Hydrogeologic Susceptibility and Vulnerability Assessment for Seven Glaciers Restaurant Public Drinking Water Well, Girdwood, Alaska

DRINKING WATER PROTECTION PROGRAM REPORT 1

August 2000

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By MICHAEL. J. CROTTEAU

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ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION: 2000

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Hydrogeologic Susceptibility and Vulnerability Assessment for Seven Glaciers Restaurant Public Drinking Water Well, Girdwood, Alaska

By Michael J. Crotteau

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

Seven Glaciers Restaurant 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 the Seven Glaciers Restaurant well include wastewater discharges associated with recreational activities on Mount Alyeska. These identified sources of contaminants are considered sources of bacteria and viruses as well nitrates and/or nitrites. Overall, Seven Glaciers Restaurant's public water system received a vulnerability rating of **low** for bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals.

INTRODUCTION

The purpose of this environmental assessment is ro provide public water system owners/operators, communities, and local governmetns with the information they can use to preserve the quality of this source of public drinking water. This assessment was completed for Seven Glaciers Restaurant's public drinking water source. This source consists of one well above 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 public drinking water supplies.

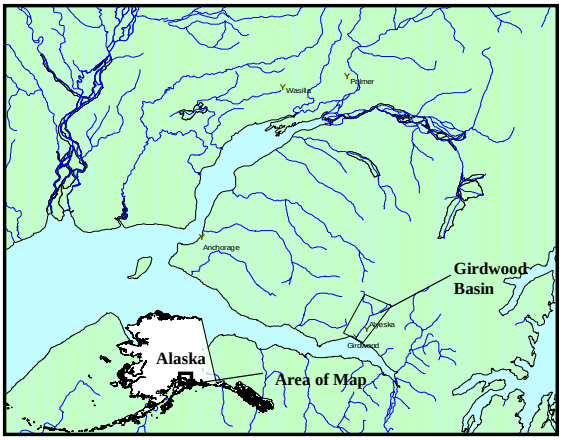

Figure 1. Index map showing the location of the Glacier Creek Valley, Alaska

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 per year has been recorded (1985-86) [*Glass and Brabets*, 1988].

Mean daily temperature ranges from 65.1° F during cool rainy summers to 13.9° F in snowy winters, with average total snow depths of 197.4 inches [*Western Regional Climate Center*, 2000].

Groundwater flows from bedrock highlands, including steep valley walls, toward sediments in the center of the valley. Flow through valley sediments is generally to the southwest toward Turnagain Arm.

SEVEN GLACIERS RESTAURANT PUBLIC WATER SYSTEM

Seven Glaciers Restaurant Public Water System is a Class B (transient/non-community) water system which is operated by Alyeska Resort. The system consists of one well, which is located on the northwest-facing slope of Mt. Alyeska at approximately 2440 feet above sea level (see Figure 2). The well is completed in fractured bedrock to a total depth of 326 feet. The bedrock is overlain by 23 feet of glacial and streambed sediments within the Alyeska Creek watershed. The well is grouted from land surface to 25 feet below land surface along its six-inch steel casing. The well has an open hole and had a static water level of 103 feet below land surface at the time of drilling (September 14, 1993). Surrounding the well on uphill sides are steep bedrock slopes, in places, overlain by stream, glacial, and slope deposits. These bedrock areas, as well as areas covered by thin deposits, have the ability to transmit water and contaminants overland and within sediments very quickly. This seasonal system serves approximately 1400 non-residents through a single connection to the restaurant.

ASSESSMENT AND PROTECTION AREA FOR SEVEN GLACIERS RESTAURANT DRINKING WATER SOURCE

The Drinking Water Protection and Assessment Area that has been established for Seven Glaciers Restaurant's public drinking water well is the area that is most sensitive to contamination. The protection area identifies the area that contributes water to the well. This area has served as a basis for assessing the risk of the drinking water source to contamination. This zone around this 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.
The Drinking Water Protection/Assessment Area for Seven Glaciers Restaurant contains only one zone, Zone A (See Map 1 and Map 2 in Appendix B). Conceptually, surface water and groundwater flow is downgradient from steep bedrock slopes toward the unconsolidated stream and glacial deposits surrounding the well (see Figure 3). This area was established using

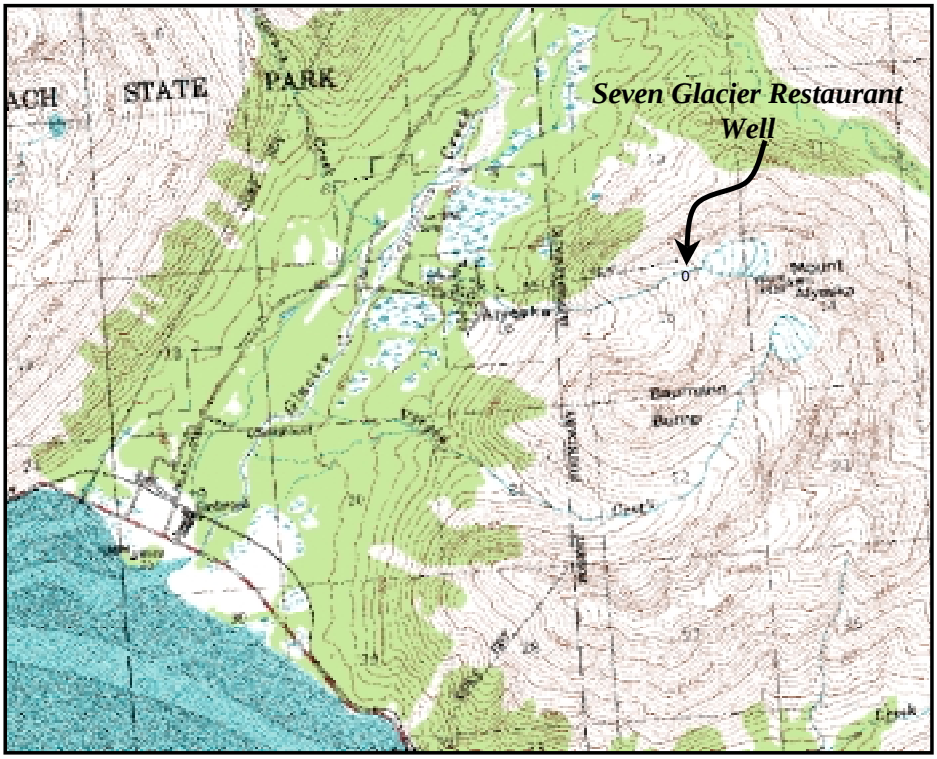

Figure 2. Map showing the drinking water source for Seven Glaciers Restaurant.

hydrogeologic mapping and includes the entire watershed up-slope from the well. Drinking Water Protection and Assessment Areas established for wells by the Alaska Department of Environmental Conservation 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 entire Zone A protection area for Seven Glaciers Restaurant corresponds to a time-of-travel of less than two years and may be on the order of several days to several hours depending where a contaminant source is located.

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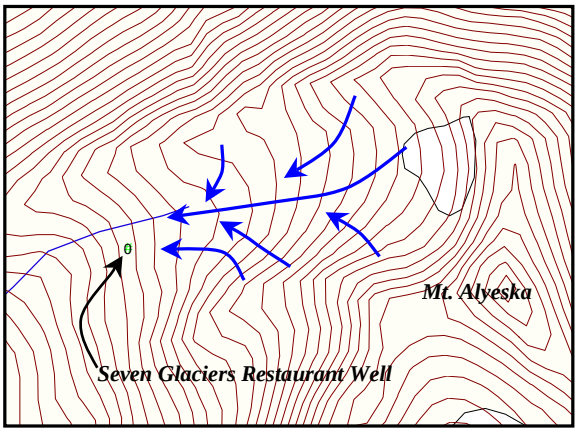


Figure 3. Map showing the conceptual groundwater flow in the Upper Alyeska Creek Basin

INVENTORY OF CONTAMINANT SOURCES

The Drinking Water Protection Program has completed an inventory of potential and existing sources of contamination within Seven Glaciers Restaurant Zone A Assessment and Protection Area. This survey was completed 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.
For the basis of this assessment and all Class A public water systems, three categories of drinking water contaminants were inventoried. They include:

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

Map 3 in Appendix C depict the Contaminant Source Inventory for Seven Glaciers Restaurant. All inventoried potential sources of contamination within Zone A were associated with wastewater discharge related with recreational activities (see Table 1 in Appendix A). These activities represent two types of risks for Seven Glaciers Restaurant's drinking water source:

- Bacteria and viruses; and
- Nitrates/nitrites.

