Hydrogeologic Susceptibility and Vulnerability Assessment for the Municipality of Anchorage (MOA) – Alyeska Utilities Public Drinking Water Wells, Girdwood, Alaska

DRINKING WATER PROTECTION PROGRAM REPORT 11

October 2000

Hydrogeologic Susceptibility and Vulnerability Assessment for Municipality of Anchorage (MOA) – Alyeska Utilities Public Drinking Water Well, Girdwood, Alaska

By MICHAEL J. CROTTEAU

DRINKING WATER PROTECTION PROGRAM REPORT 11

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION: 2000

CONTENTS

TABLES

ILLUSTRATIONS

APPENDICES

Hydrogeologic Susceptibility and Vulnerability Assessment for the Municipality of Anchorage (MOA) – Alyeska Utilities Public Drinking Water Wells, Girdwood, Alaska

By Michael J. Crotteau

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

The Municipality of Anchorage (MOA) Alyeska Utilities Public Water System is a Class A (community) water system consisting of two wells. Identified potential and existing sources of contamination include: recreation trails, unsewered residential areas, placer gold mining, and activities associated with gravel roads and right-of-ways. These identified potential and existing sources of contamination are considered sources of bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other synthetic organic chemicals. Overall, MOA Alyeska Utilities' public water system received a vulnerability rating of **Low** for bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other synthetic organic chemicals.

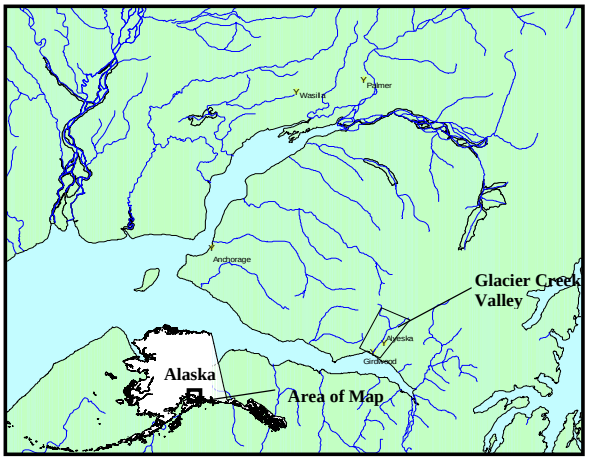


Figure 1. Index map showing the location of the Glacier Creek Valley, Alaska

INTRODUCTION

The purpose of this environmental assessment is to provide public water system owners/operators, communities, and local governments with information they can use to preserve the quality of Alaska's public drinking water supplies. This assessment was completed for the MOA Alyeska Utilities' public drinking water sources consisting of two wells 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 completed as a basis for voluntary local protection efforts and to assist agencies in their efforts to reduce risk to public drinking water supplies.

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 Glacier Creek 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^{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].

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

MOA ALYESKA UTILITIES PUBLIC WATER SYSTEM

MOA Alyeska Utilities Public Water System is a Class A (community) water system, which is owned and operated by the Anchorage Water & Wastewater Utility. The system consists of two wells, which are located northeast of the Girdwood Airstrip (see Figure 2). Well #1 for MOA Alyeska Utilities is grouted and penetrates silty gravel, discontinuous layers of clay, and gravel. The well log indicates that bedrock was encountered at 70 feet below land surface. The completed well has a total depth of 73 feet below land surface. The well has an eight-inch casing and is screened in gravel, sand, and bedrock from 52 to 73 feet below land surface. A static water level was not indicated on the well log at the time of drilling (November 1989). Well #2, situated approximately 250 feet south of Well #1, penetrates gravel to a depth of 55 feet below land surface and bedrock from 55 to 60 feet below land surface. The well appears to be grouted and is screened in gravel and bedrock from 40 to 59 feet below land surface. Well #2 had a static water level of twelve feet below

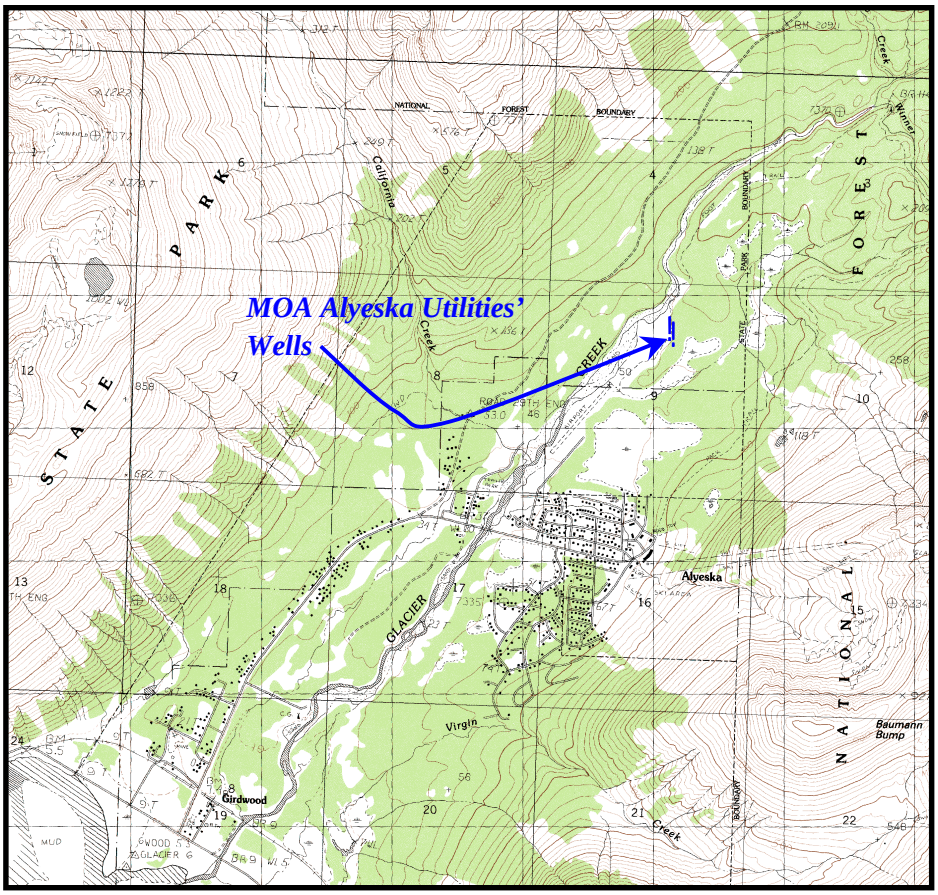


Figure 2. Map showing the location of the drinking water sources for MOA Alyeska Utilities.

land surface at the time of drilling (November 1989). No data is available from the U.S Army Corps of Engineers on floodplain hazards. However, there appears to be a slight potential for flood hazard for the MOA Alyeska Utilities' public wells. This system operates year round and serves approximately 1200 residents and 335 non-residents through 600 service connections.

ASSESSMENT AND PROTECTION AREAS FOR MOA ALYESKA UTILITIES' DRINKING WATER SOURCES

The Drinking Water Protection and Assessment Areas that have been established for MOA Alyeska Utilities' public drinking water wells are the areas that are most sensitive to contamination. These areas have served as a basis for assessing the risk of the drinking water sources to contamination. These zones around the drinking water sources are the most critical areas for the preservation of the quality of the water system's drinking water. For simplicity, these areas will be known as your Drinking Water Protection Areas and will serve as the area of focus for voluntary protection efforts.

Conceptually, surface water and groundwater flow is from steep bedrock slopes toward the unconsolidated stream and glacial deposits in the valley (see Figure 4). 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 MOA Alyeska Utilities' sources of public drinking water. Additional methods were further employed to take into account any uncertainties in groundwater flow and aquifer characteristics to arrive at a meaningful and conservative protection and assessment area with respect to public health (Please refer to the Guidance Manual for Class A Public Water Systems for additional information).

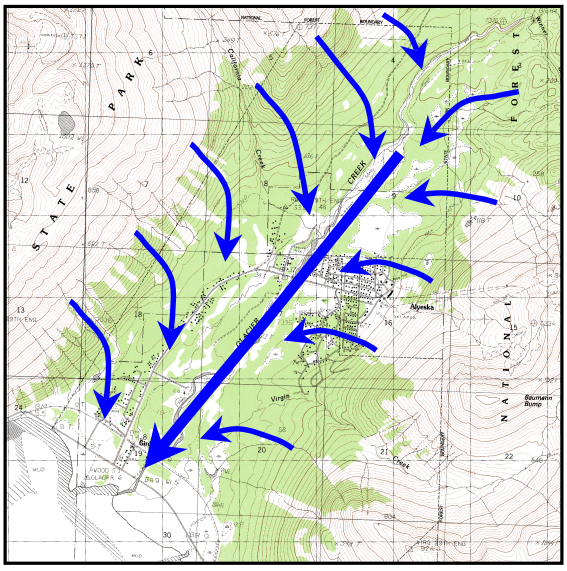


Figure 3. Map showing the conceptual groundwater flow in the Glacier Creek Valley.

The Drinking Water Protection 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 Areas for the MOA Alyeska Utilities contains five zones, Zone A through Zone G (See Map 1 - Map 3 in Appendix B). Zone A corresponds to ¼ of the distance to the 2-year time-of-travel isochron (an isochron is a line on a map at which the time interval has the same value). Depending on where a contaminant source is located, travel time for a contaminant to the well may be on the order of several days to several hours.

The Zone B protection area for MOA Alyeska Utilities 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 on bedrock in the upper portion of Zone B and enter valley sediments.

Zones E through G identify the areas along Glacier Creek upstream from the MOA Alyeska Utilities sources of drinking water. There appears to be a potential for flooding of the wells for MOA Alyeska Utilities by Glacier Creek. Contaminants released along Glacier Creek may enter the creek at any point by flowing overland or in small tributaries or feeder streams. Contaminants may also enter the subsurface, reach the groundwater, and enter Glacier Creek through baseflow. Baseflow is the portion of a stream's discharge or flow from groundwater seeping into the stream. This type of release can lead to pollution of the wells either through flooding of the well casing or through the subsurface where the aquifer may be in close hydraulic connection with Glacier Creek. Zone E identifies an area within 1000 feet of Glacier Creek and its upstream tributaries. Zones F and G identifies the area within 1 mile of Glacier Creek and the entire watershed or the area that contributes water to Glacier Creek, respectively.

INVENTORY OF CONTAMINANT SOURCES

The Drinking Water Protection Program has completed an inventory of potential and existing sources of contamination within MOA Alyeska Utilities' Drinking Water Protection Areas. 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.

For the basis of this assessment and all Class A assessments, six categories of drinking water regulated contaminant categories were inventoried. They include:

- Bacteria and viruses;
- Nitrates and/or nitrites;
- Volatile organic chemicals;
- Heavy metals, cyanide, and other inorganic chemicals;
- Synthetic organic chemicals; and
- Other synthetic organic chemicals.

Map 4 and Map 5 in Appendix C depict the Contaminant Source Inventory for MOA Alyeska Utilities. Inventoried potential sources of contamination within Zones A through Zone G were associated with recreational, residential and light commercial type activities (see Table 1 in Appendix A). Below is a summary of the contaminant sources inventoried within MOA Alyeska Utilities' protection area:

- Gravel and paved roads and right-of-ways;
- Unsewered residential areas;
- Recreation trails; and
- Placer mining.

These potential contaminant sources present risk for all six categories of drinking water contaminants for MOA Alyeska Utilities' drinking water sources.

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/or density of those types of contaminant sources as well as the proximity of those sources to the well.

VULNERABILITY OF MOA ALYESKA UTILITIES' DRINKING WATER SOURCES

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

- natural susceptibility; and
- contaminant risks.

Appendix D contains fourteen 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 11contains the Vulnerability Analysis for nitrates/nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other synthetic organic chemicals, respectively.

Each of the six 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 MOA Alyeska Utilities' wells penetrate mostly gravel with only minor discontinuous layers of silty gravel and clay, which provide little if any protective barrier for the movement of contaminants in the subsurface. The water table is high near the wells, ranging from three to fifteen feet below land surface. The wells have slight potential flood hazards, but appear to be properly grouted, which can inhibit the transport of contaminants along the well casing. Combining the susceptibility of the wellhead and the aquifer to contamination leads to a score (0 – 50 points) and rating of overall Susceptibility (See Appendix D). Table 1 shows the overall Susceptibility score and rating for MOA Alyeska Utilities.

Table 1. Susceptibility of the Wellhead and Aquifer to Contamination

	Score	Rating
Susceptibility	27	Medium

Contaminant Risks to a drinking water source depends on the type, number and/or density, and distribution of contaminant sources.

Tables 2 through 7 in Appendix A contain the ranking of potential and existing sources of contamination with respect to bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other synthetic organic chemicals, respectively.

Activities associated with recreation trails (Glacier Creek and Winner Creek Trails) contribute the highest risk for potential contamination to the MOA Alyeska Utilities' sources of public drinking water. The trails are the only identified potential contaminant sources directly upgradient of the wells (Zone A). However, trail use by humans and domestic animals during all times of the year is considered low. Other identified potential sources of contamination include unsewered residential areas, gravel roads and right-of-ways, and placer mining. These potential contaminant sources are found within Zone E and Zone F where dilution by Glacier Creek has played a factor in downgrading risk. Therefore, these identified potential contaminant sources within Zones E and F carry no weight when determining the overall vulnerability of the drinking water sources to contamination.

