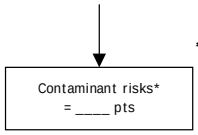


Chart 8. Contaminant risks for Girdwood Station Mall – Volatile Organic Chemicals (Continued)





**** Truncate risk at 50 pts***

3. Level of Background Contamination

> MCL	50 pts
0.5 MCL to < MCL	20 pts
0.2 MCL to < 0.5 MCL	10 pts
'detect' to < 0.2 MCL	5 pts

Contaminant Risk Ratings

40 to 50 pts	very high
30 to < 40 pts	high
20 to < 30 pts	medium
< 20	low

High

Table 7. Risk Matrix for Contaminant Sources for Volatile Organic Chemicals – Girdwood Station Mall

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	**LOW** **10 pts**	**MEDIUM** **20 pts**	**HIGH** **30 pts**	**VERY HIGH** **40 pts**
Low	≥ 10 sources + 10 pts	≥ 10 sources + 5 pts	≥ 20 sources + 5 pts	—
Medium	—	≥ 2 sources + 5 pts	≥ 5 sources + 5 pts	≥ 10 sources + 5 pts
High	—	—	1 source + 10 pts	≥ 2 sources + 10 pts
Very High	—	—	—	1 source + 10 pts