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 SEVEN GLACIERS RESTAURANT'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 seven 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. Chart 4 analyzes bacteria and virus 'Contaminant Risks' for this drinking water source. 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 at the well. The 'Contaminant Risks' portion of the analysis also considers potential sources of contaminants.

Chart 5 and Chart 6 contain the 'Vulnerability Analysis' and 'Contaminant Risks' for nitrates and/or nitrites. Lastly, Chart 7 is the 'Vulnerability Analysis' for volatile organic chemicals. No potential or existing

source of contamination was identified for volatile organic chemicals. Therefore, there is no 'Contaminant Risks' analysis for volatile organic chemicals.
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 Seven Glaciers Restaurant well appears to be properly constructed. However, the thin layer of unconsolidated deposits overlaying fractured bedrock in the upper Alyeska Creek basin provides little if any protective layer to inhibit the transport of contaminants through fractures in the bedrock to the well. 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 Seven Glaciers Restaurant.

Table 1. Susceptibility of the Wellhead and Aquifer to Contamination

	Score	Rating
Susceptibility	24	Low

Contaminant Risks to a drinking water source depends on the type, number/density, and distribution of contaminant sources. Recreational activities contribute the highest risk for potential contamination to Seven Glaciers Restaurant source of public drinking water. These activities associated with wastewater discharge pose a bacteria and virus risk as well as a nitrate/nitrite risk. No sources of volatile organic chemicals where inventoried within the Zone A protection/assessment area for Seven Glaciers Restaurant.

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 2 below summarizes the Contaminant Risks for Seven Glaciers Restaurant for each category of drinking regulated contaminants.

Table 2. Contaminant Risks

Contaminant Risks	Score	Rating
Bacteria & Viruses	11	Low
Nitrates/Nitrites	11	Low
Volatile Organic Chemicals	0	Low

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. Overall scores reflect the potential risk to Seven Glaciers Restaurant by all three categories of contaminants. Even though no potential or existing sources of volatile organic chemicals were identified, the natural susceptibility of the well and the aquifer (Low) to contamination makes the drinking water source vulnerable to contamination. Note: Overall vulnerability is rounded off to the nearest score of five.

Table 3. Overall Vulnerability of Seven Glaciers Restaurant Public Drinking Water System to Contamination by Category

Category	Score	Rating
Bacteria & Viruses	35	Low
Nitrates/Nitrites	35	Low
Volatile Organic Chemicals	25	Low

SUMMARY

A *Source Water Assessment* has been completed for Seven Glaciers Restaurant's source of public drinking water. The overall vulnerability of this source to contamination by bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals is **low**. 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 Alyeska Resort 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 the 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 Seven Glaciers Restaurant

Table 1

Contaminant Source Inventory and Risk Ranking for Seven Glacier Restaurant (PWSID 214340)

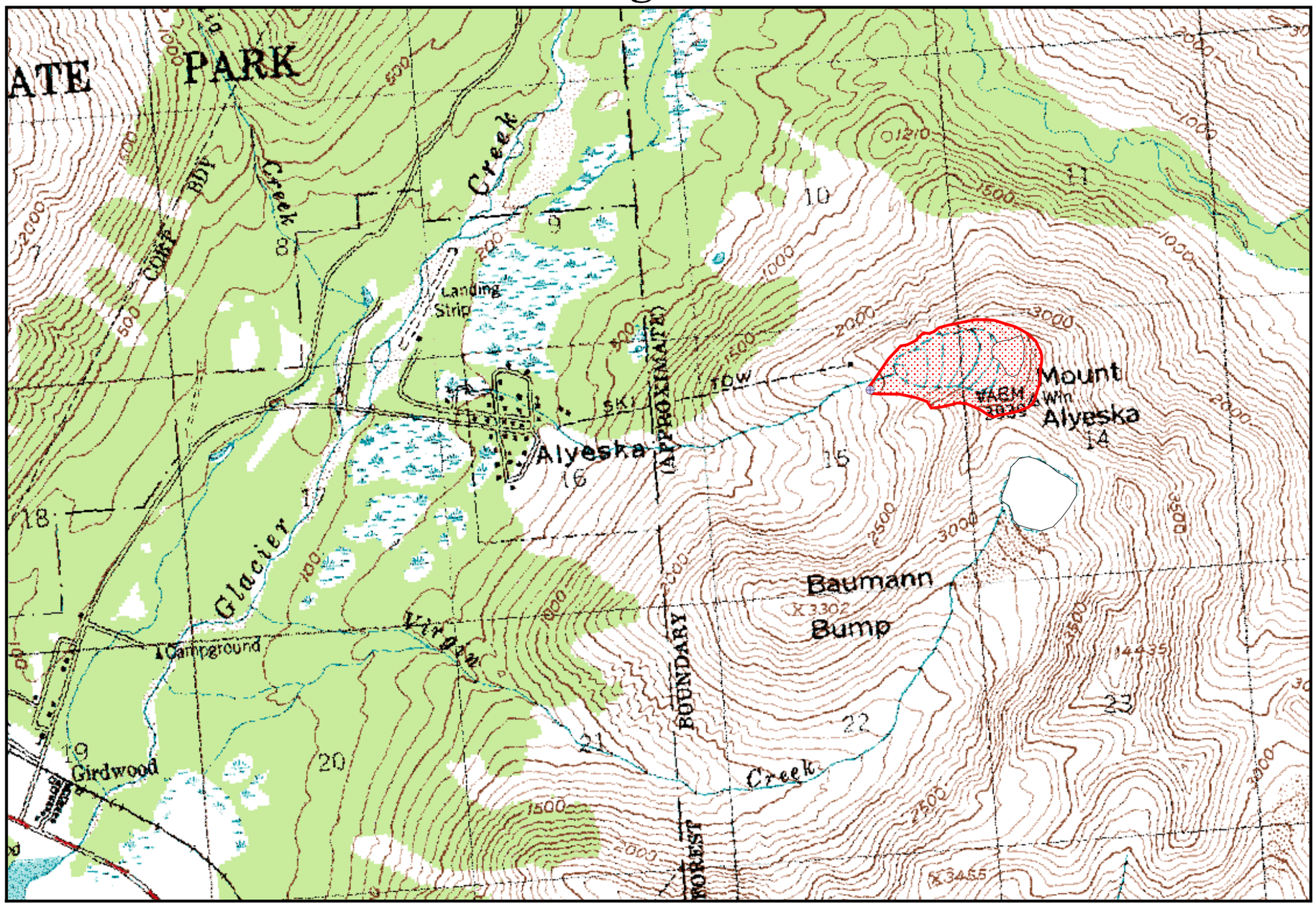
Name of Public Water System: **Seven Glaciers Restaurant**
PWSID: **214340**

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking	Location	Map Number	Notes/Comments
Recreation trails	X46	1	A	Low for Bacteria and Viruses	Mt. Alyeska	2	Skiing in winter and hiking in summer
Recreation trails	X46	1	A	Low for Nitrates/nitrites	Mt. Alyeska	2	Skiing in winter and hiking in summer