Recreation trails, unsewered residential areas, and activities associated with gravel roads and right-of-ways, rank as the highest potential and existing sources of contamination by bacteria and viruses and nitrates and/or nitrites.

Gravel roads and right-of-ways and unsewered residential areas within Zone E rank as the highest sources for volatile organic chemicals and other synthetic organic chemicals. Residential areas are the only potential or existing source of synthetic organic chemicals identified within MOA Alyeska Utilities' Drinking Water Protection Areas.

Gravel roads and right-of-ways, unsewered residential areas, and placer gold mining rank as the highest identified potential or existing source of contamination for heavy metals, cyanide, and other inorganic chemicals. However, sampling history indicates an existing source of heavy metals within the recharge area or the area that contributes water to the wells. Existing barium contamination is approximately 3% of the allowable limit (MCL) for this contaminant. This contamination may be the result from an increased pumping rate where the area that contributes water to the well is increased, thus perhaps coming in contact with a highly mineralized zone of bedrock.

Nitrates and/or nitrites are found in natural background concentrations in the source waters of MOA Alyeska Utilities, as elsewhere in the Glacier Creek Valley. Sampling history of the MOA Alyeska Utilities' source waters indicate low concentrations of nitrate (See Chart 6 – Contaminant Risks for Nitrates/Nitrites in Appendix D). Existing nitrate contamination is approximately 8% of the allowable limit (MCL) for this contaminant and parallels what is found throughout the valley. The recreation trails (Glacier Creek and Winner Creek Trails) have the potential for increasing the input of nitrate into the groundwater system at this site. Due to the high solubility and weak retention by soil, nitrates are very mobile in soil, moving at approximately the same rate as water. This existing low level contamination, coupled with the existence of recreation trails within Zone A (within several months travel time), has lead to nitrates and/or nitrites receiving the highest score for Contaminant Risks for all categories of drinking water-regulated contaminants (although low potential risk). The recreation trails (Glacier Creek and Winner Creek Trails) represent the highest risk sources for nitrates and/or nitrites, as well as bacteria and viruses for this drinking water source. However, potential contaminant risks derived from the recreation trails have been downgraded due to "low traffic" conditions that exist on the trail and adjacent areas throughout the year.

A score (0 – 50 points) and rating of Contaminant Risks (See Appendix D) is assigned based on the findings of the Contaminant Source Inventory (Appendix A - Table 1 – Table 7). Table 2 below summarizes the Contaminant Risks for MOA Alyeska Utilities for each category of drinking water contaminants.

Table 2. Contaminant Risks

Contaminant Risks	Score	Rating
Bacteria and Viruses	7	Low
Nitrates and/or Nitrites	9	Low
Volatile Organic Chemicals	0	Low
Heavy Metals, Cyanide, and other inorganic Chemicals	1	Low
Synthetic Organic Chemicals	0	Low
Other Sythetic 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 six categories of drinking water contaminants (See Appendix D). Note: scores are rounded off to the nearest five.

Table 3. Overall Vulnerability of MOA Alyeska Utilities Public Drinking Water System to Contamination by Category

Category	Score	Rating
Bacteria and Viruses	35	Low
Nitrates and/or Nitrites	35	Low
Volatile Organic Chemicals	25	Low
Heavy Metals, Cyanide, and other Inorganic Chemicals	30	Low
Synthetic Organic Chemicals	25	Low
Other Synthetic Organic Chemicals	25	Low

SUMMARY

A *Source Water Assessment* has been performed for the MOA Alyeska Utilities' sources of public drinking water. The overall vulnerability of these sources to contamination is **Low** for bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, cyanide, and other inorganic chemicals, synthetic organic chemicals, and other synthetic 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 susceptibility and/or vulnerability of this public drinking water source to contamination.

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 MOA Alyeska Utilities

Table 1

Contaminant Source Inventory for MOA Alyeska Utilities

PWS ID 212021

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Location	Map Number	Notes/Comments
Highways and roads, dirt/gravel	X24	X24-1	E and F	Crow Creek Road	4 and 5	
Dog walking areas/foot trails	X46	X46-1	A and E	From Alyeska Prince Hotel and along Glacier and Winner Creeks	4 and 5	Winner Creek Trail
Metals mining, placer (active)	E4	E1-1	E	Crow Creek Mine	4	Mostly limited to recreational/gift shop scale placer gold mining
Unsewered residential areas	R1	R1-1	E	Approximately Mile 4 to Mile 5 of Crow Creek Road	4	Areas that have onsite wastewater disposal treatment

Table 2

Contaminant Source Inventory and Risk Ranking for MOA Alyeska Utilities Sources of Bacteria and Viruses

PWS ID 212021

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Anaysis	Location	Map Number	Notes/Comments
Dog walking areas/foot trails	X46	X46-1	A and E	Low	1	From Alyeska Prince Hotel and along Glacier and Winner Creeks	4 and 5	Winner Creek Trail
Unsewered residential areas	R1	R1-1	E	Low	2	Approximately Mile 4 to Mile 5 of Crow Creek Road	4	Areas that have onsite wastewater disposal treatment
Highways and roads, dirt/gravel	X24	X24-1	E and F	Low	3	Crow Creek Road	4 and 5	

Table 3

Contaminant Source Inventory and Risk Ranking for MOA Alyeska Utilities Sources of Nitrates/Nitrites

PWS ID 212021

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Anaysis	Location	Map Number	Notes/Comments
Dog walking areas/foot trails	X46	X46-1	A and E	Low	1	From Alyeska Prince Hotel and along Glacier and Winner Creeks	4 and 5	Winner Creek Trail
Unsewered residential areas	R1	R1-1	E	Low	2	Approximately Mile 4 to Mile 5 of Crow Creek Road	4	Areas that have onsite wastewater disposal treatment
Highways and roads, dirt/gravel	X24	X24-1	E and F	Low	3	Crow Creek Road	4 and 5	

Table 4

Contaminant Source Inventory and Risk Ranking for MOA Alyeska Utilities Sources of Volatile Organic Chemicals

PWS ID 212021

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Anaysis	Location	Map Number	Notes/Comments
Highways and roads, dirt/gravel	X24	X24-1	E and F	Low	1	Crow Creek Road	4 and 5	
Unsewered residential areas	R1	R1-1	E	Low	2	Approximately Mile 4 to Mile 5 of Crow Creek Road	4	Areas that have onsite wastewater disposal treatment

Table 5

Contaminant Source Inventory and Risk Ranking for MOA Alyeska Utilities Sources of Heavy Metals, Cyanide, and other Inorganic Chemicals

PWS ID 212021

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Anaysis	Location	Map Number	Notes/Comments
Highways and roads, dirt/gravel	X24	X24-1	E and F	Low	1	Crow Creek Road	4 and 5	
Unsewered residential areas	R1	R1-1	E	Low	2	Approximately Mile 4 to Mile 5 of Crow Creek Road	4	Areas that have onsite wastewater disposal treatment
Metals mining, placer (active)	E4	E1-1	E	Low	3	Crow Creek Mine	4	Mostly limited to recreational/gift shop scale placer gold mining

Table 6

Contaminant Source Inventory and Risk Ranking for MOA Alyeska Utilities Sources of Synthetic Organic Chemicals

PWS ID 212021

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Anaysis	Location	Map Number	Notes/Comments
Unsewered residential areas	R1	R1-1	E	Low	1	Approximately Mile 4 to Mile 5 of Crow Creek Road	4	Areas that have onsite wastewater disposal treatment

Table 7

Contaminant Source Inventory and Risk Ranking for MOA Alyeska Utilities Sources of Other Synthetic Organic Chemicals

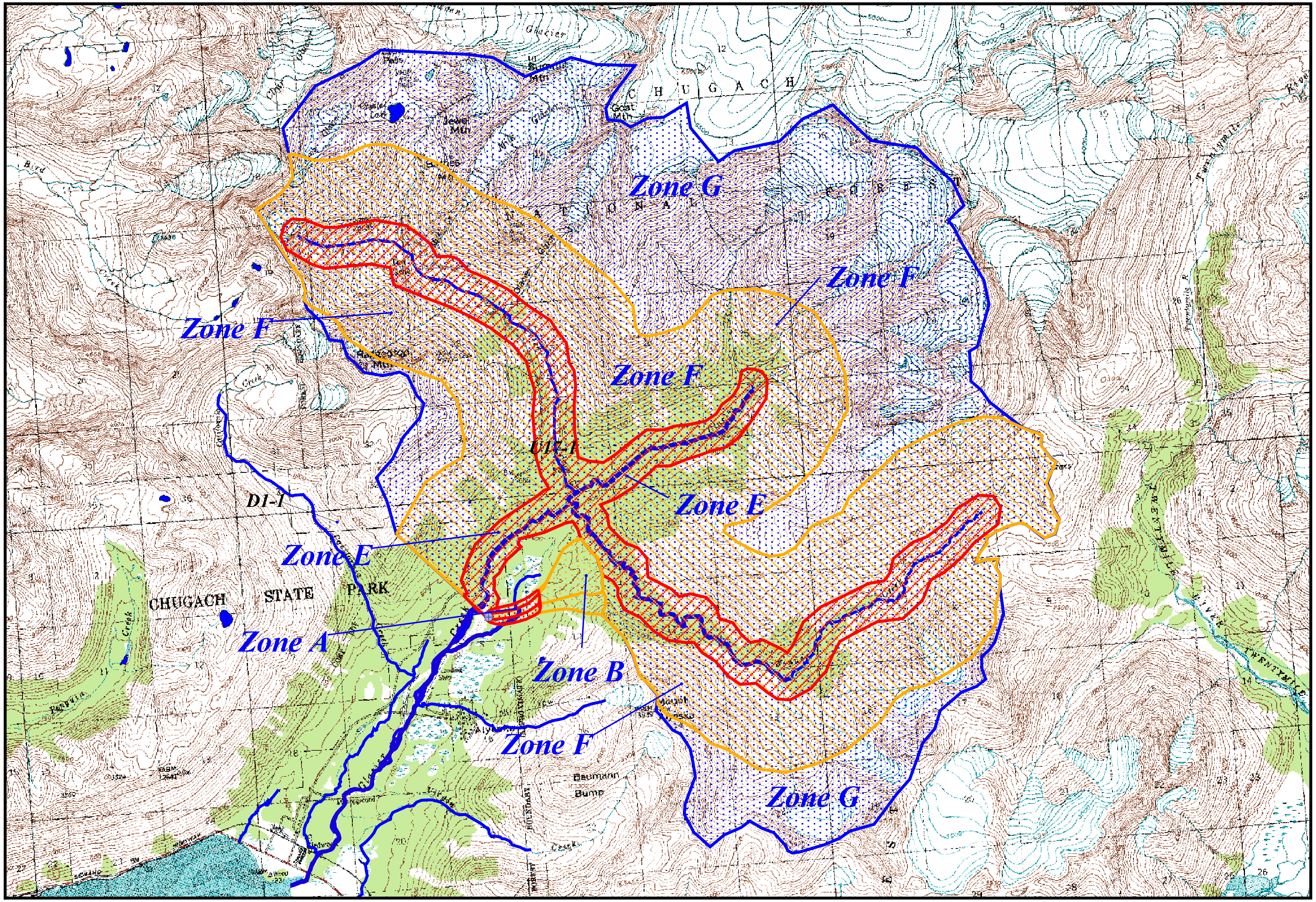
PWS ID 212021

Contaminant Source Type	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Anaysis	Location	Map Number	Notes/Comments
Unsewered residential areas	R1	R1-1	E	Low	1	Approximately Mile 4 to Mile 5 of Crow Creek Road	4	Areas that have onsite wastewater disposal treatment
Highways and roads, dirt/gravel	X24	X24-1	E and F	Low	2	Crow Creek Road	4 and 5	