APPENDIX B

Seven Glaciers Restaurant
Drinking Water Protection Area

Seven Glaciers Restaurant (PWSID 214340)
Drinking Water Protection Area

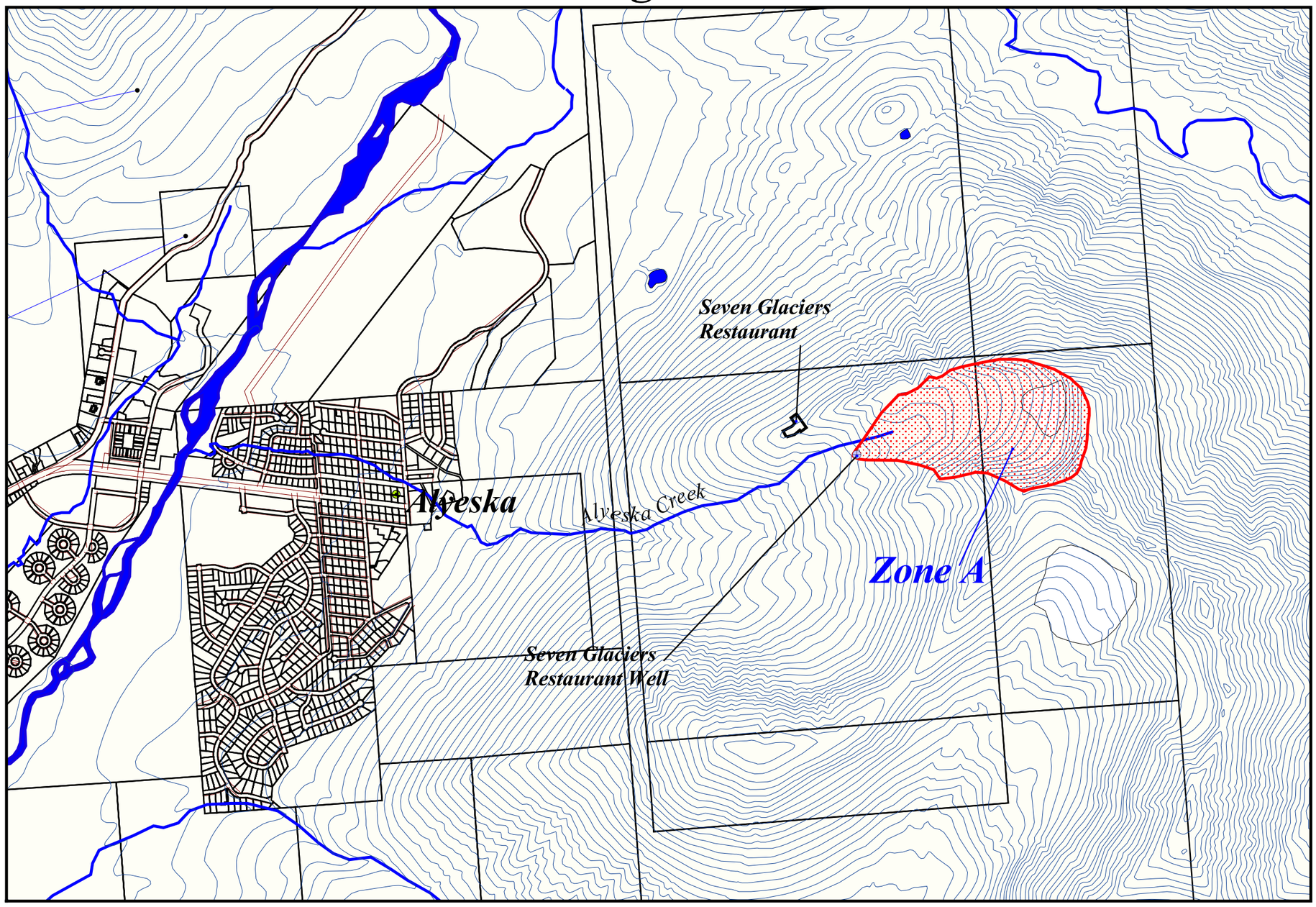


Seven Glaciers Restaurant Well
Zone A Protection Area
Glaciers

2000 0 2000 Feet

Map 1

Seven Glaciers Restaurant (PWSID 214340)
Drinking Water Protection Area

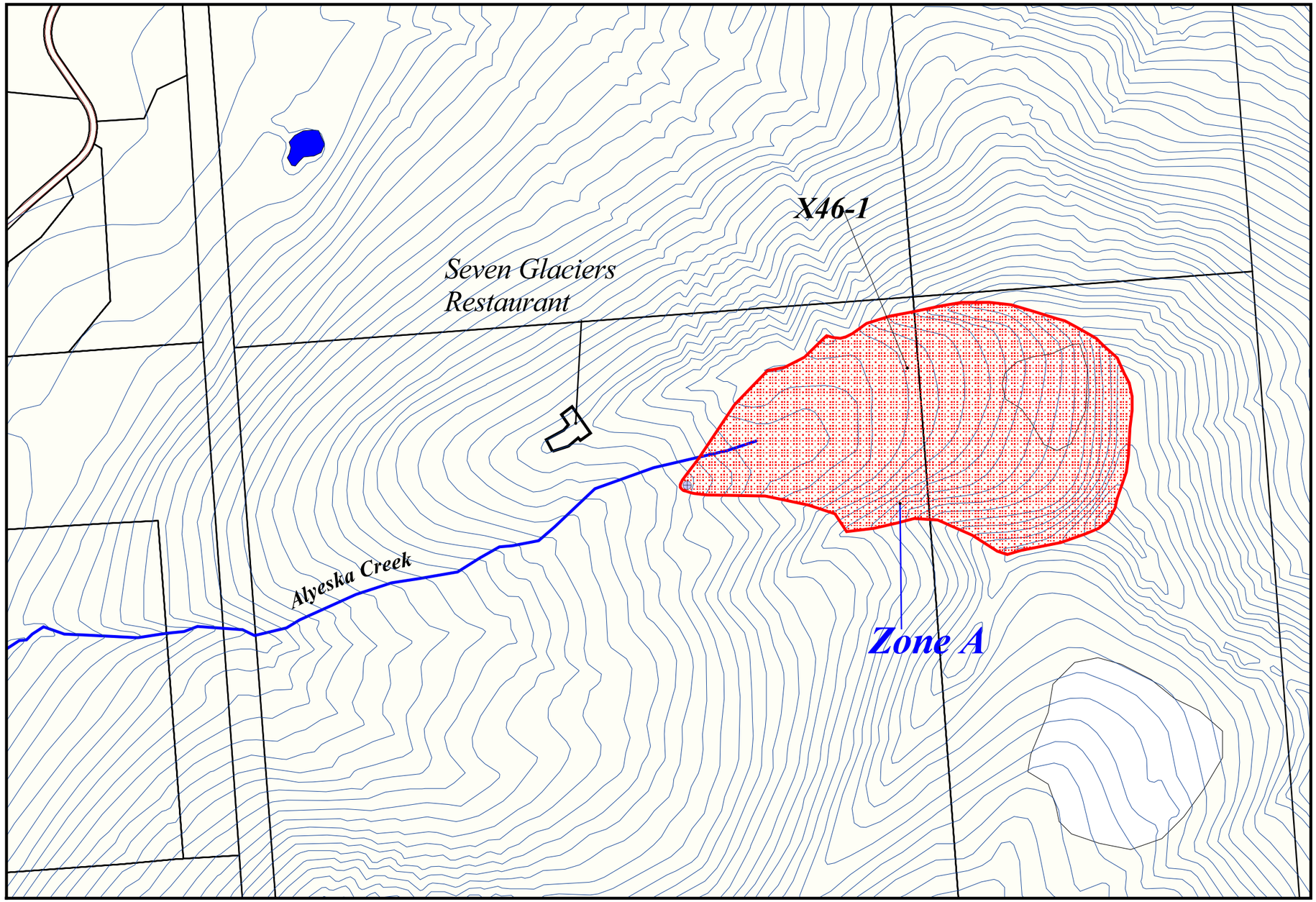


Map 2

APPENDIX C

Seven Glaciers Restaurant Drinking Water Protection Area and Contaminant Sources

Seven Glaciers Restaurant (PWSID 214340)
Drinking Water Protection Area and Contaminant Source Inventory



Seven Glaciers Restaurant Well

Potential & Existing Sources of Contamination

Winter and Summer Recreation

Zone A Protection Area

Several Months Travel Time

Elevation Contours

2nd order streams

3rd order streams

4th order streams

Lakes and Ponds

Glacier Creek

MOA Land Parcels

MOA Roads

Buildings

Glaciers

Cities and Villages

Map 3

APPENDIX D

Vulnerability Analysis for Seven Glaciers Restaurant Public Drinking Water System

Chart 1. Vulnerability analysis for Bacteria & Viruses – Seven Glaciers Restaurant

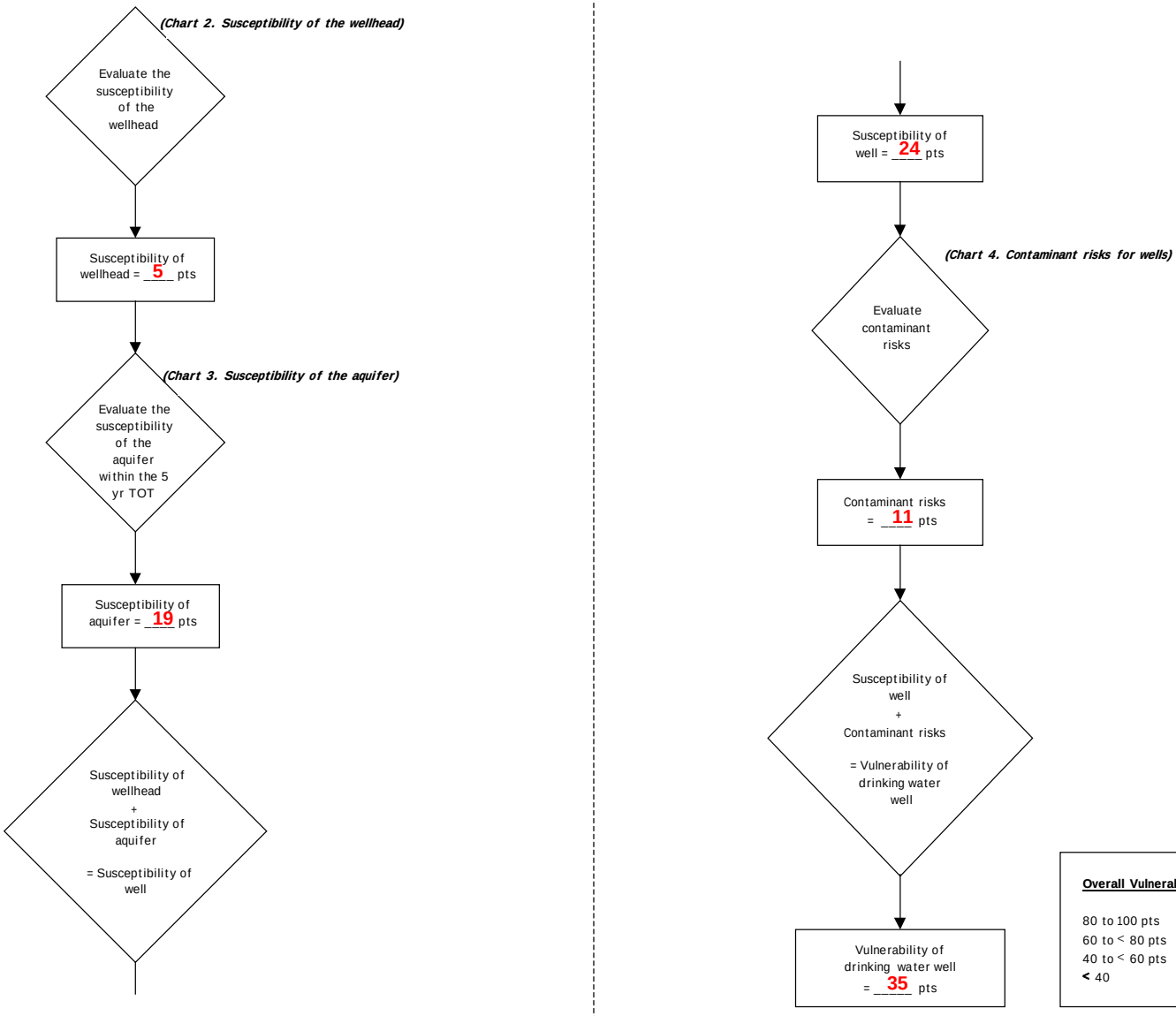
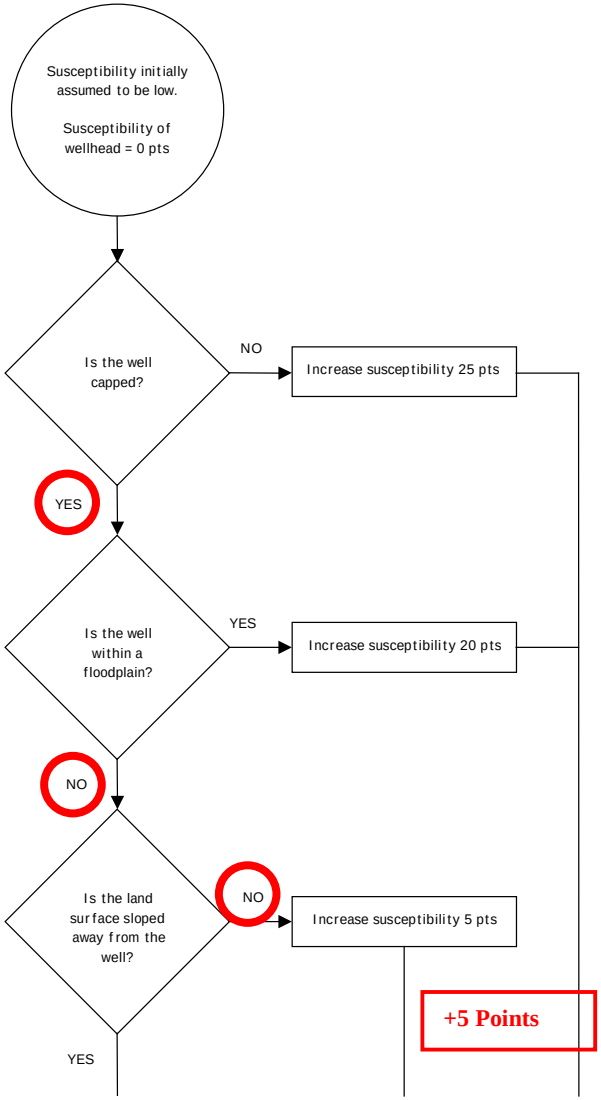
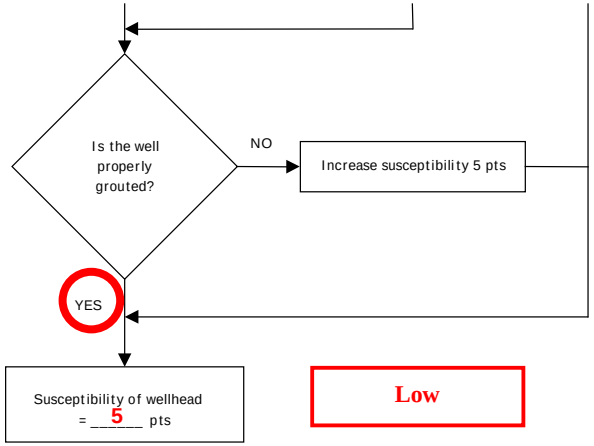


Chart 2. Susceptibility of the wellhead

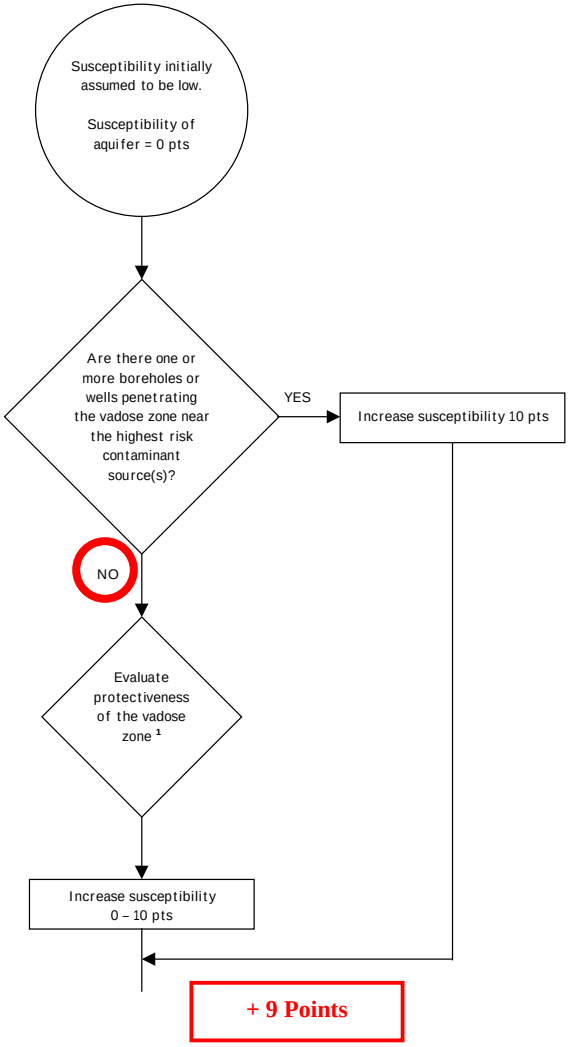


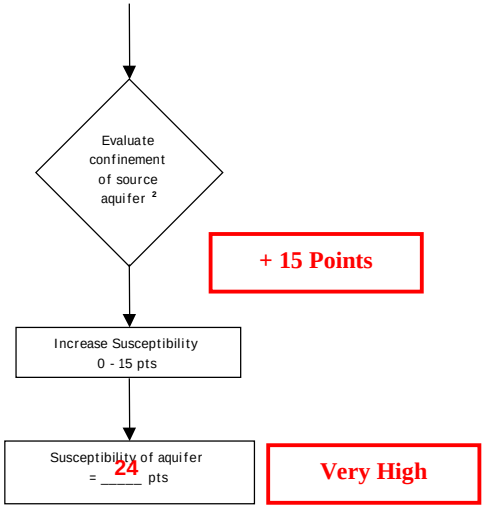


Wellhead Susceptibility Ratings

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]