APPENDIX B

MOA Alyeska Utilities'
Drinking Water Protection Areas

MOA Alyeska Utilities (PWSID 212021)
Drinking Water Protection Areas



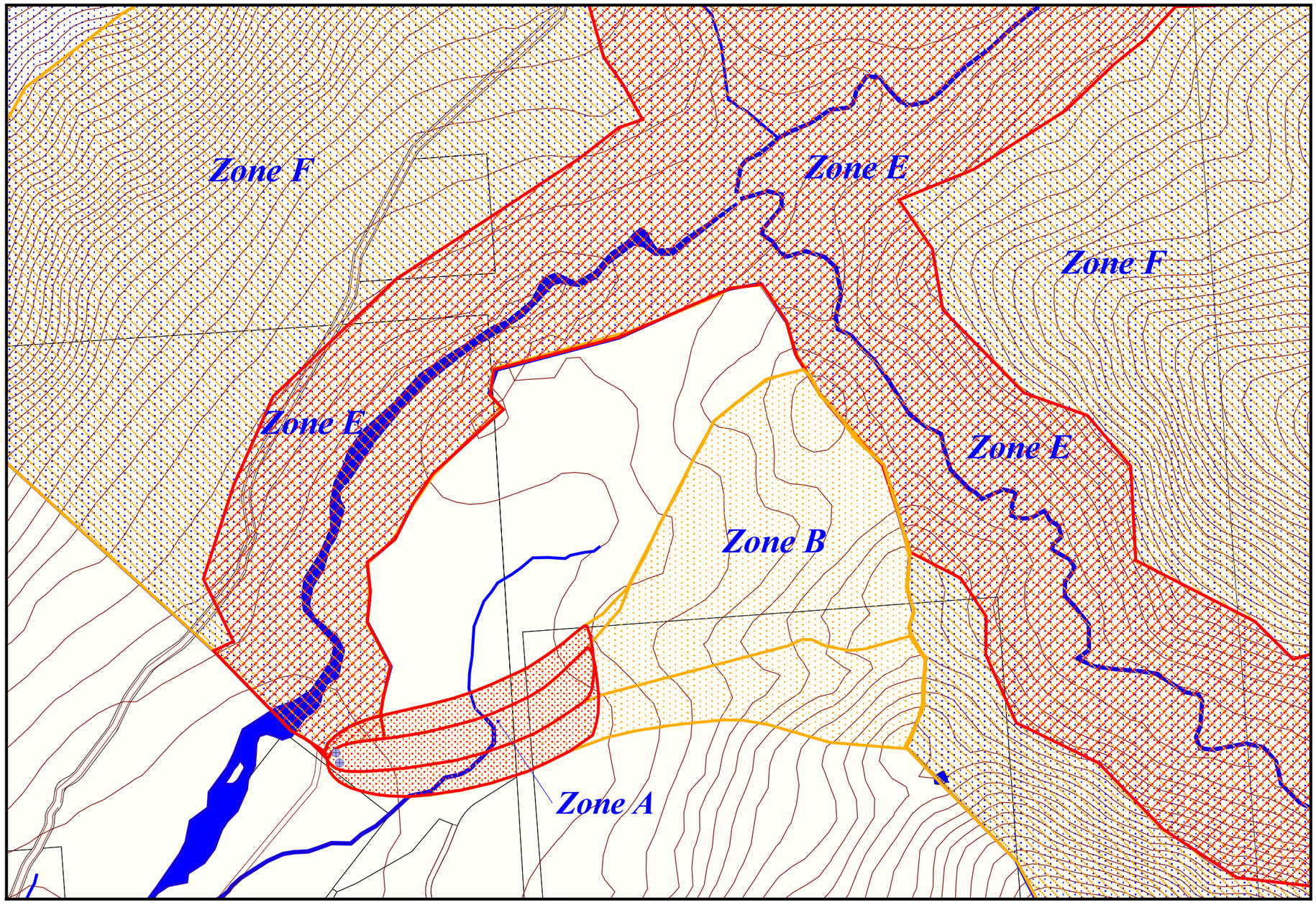
MOA Alyeska Utilities Wells
Zone A Protection Area
Several Months Travel Time
Zone B Protection Area
Less than 2 Years Travel Time
Zone E Protection Area
1000 Feet from Surface Water
Zone F Protection Area
1 Mile from Surface Water
Zone G Protection Area
Entire Watershed
2nd order streams
3rd order streams
4th order streams
Glacier Creek
Lakes and Ponds

N
W E
S

5000 0 5000 Feet

Map 1

MOA Alyeska Utilities (PWSID 212021)
Drinking Water Protection Areas



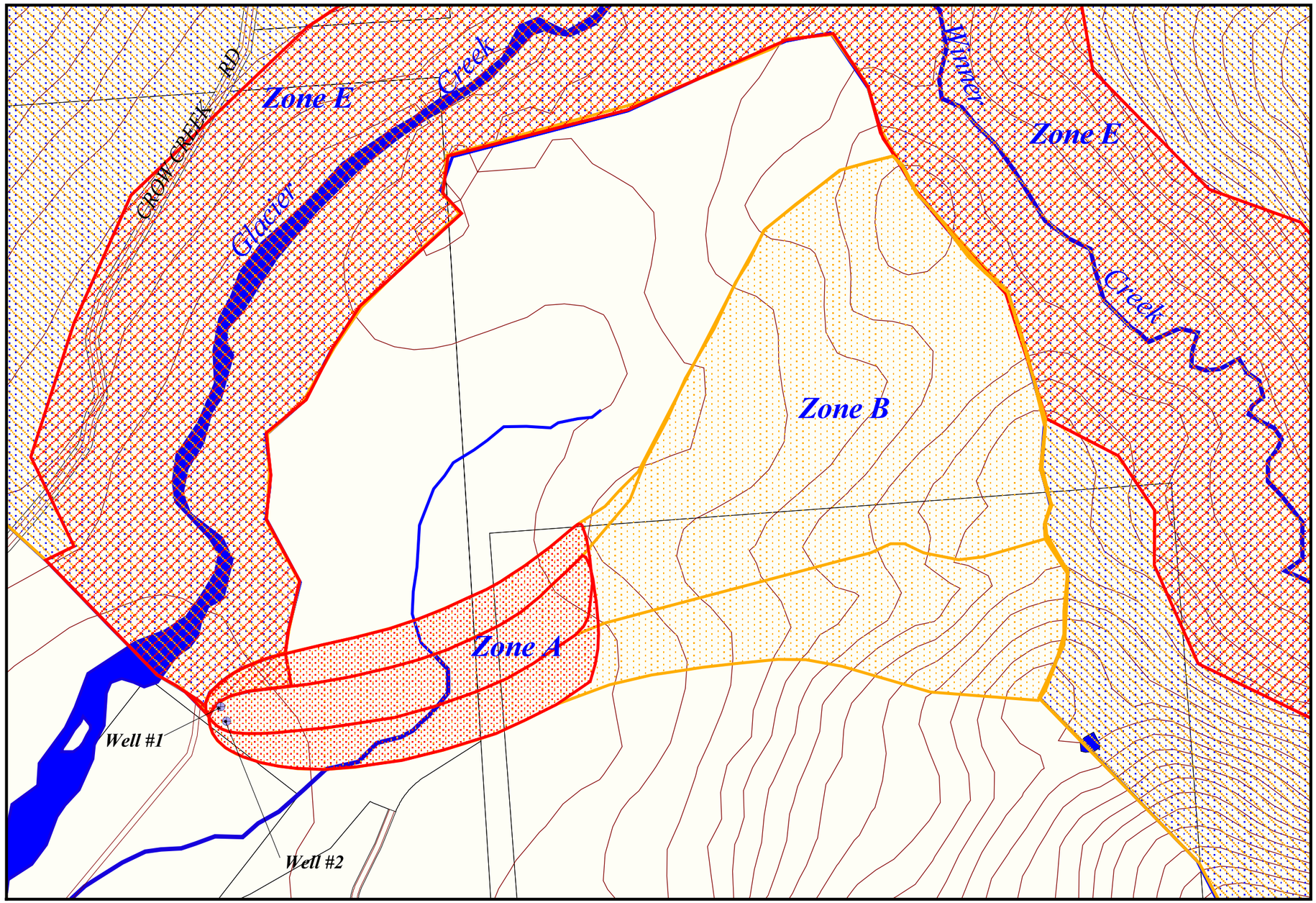
MOA Alyeska Utilities Wells
Zone A Protection Area
Several Months Travel Time
Zone B Protection Area
Less than 2 Years Travel Time
Zone E Protection Area
1000 Feet from Surface Water
Zone F Protection Area
1 Mile from Surface Water
Zone G Protection Area
Entire Watershed
MOA Roads
2nd order streams
3rd order streams
4th order streams
Glacier Creek
Lakes and Ponds
Elevation Contours = 20 meters
MOA Land Parcels

N
W
E
S

1000 0 1000 Feet

Map 2

MOA Alyeska Utilities (PWSID 212021)
Drinking Water Protection Areas



MOA Alyeska Utilities Wells
Zone A Protection Area
Several Months Travel Time
Zone B Protection Area
Less than 2 Years Travel Time
Zone E Protection Area
1000 Feet from Surface Water
Zone F Protection Area
1 Mile from Surface Water
Zone G Protection Area
Entire Watershed
MOA Roads
2nd order streams
3rd order streams
4th order streams
Glacier Creek
Lakes and Ponds
Elevation Contours = 20 meters
MOA Land Parcels

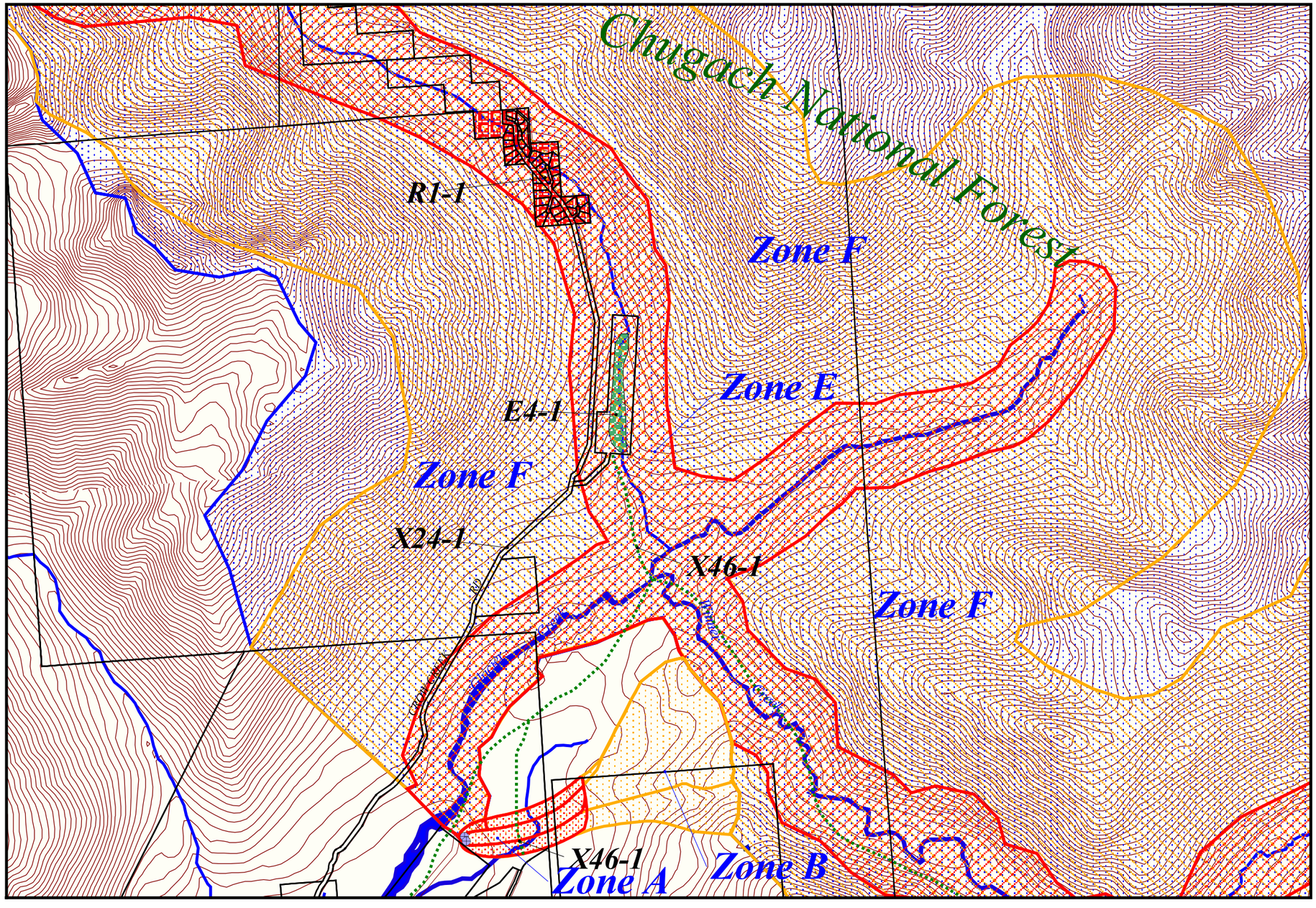
N
W E
S

Map 3

APPENDIX C

MOA Alyeska Utilities' Drinking Water Protection Areas and Potential & Existing Contaminant Sources

MOA Alyeska Utilities Drinking Water Protection Areas and Potential and Existing Contaminant Sources