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]

Aquifer Susceptibility Ratings

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

Chart 4. Contaminant risks for Seven Glaciers Restaurant

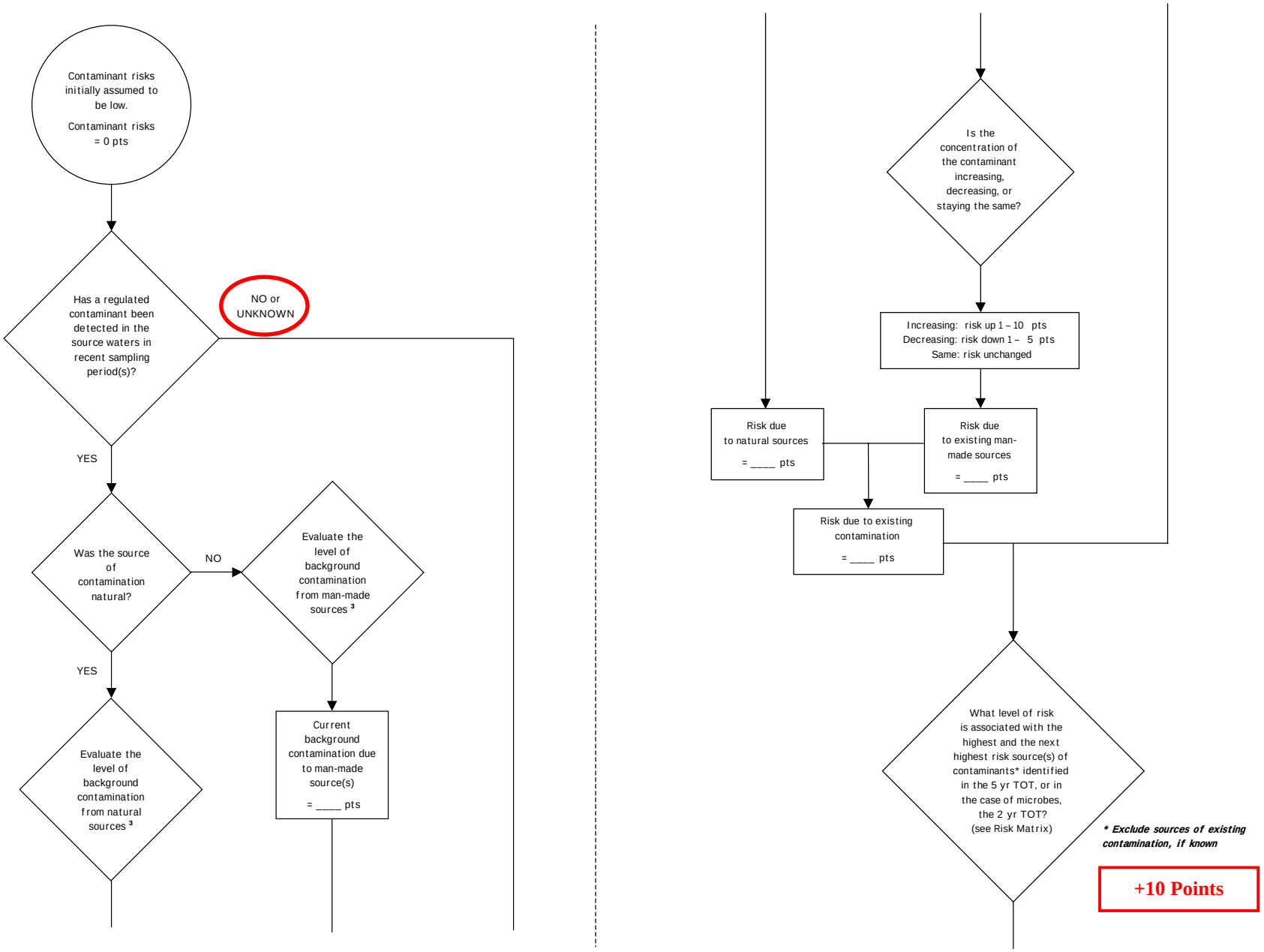
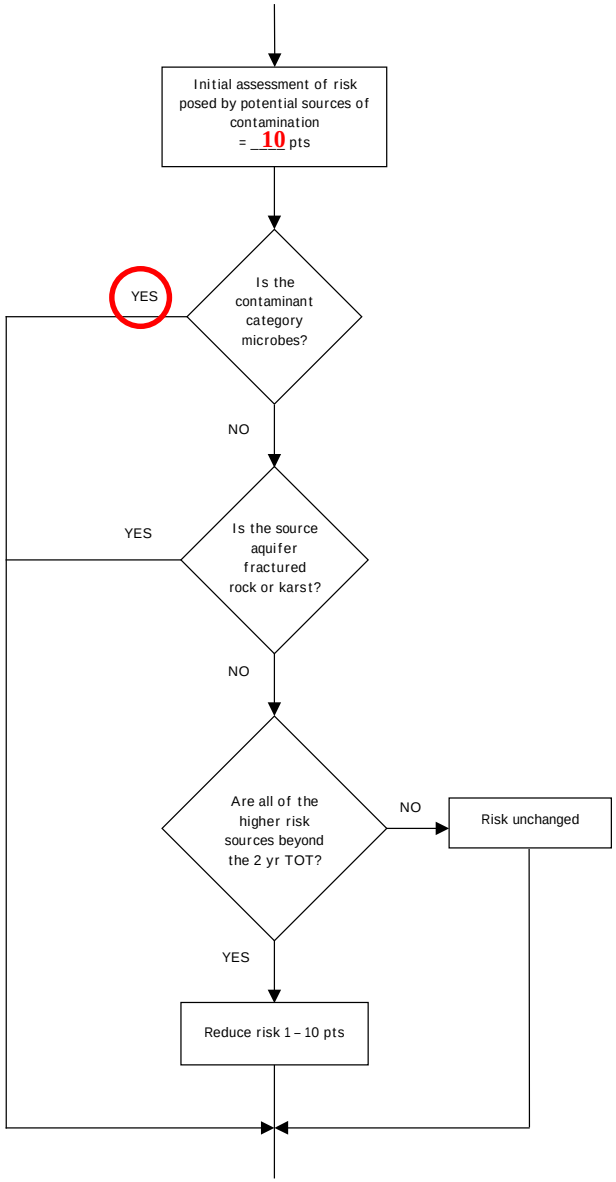


Chart 4. Contaminant risks for Seven Glaciers Restaurant (Continued)