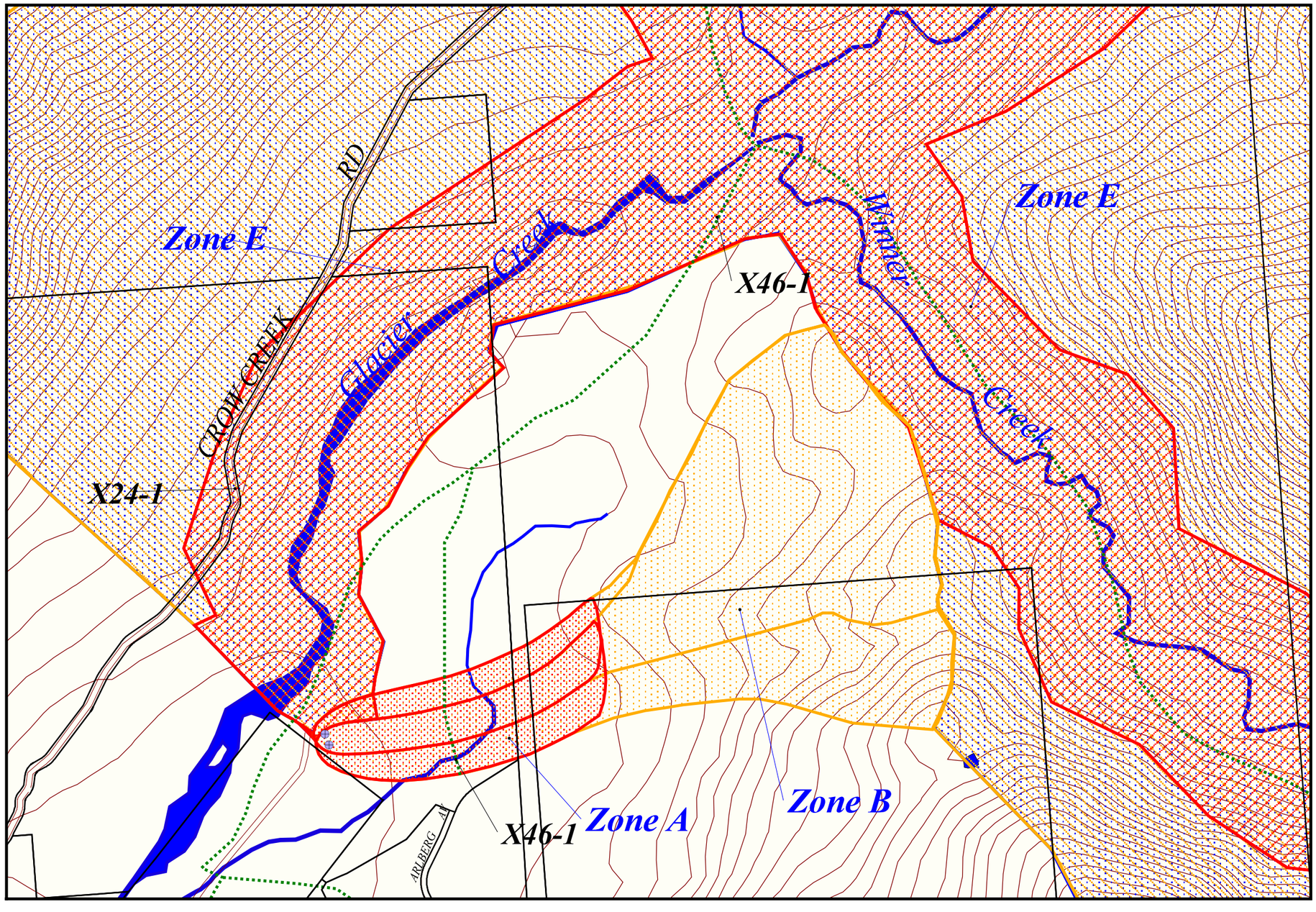
MOA Land Parcels
Unsewered redidential areas.shp
Placer Mining
Recreation Trails
MOA Alyeska Utilities Wells
Zone A Protection Area
Several Months Travel Time
Zone B Protection Area
Less than 2 Years Travel Time
Zone E Protection Area
1000 Feet from Surface Water
Zone F Protection Area
1 Mile from Surface Water
Zone G Protection Area
Entire Watershed
MOA Roads
2nd order streams
3rd order streams
4th order streams
Glacier Creek
Lakes and Ponds
Elevation Contours = 20 meters

N
W
E
S

2000 0 2000 Feet

Map 4

MOA Alyeska Utilities Drinking Water Protection Areas and Potential and Existing Contaminant Sources



MOA Land Parcels
Recreation Trails
MOA Alyeska Utilities Wells
Zone A Protection Area
Several Months Travel Time
Zone B Protection Area
Less than 2 Years Travel Time
Zone E Protection Area
1000 Feet from Surface Water
Zone F Protection Area
1 Mile from Surface Water
Zone G Protection Area
Entire Watershed
MOA Roads
2nd order streams
3rd order streams
4th order streams
Glacier Creek
Lakes and Ponds
Elevation Contours = 20 meters

N
W
E
S

900 0 900 Feet

Map 5

APPENDIX D

Vulnerability Analysis for MOA Alyeska Utilities Public Drinking Water System

Chart 1. Vulnerability analysis for Bacteria & Viruses – MOA Alyeska Utilities

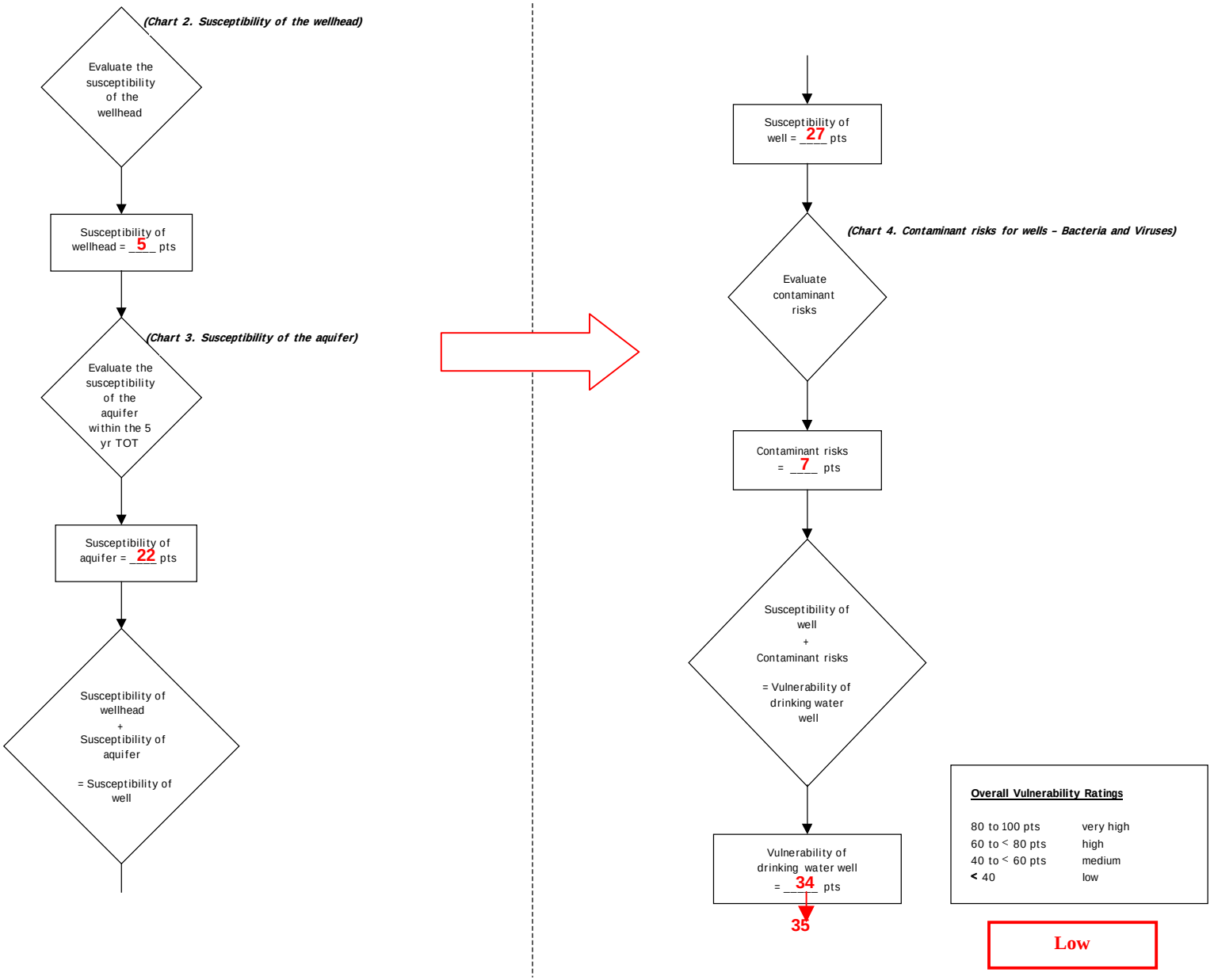


Chart 2. Susceptibility of the wellhead

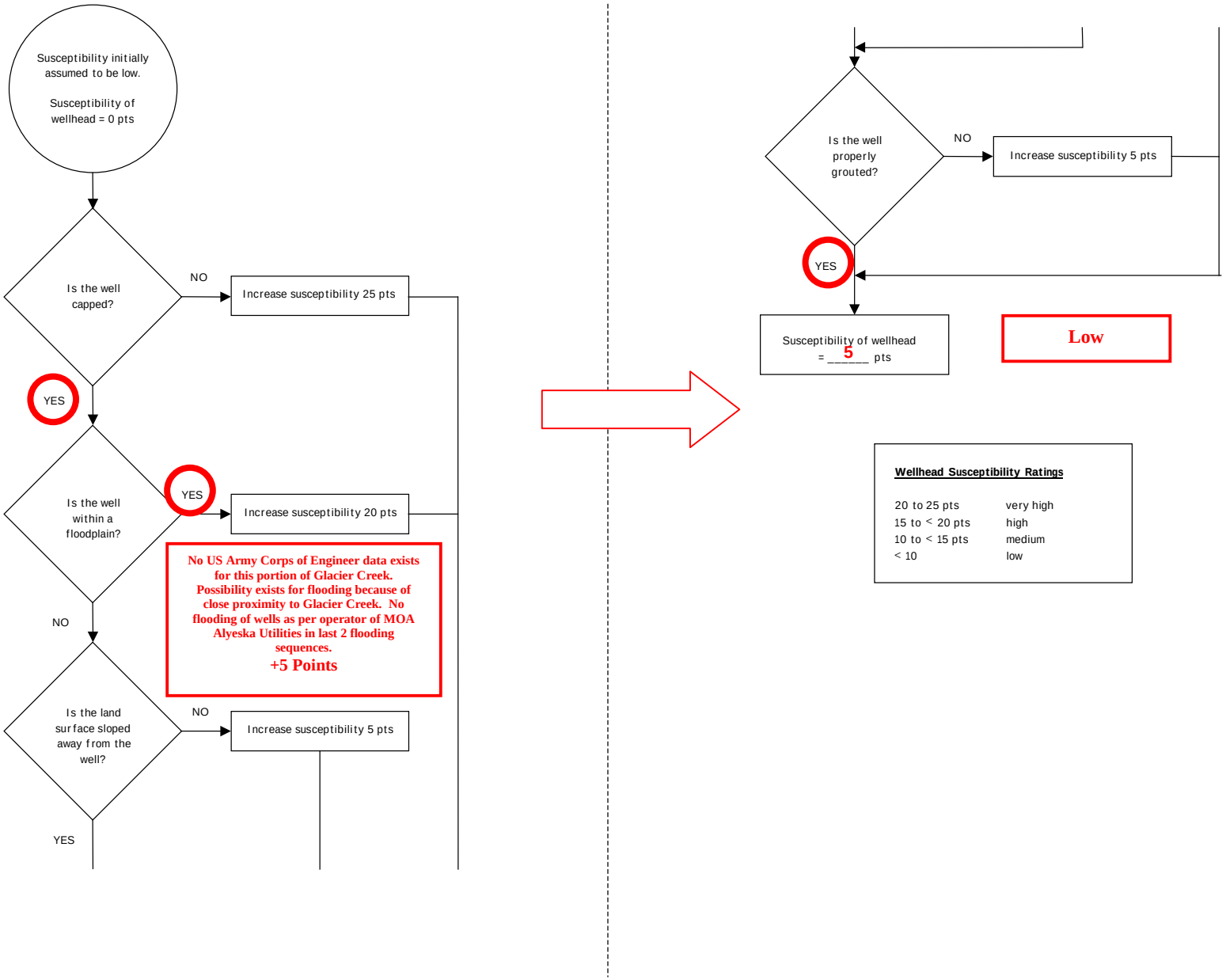
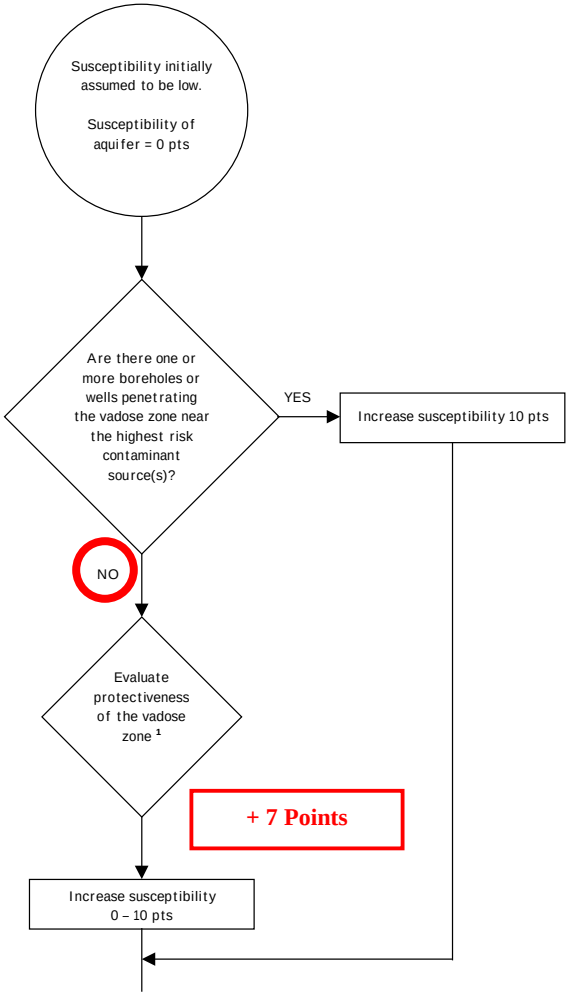
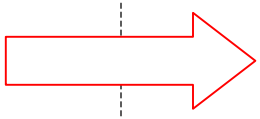
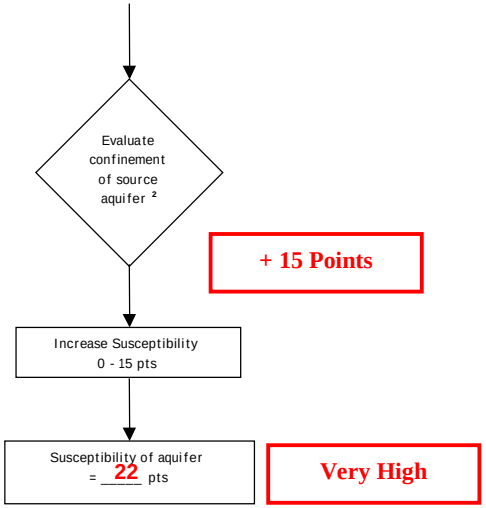


Chart 3. Susceptibility of the aquifer







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]

Recharge 6/10 = 3 Points
Depth to water table 8/10 = 4 Points

Protectiveness of the Vadose Zone Total = **7 Points**

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 15/15 = 9.75 Points
Depth to water table 15/15 = 5.25 Points

Degree of Confinement Total = **15 Points**

Aquifer Susceptibility Ratings

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

Very High

Chart 4. Contaminant risks for MOA Alyeska Utilities – Bacteria & Viruses

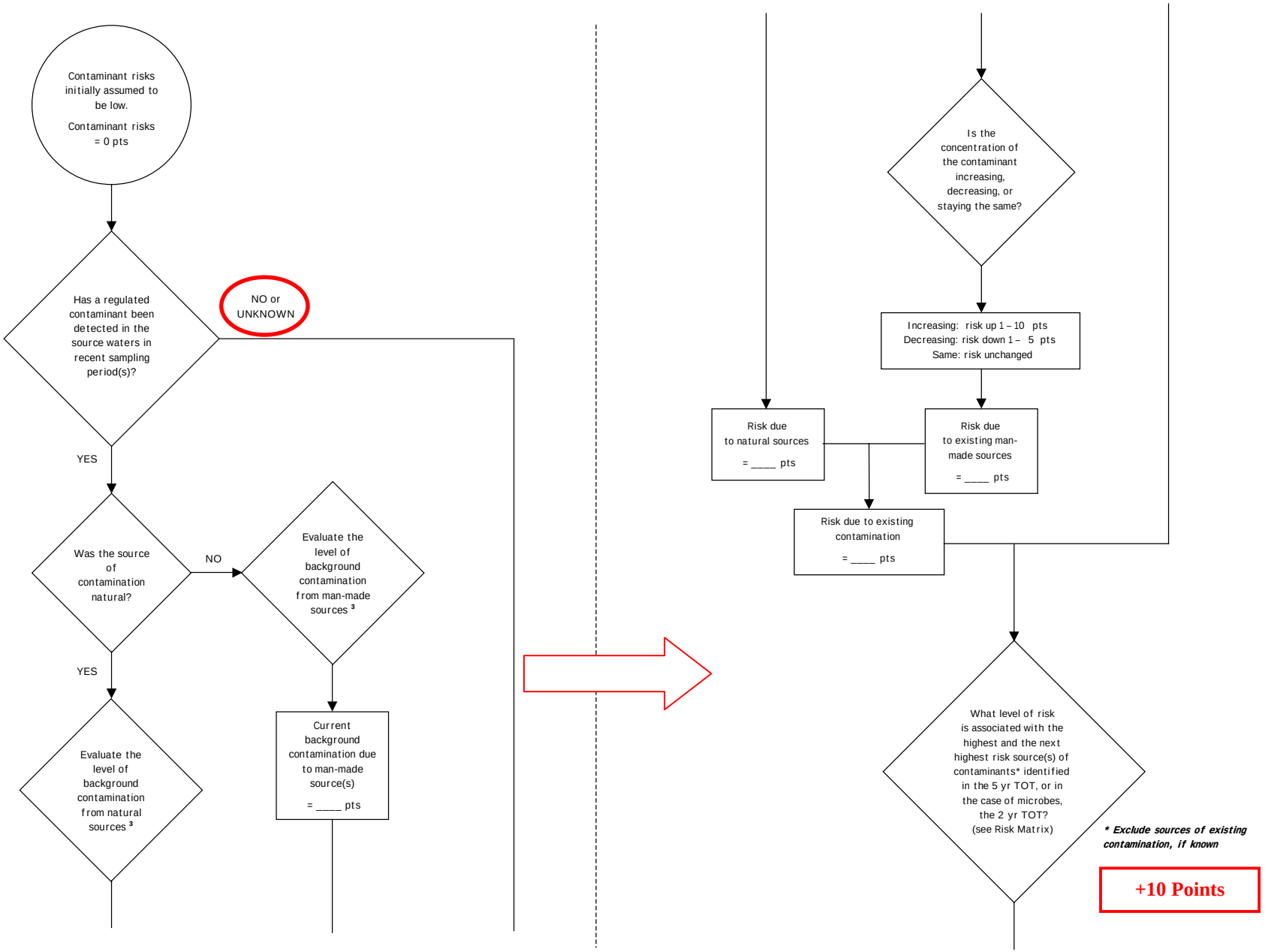


Chart 4. Contaminant risks for MOA Alyeska Utilities – Bacteria & Viruses (Continued)

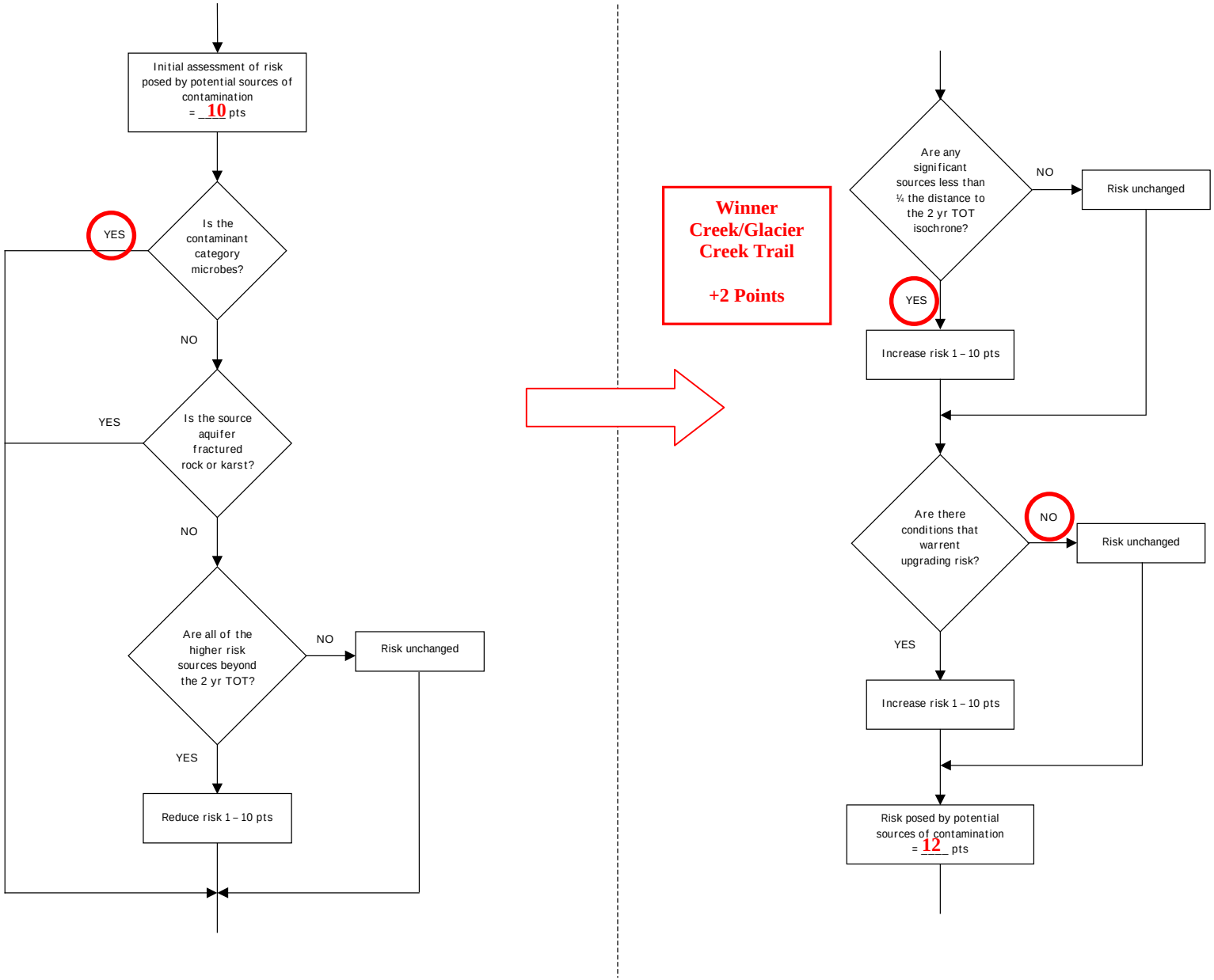
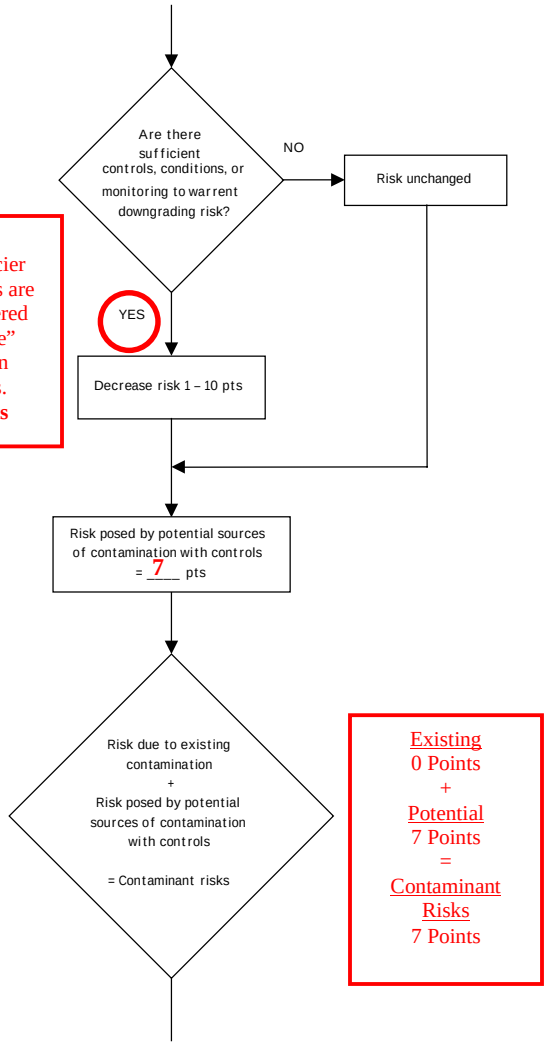


Chart 4. Contaminant risks for MOA Alyeska Utilities – Bacteria & Viruses (Continued)



Winner Creek/Glacier Creek Trails are not considered "High Use" recreation corridors.
- 5 Points

Existing
0 Points
+
Potential
7 Points
=
Contaminant Risks
7 Points

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

Contaminant risks*
= 7 pts

Low

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 1. Risk Matrix for Contaminant Sources for Bacteria & Viruses – MOA Alyeska Utilities

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)

GLACIER CREEK/WINNER CREEK TRAIL WITHIN ZONE A INITIALLY RANKED AS LOW	**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 – MOA Alyeska Utilities