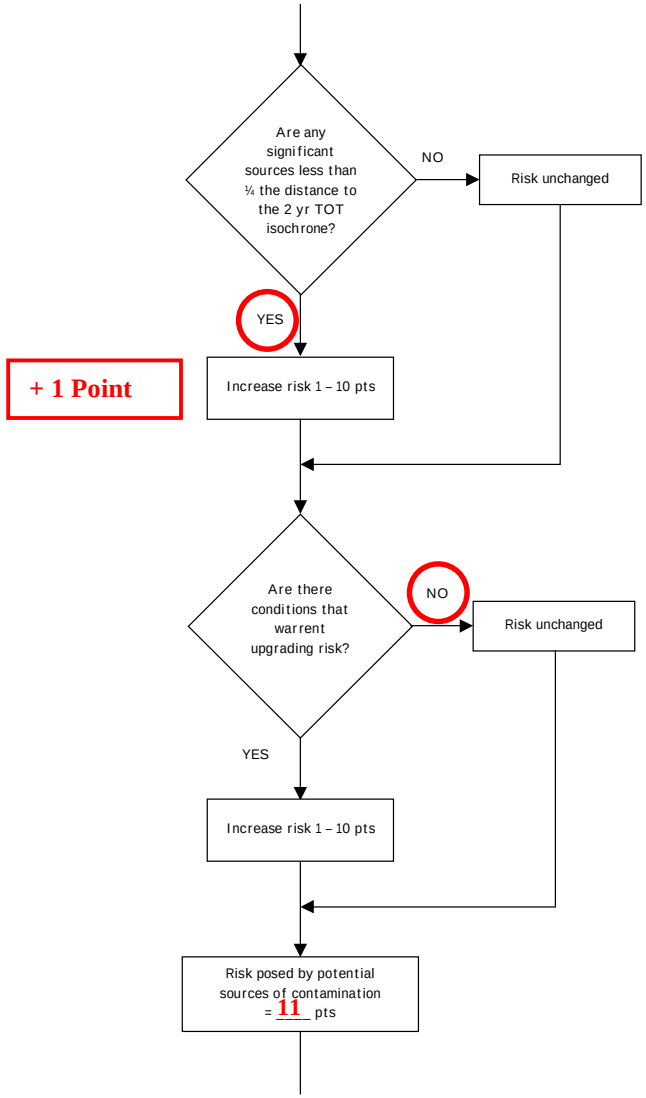
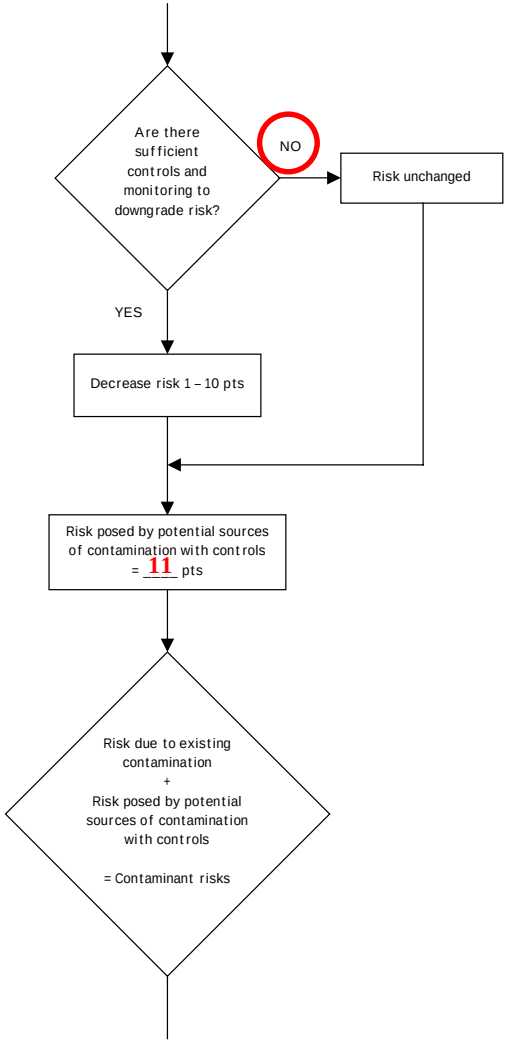


Chart 4. Contaminant risks for Seven Glaciers Restaurant (Continued)



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

Contaminant risks*
= 11 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

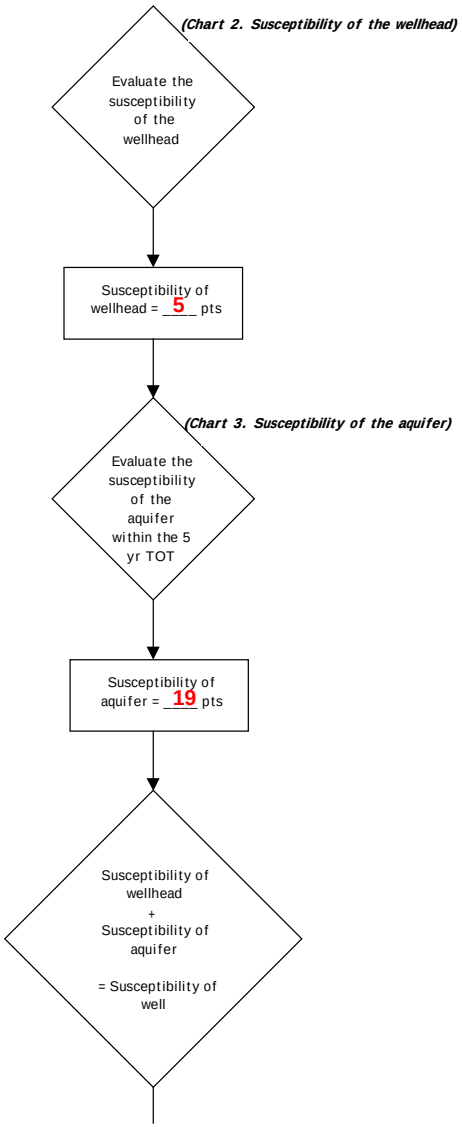
40 to 50 pts	very high
30 to < 40 pts	high
20 to < 30 pts	medium
< 20	low

Table 2. Risk Matrix for Contaminant Sources for Bacteria & Viruses – Seven Glaciers Restaurant

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 – Seven Glaciers Restaurant



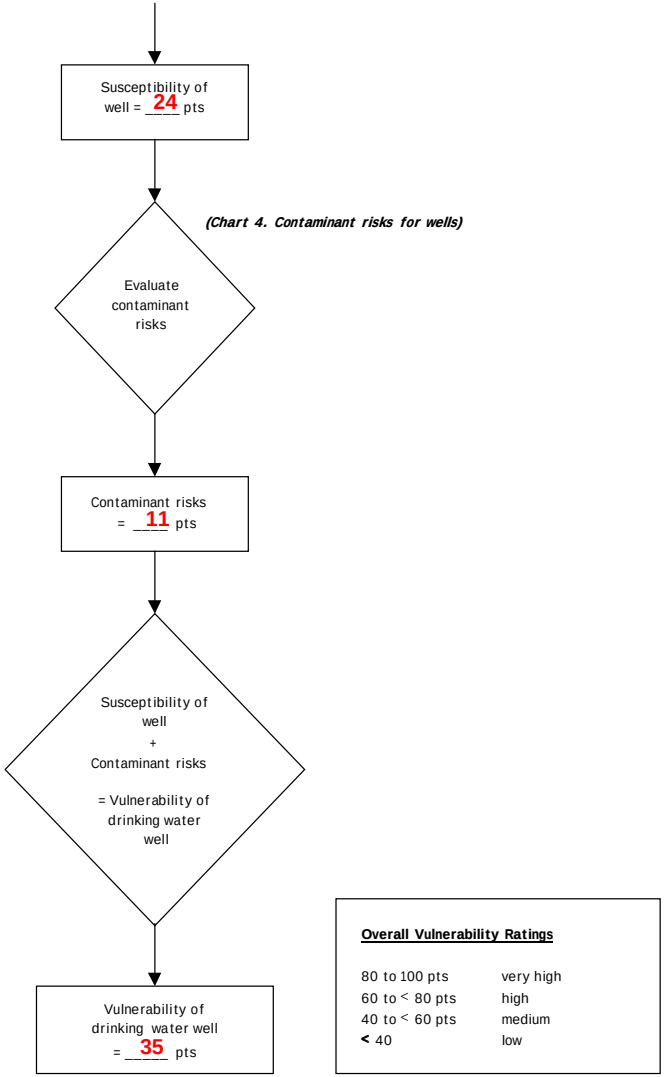
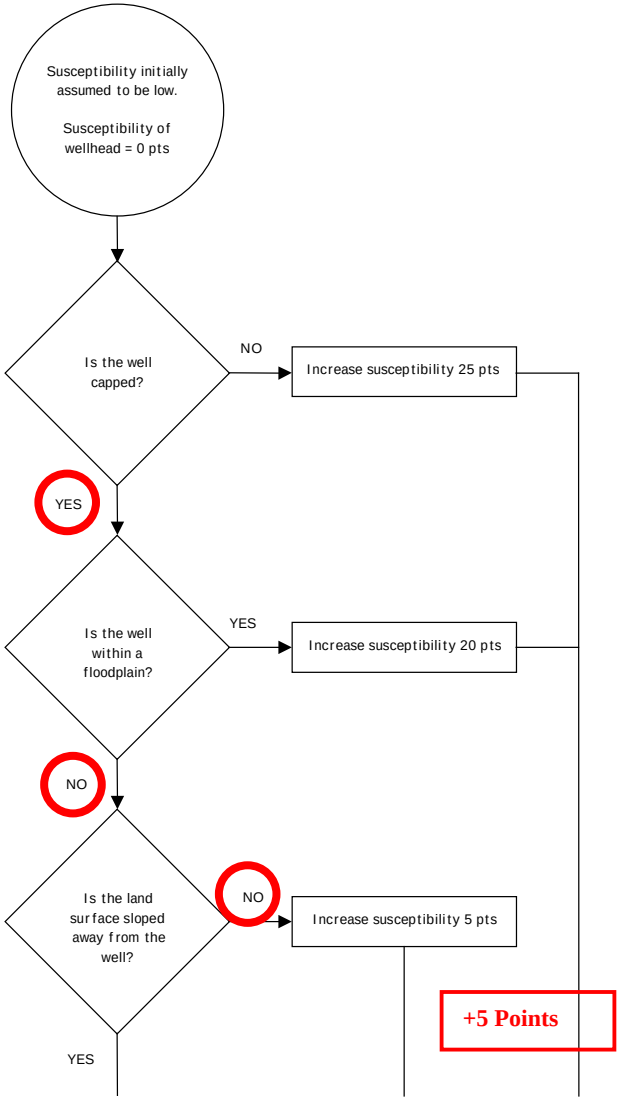
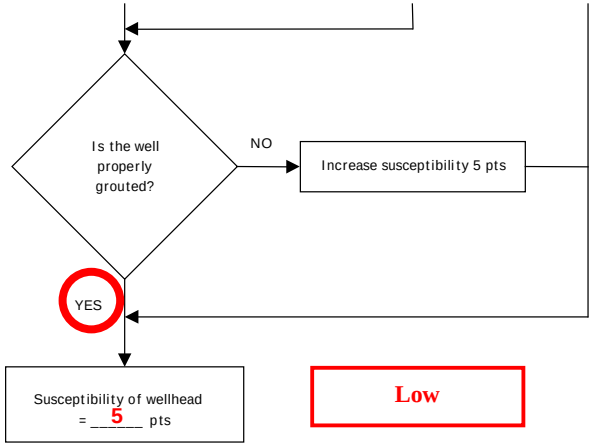