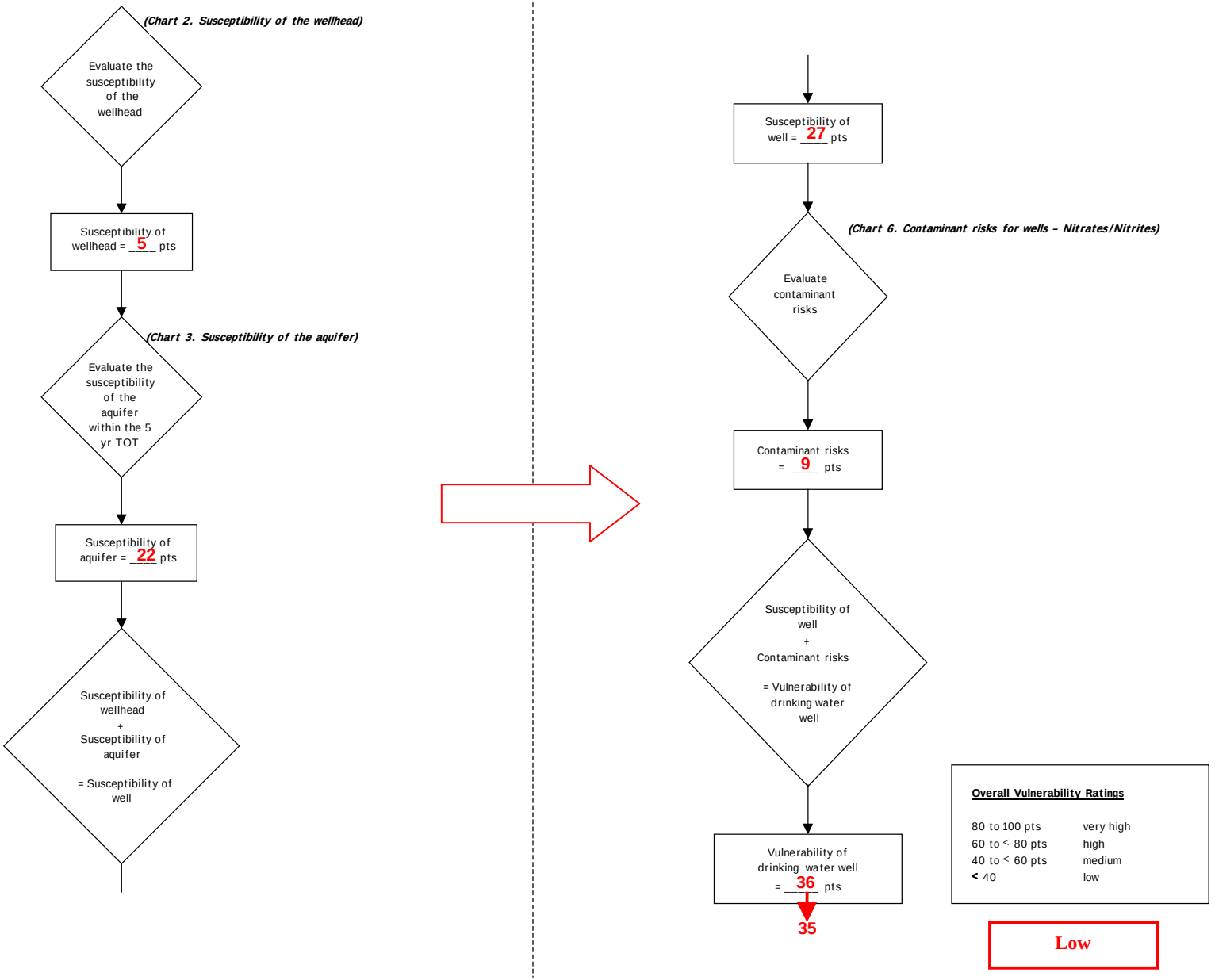


Chart 6. Contaminant risks for MOA Alyeska Utilities – Nitrates/Nitrites

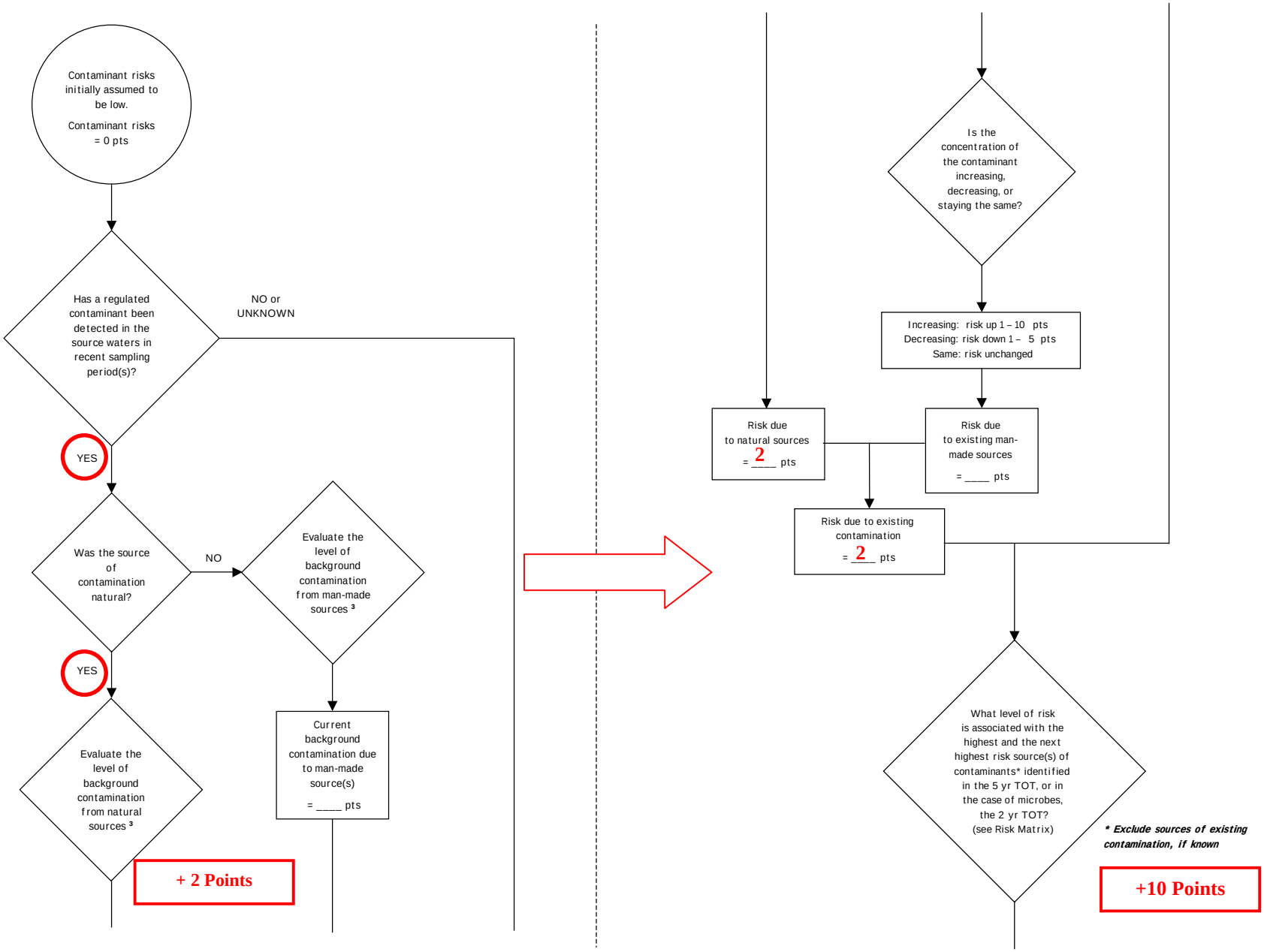


Chart 6. Contaminant risks for MOA Alyeska Utilities – Nitrates/Nitrites (Continued)

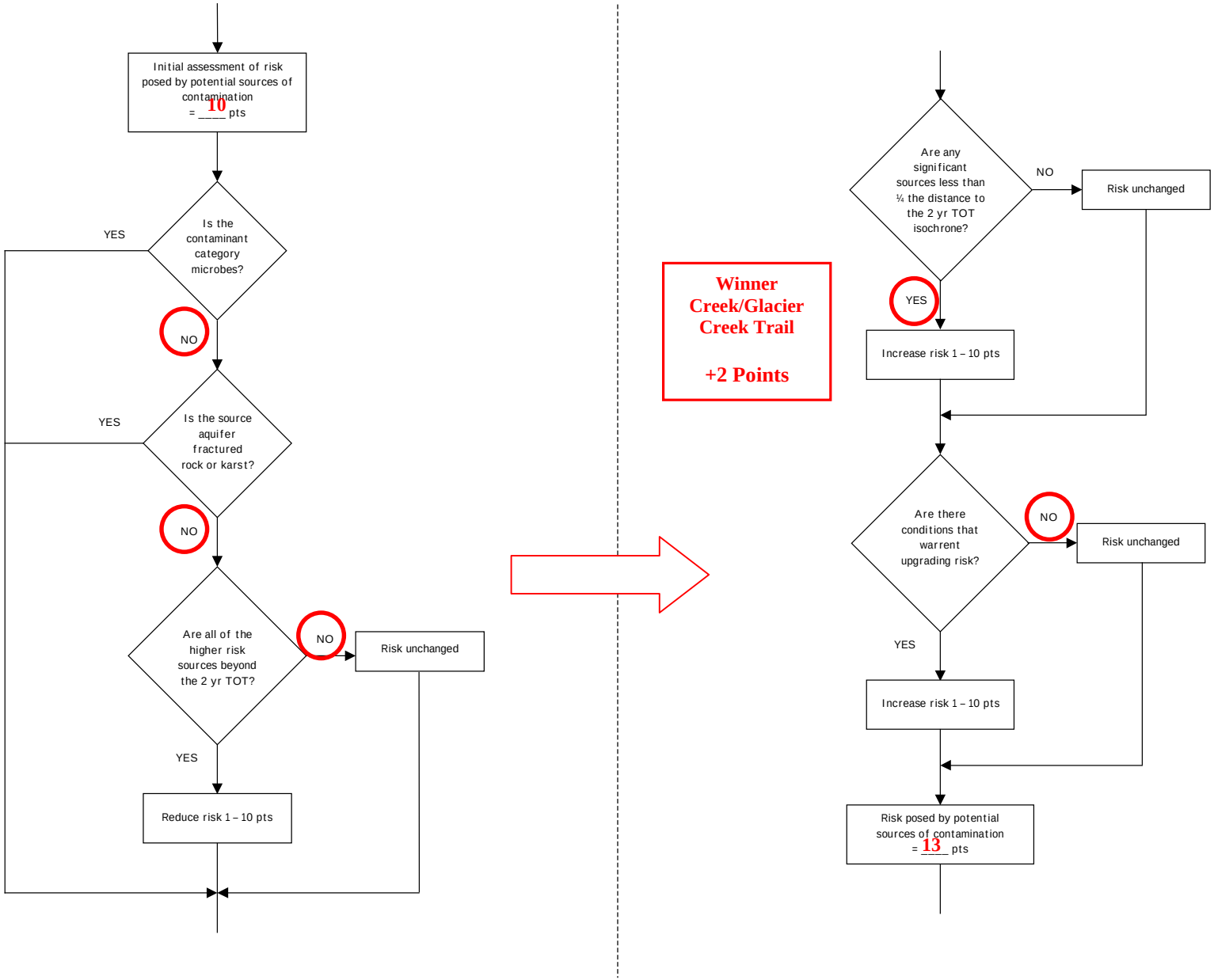
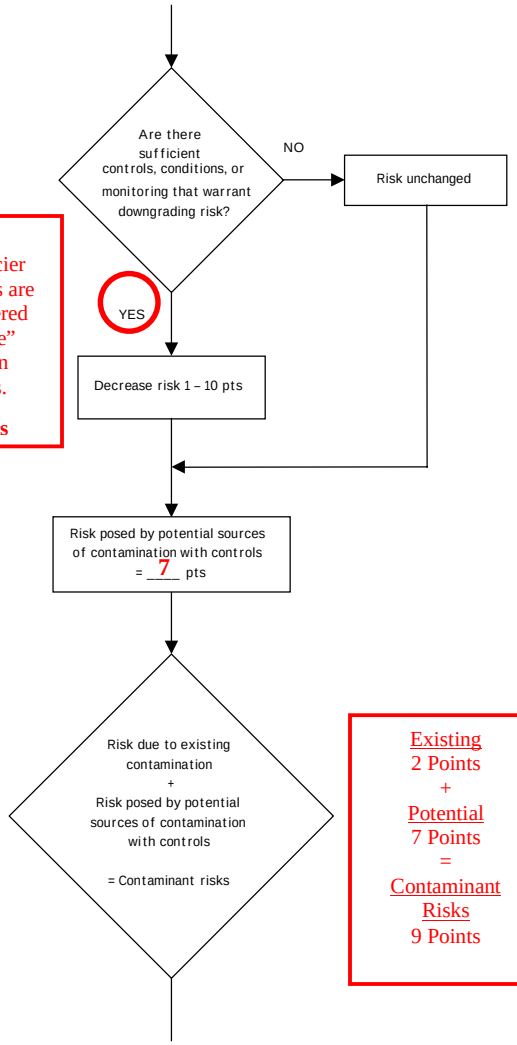


Chart 6. Contaminant risks for MOA Alyeska Utilities – Nitrates/Nitrites (Continued)



Winner Creek/Glacier Creek Trails are not considered "High Use" recreation corridors.

- 5 Points

Existing
2 Points
+
Potential
7 Points
=
Contaminant Risks
9 Points

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

Contaminant risks*
= 9 pts

Low

3. Level of Background Contamination

> MCL	21 - 50 pts
0.5 MCL to < MCL	11 - 20 pts
0.2 MCL to < 0.5 MCL	6 – 10 pts
'detect' to < 0.2 MCL	1 - 5 pts

Contaminant Risk Ratings

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

Nitrate concentration = 0.79 mg/L in source waters
Maximum Contaminant Level (MCL) = 10 mg/L

0.79/10 = 0.079 or 7.9% of MCL
0.079/0.2 = 0.39 * 5 points = 2 Points

+ 2 Points for detection of Nitrate in source waters

Table 2. Risk Matrix for Contaminant Sources for Nitrates/Nitrites – MOA Alyeska Utilities

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 – MOA Alyeska Utilities

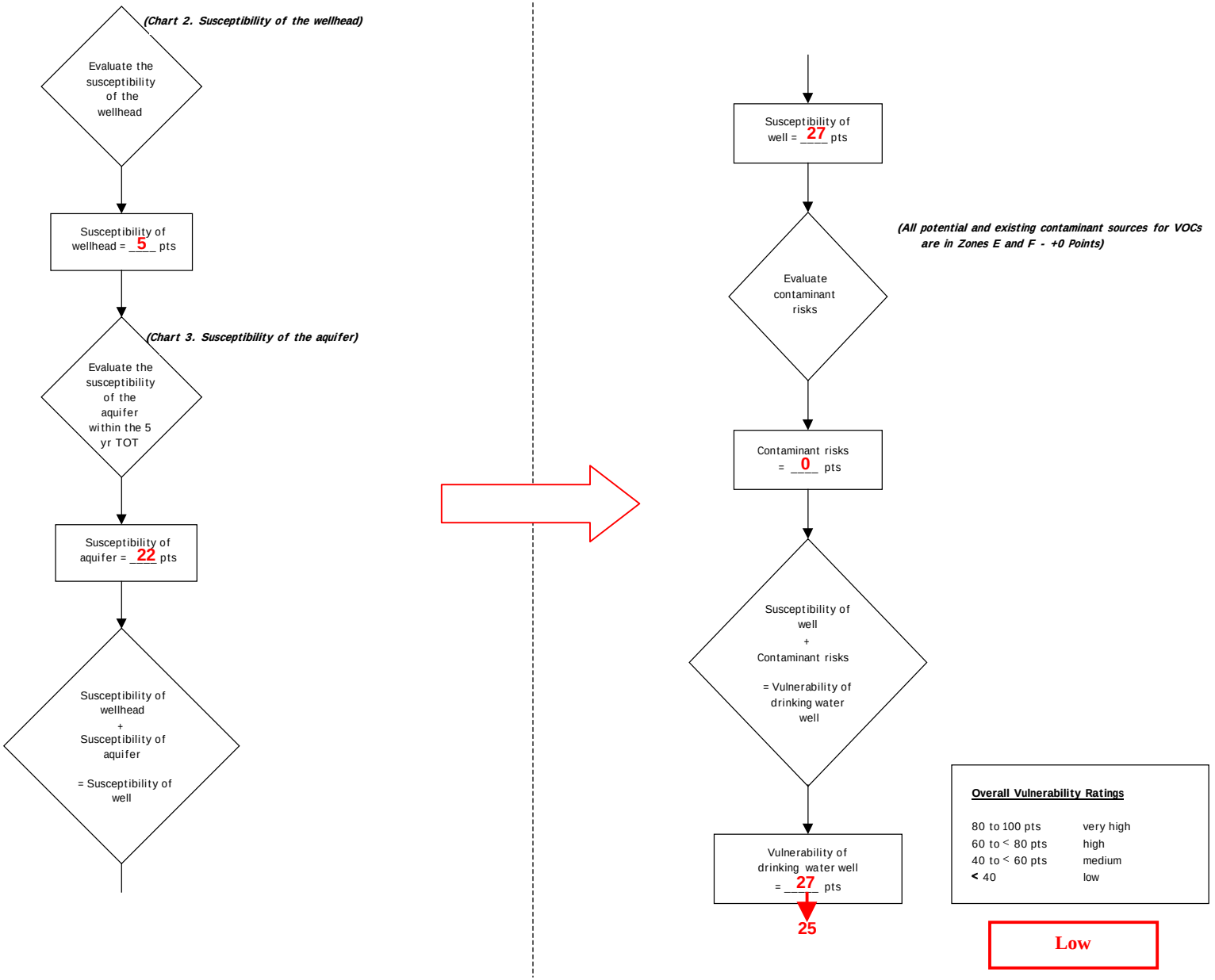


Table 3. Risk Matrix for Contaminant Sources for Volatile Organic Chemicals – MOA Alyeska Utilities

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	**ALL POTENTIAL CONTAMINANT SOURCES FOR VOLATILE ORGANIC CHEMICALS ARE WITHIN ZONE E AND F +0 POINTS**	**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 8. Vulnerability analysis for Heavy Metals, Cyanide, and other Inorganic Chemicals – MOA Alyeska Utilities

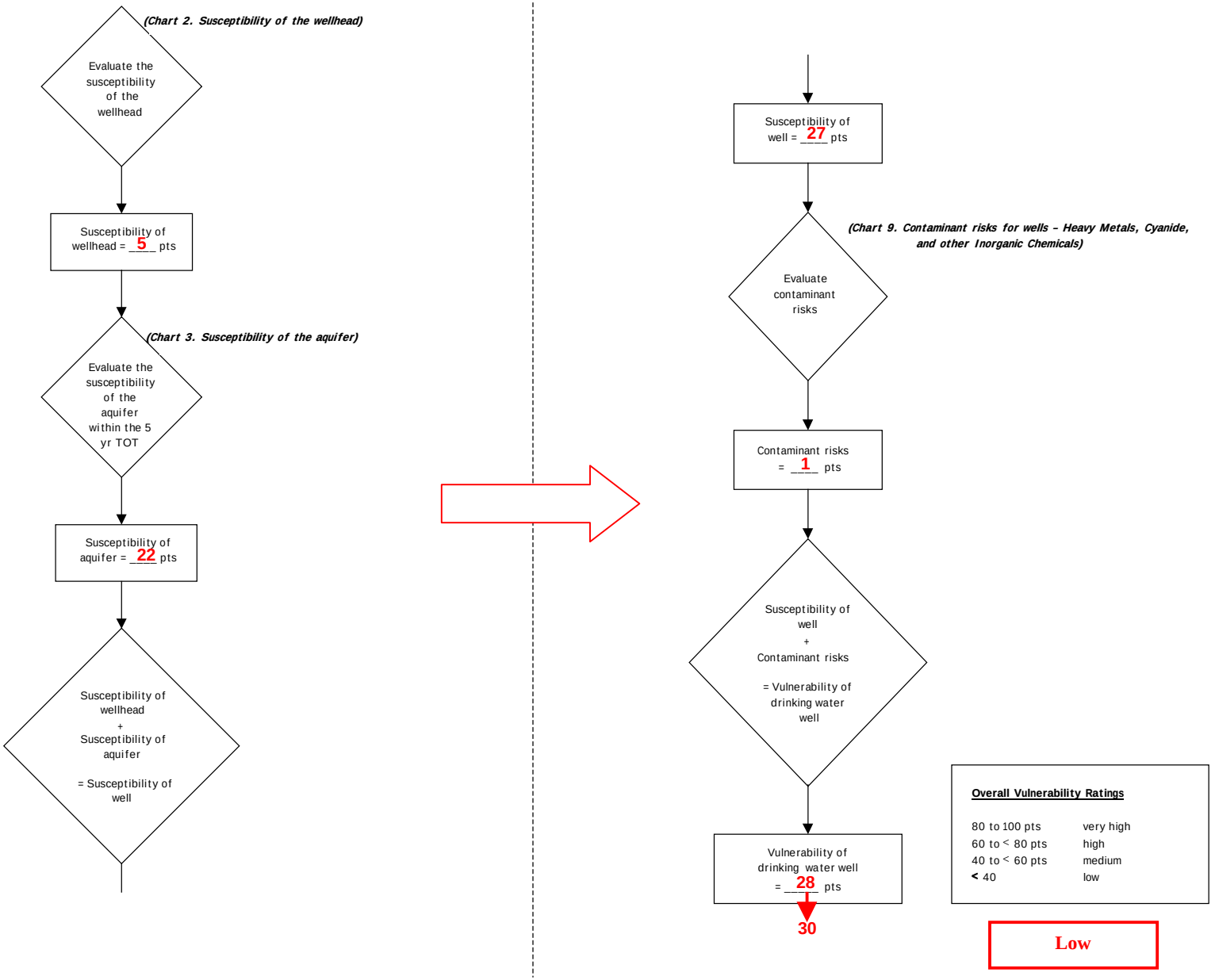


Chart 9. Contaminant risks for MOA Alyeska Utilities – Heavy Metals, Cyanide, and other Inorganic Chemicals

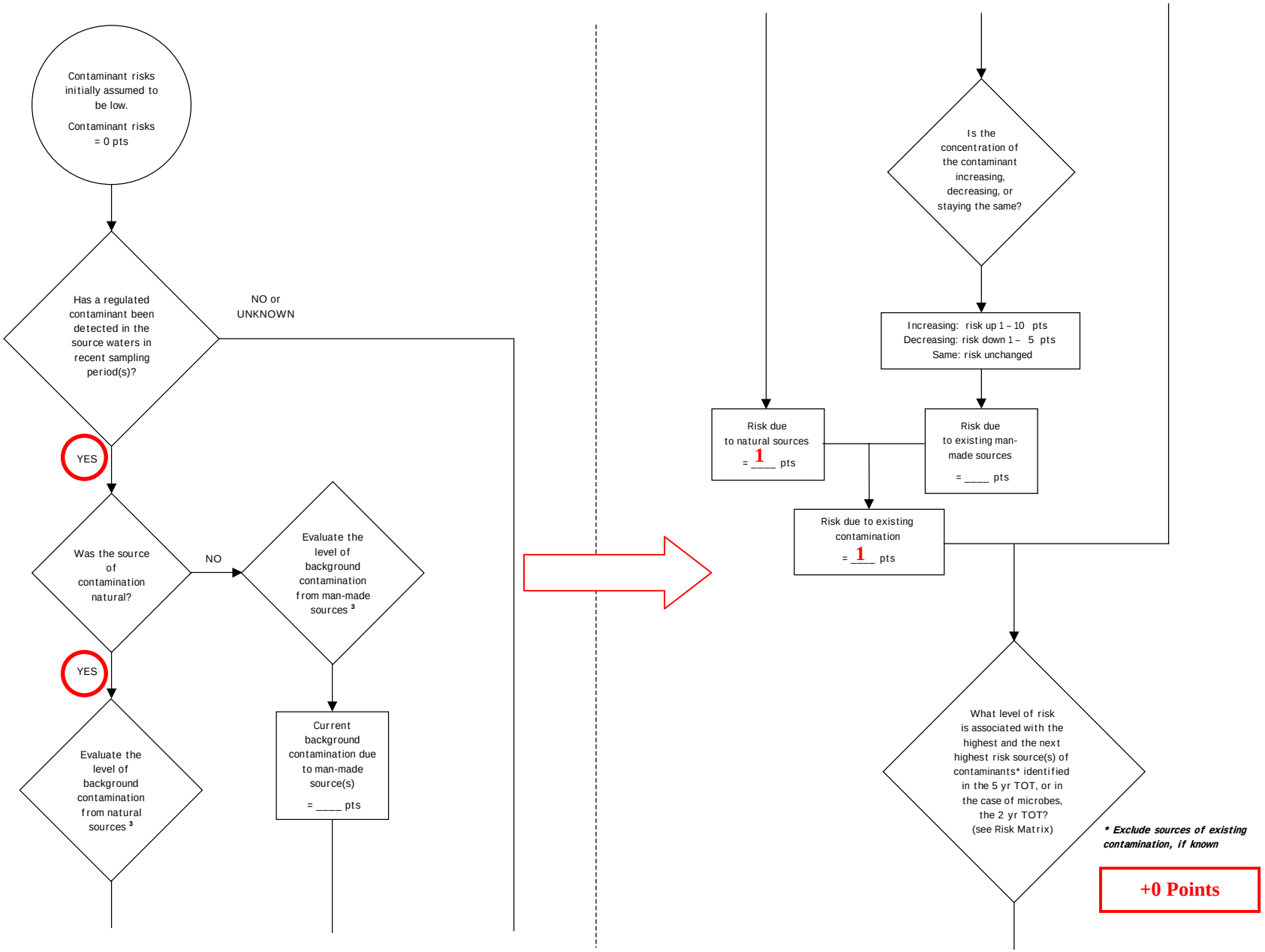


Chart 9. Contaminant risks for MOA Alyeska Utilities – Heavy Metals, Cyanide, and other Inorganic Chemicals (Continued)