Chart 2. Susceptibility of the wellhead

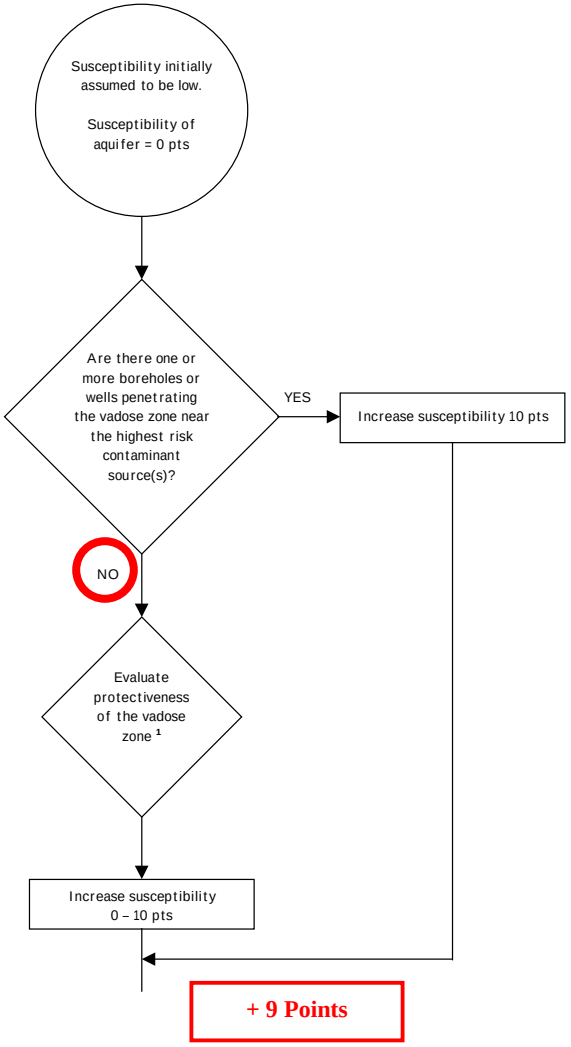


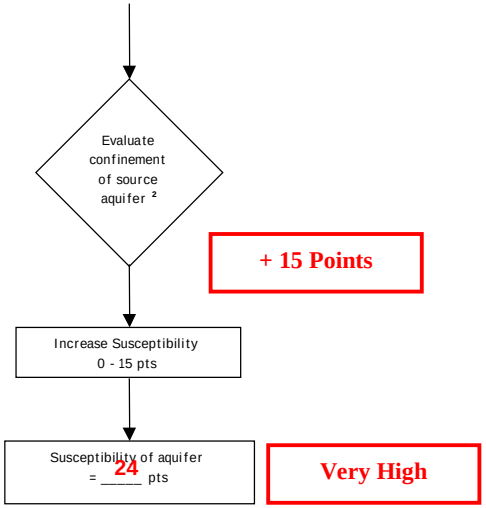


Wellhead Susceptibility Ratings

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]

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]

Aquifer Susceptibility Ratings

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

Chart 6. Contaminant risks for Seven Glaciers Restaurant

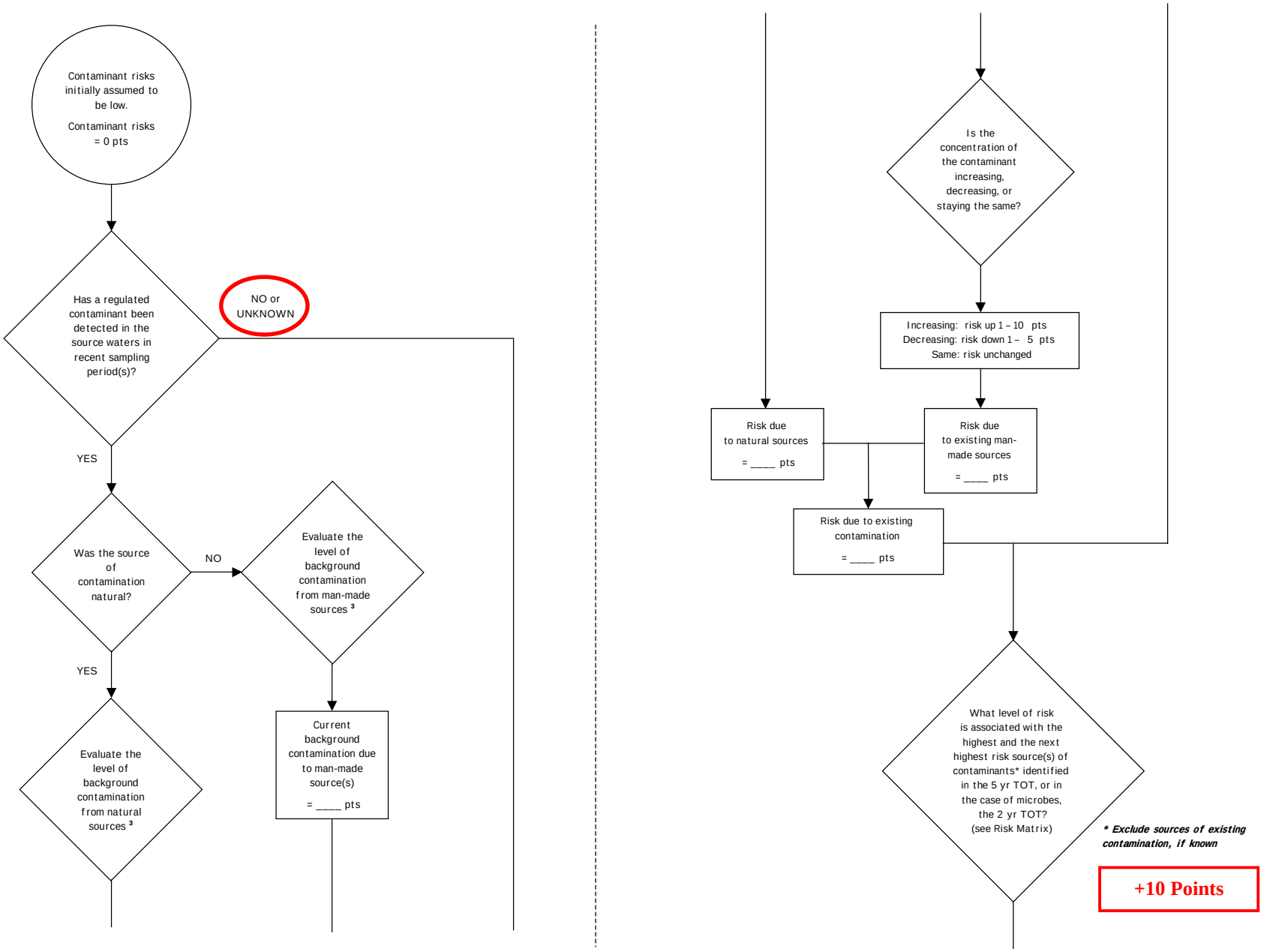
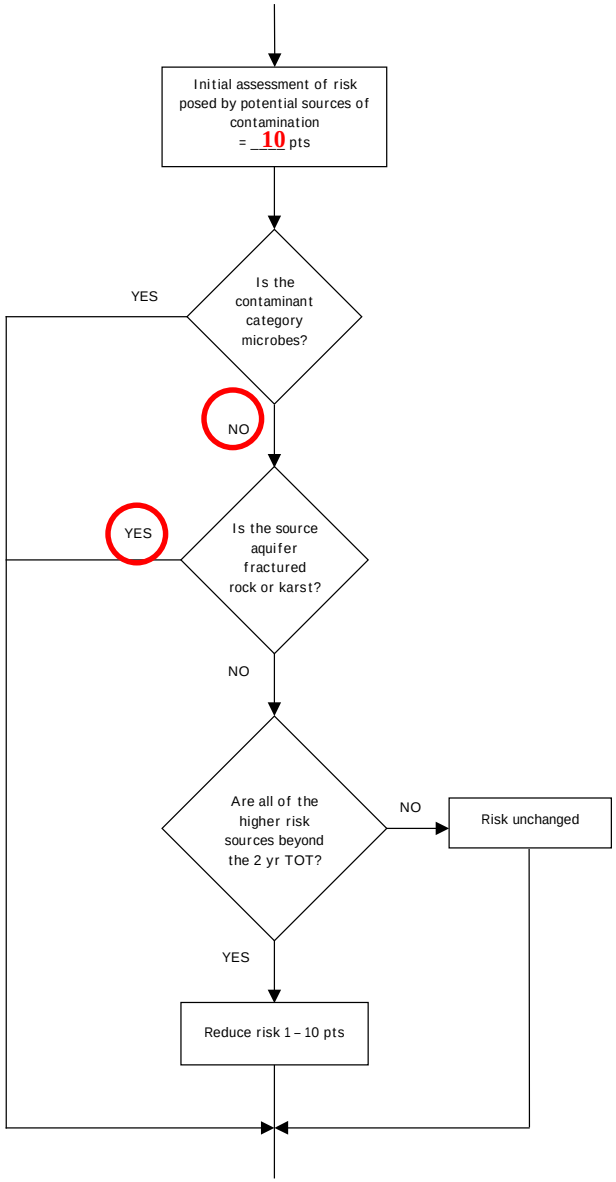


Chart 6. Contaminant risks for Seven Glaciers Restaurant (Continued)



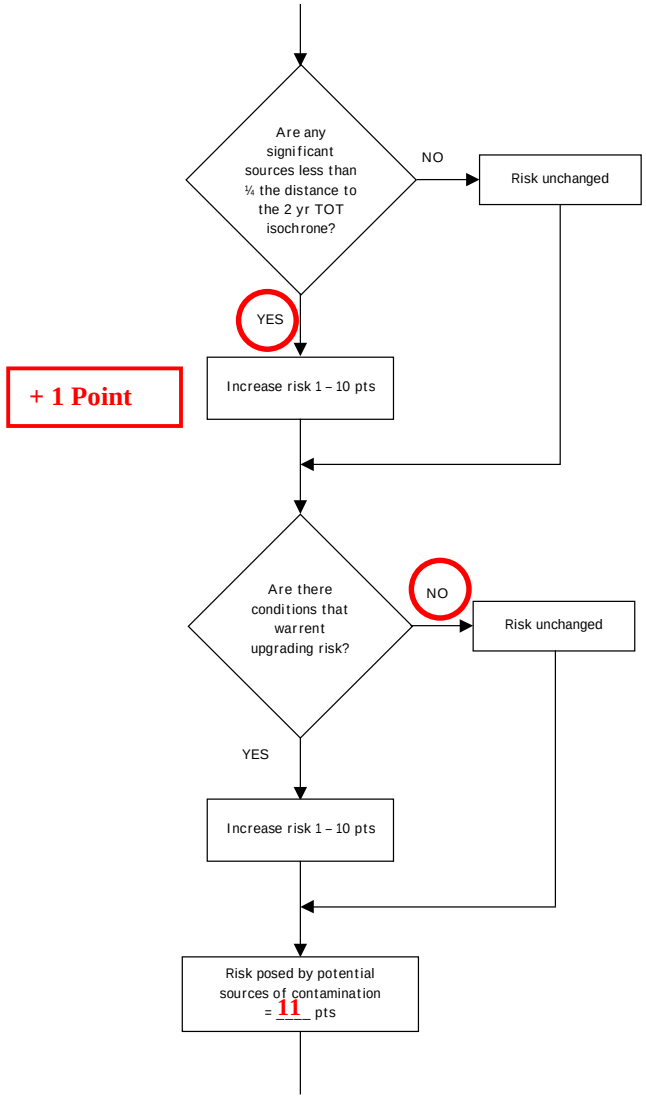
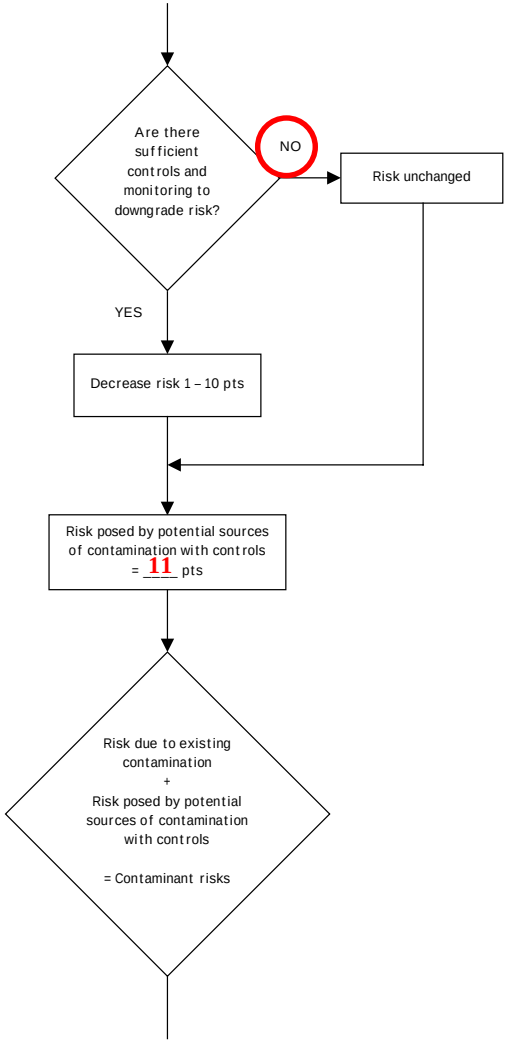
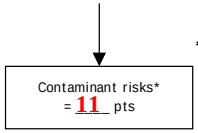


Chart 6. Contaminant risks for Seven Glaciers Restaurant (Continued)





**** 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

Table 3. Risk Matrix for Contaminant Sources for Nitrates/Nitrites – Seven Glaciers Restaurant

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 – Seven Glaciers Restaurant