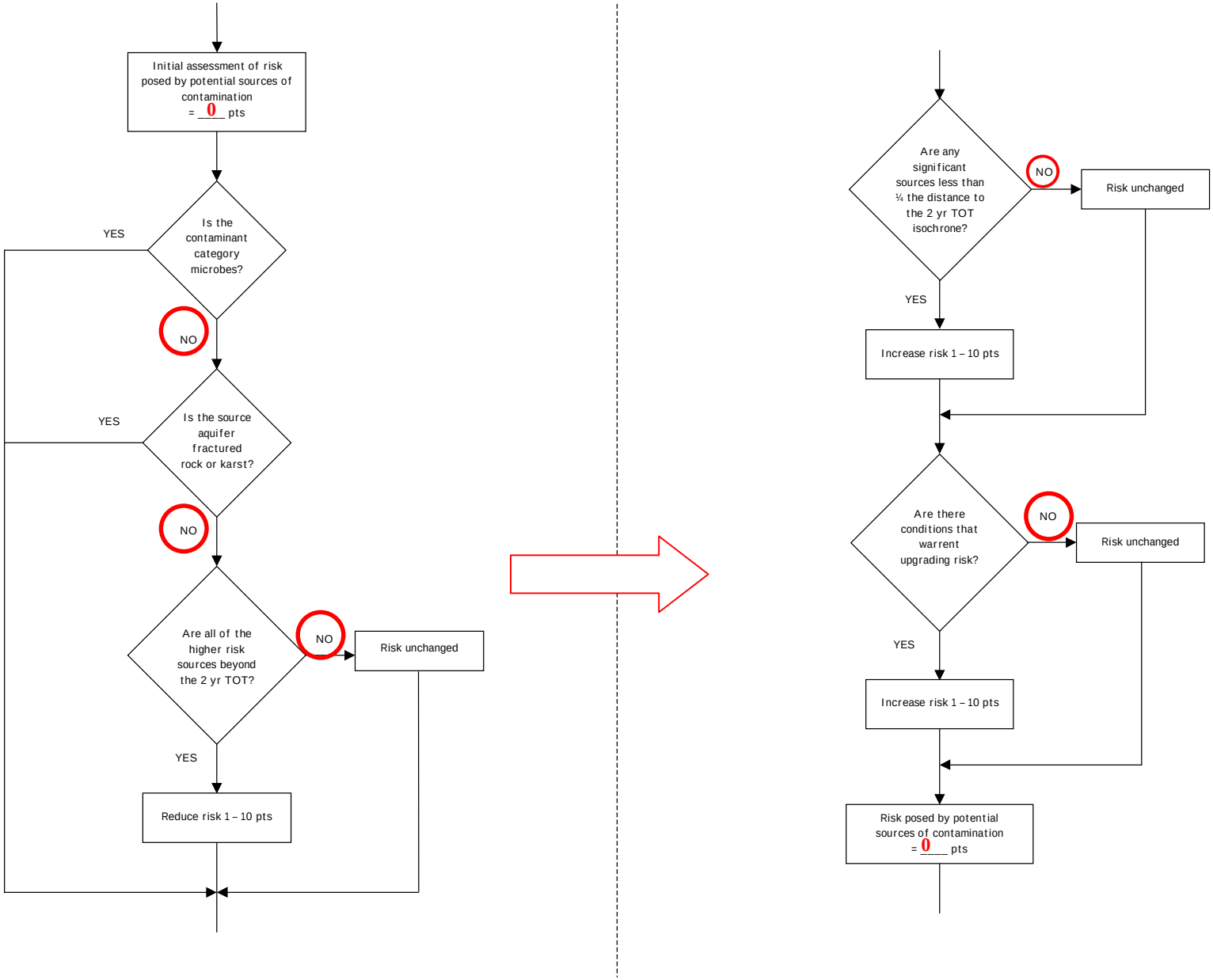
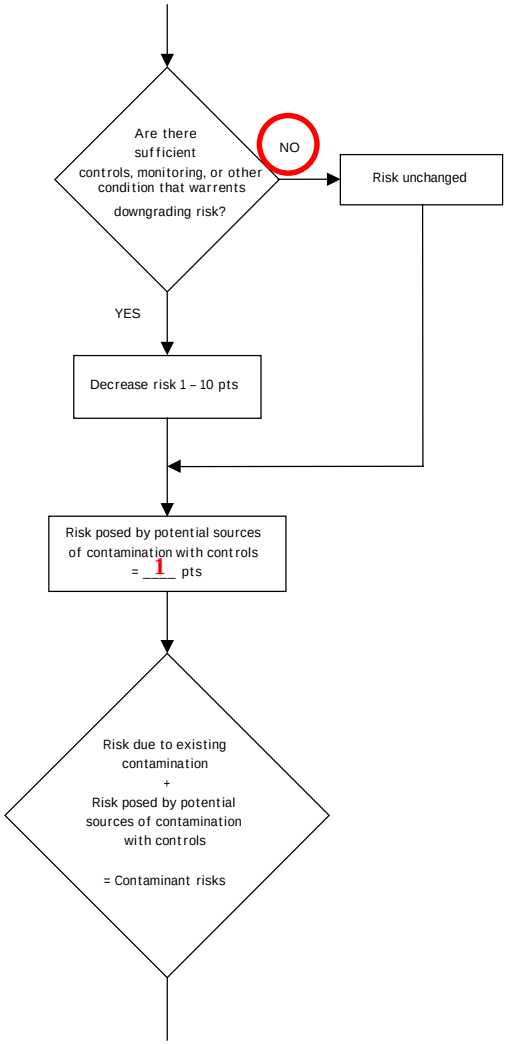
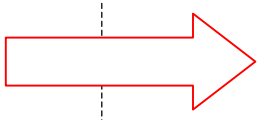


Chart 9. Contaminant risks for MOA Alyeska Utilities – Heavy Metals, Cyanide, and other Inorganic Chemicals (Continued)





* *Truncate risk at 50 pts*

Contaminant risks* = 1 pts

Low

3. Level of Background Contamination

> MCL	21 - 50 pts
0.5 MCL to < MCL	11 - 20 pts
0.2 MCL to < 0.5 MCL	6 – 10 pts
'detect' to < 0.2 MCL	1 - 5 pts

Contaminant Risk Ratings

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

Barium concentration = 0.055 mg/L in source waters
Maximum Contaminant Level (MCL) = 2 mg/L

0.05/2 = 0.028 or 2.8% of MCL
0.028/0.2 = 0.14 * 5 points = 1 Points

+ 1 Point for detection of Barium in source waters

Table 4. Risk Matrix for Contaminant Sources for Heavy Metals, Cyanide, and other Inorganic Chemicals – MOA Alyeska Utilities

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)

ALL POTENTIAL CONTAMINANT SOURCES FOR VOLATILE ORGANIC CHEMICALS ARE WITHIN ZONE E AND F	**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 10. Vulnerability analysis for Synthetic Organic Chemicals – MOA Alyeska Utilities

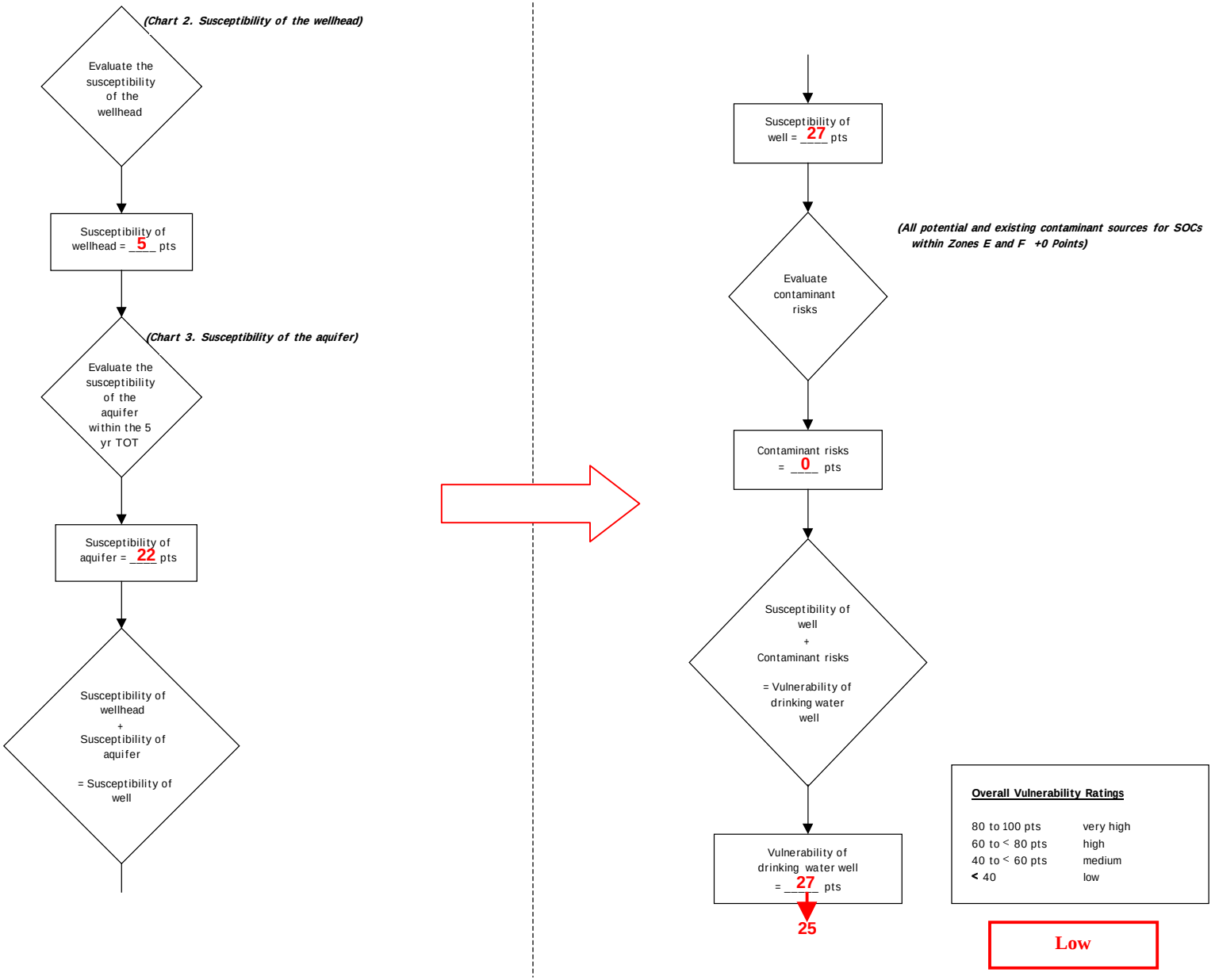


Table 5. Risk Matrix for Contaminant Sources for Synthetic Organic Chemicals – MOA Alyeska Utilities

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)

ALL POTENTIAL CONTAMINANT SOURCES FOR SYNTHETIC ORGANIC CHEMICALS ARE WITHIN ZONE E AND F +0 POINTS	**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 11. Vulnerability analysis for Other Synthetic Organic Chemicals – MOA Alyeska Utilities

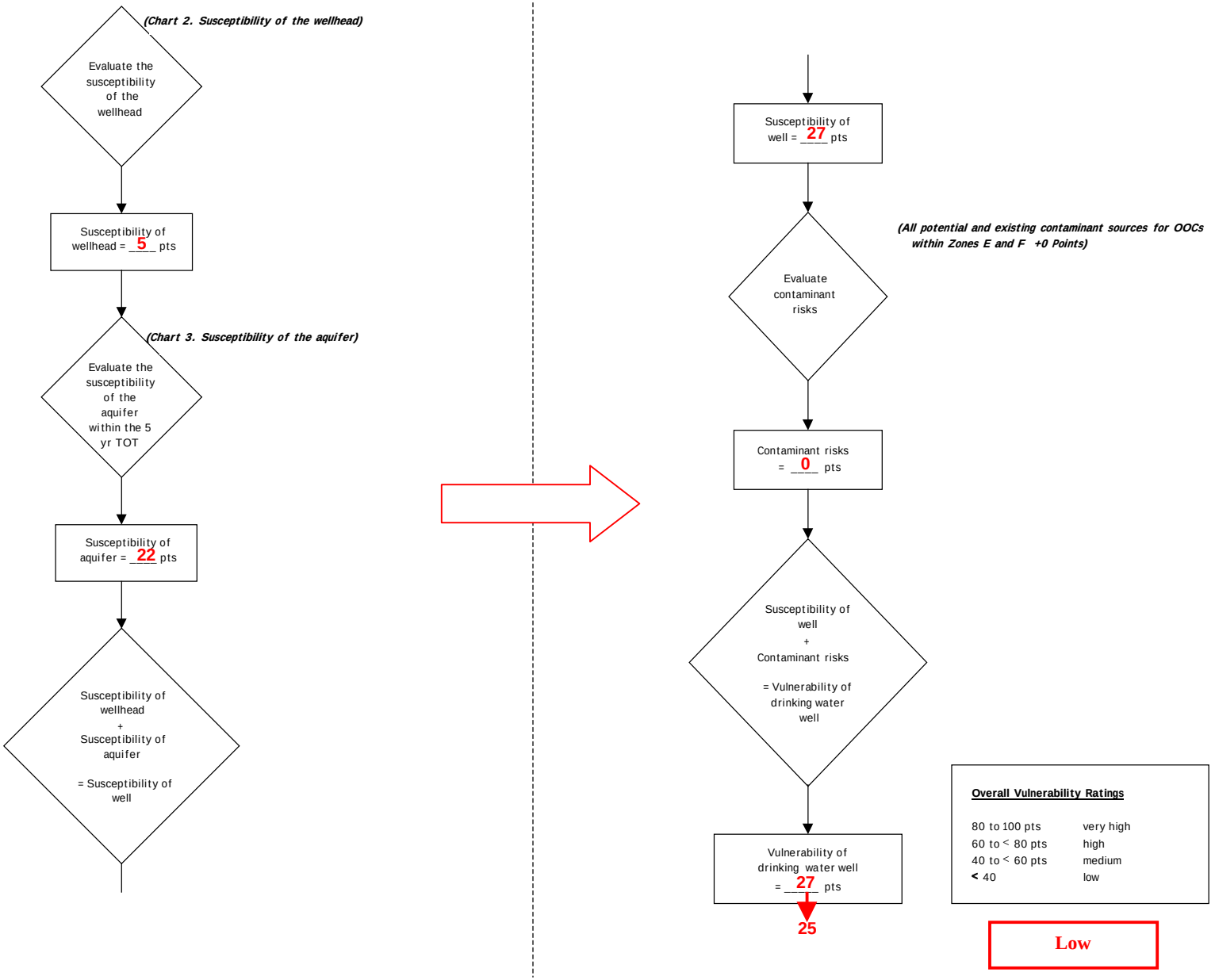


Table 6. Risk Matrix for Contaminant Sources for Other Synthetic Organic Chemicals – MOA Alyeska Utilities

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)

ALL POTENTIAL CONTAMINANT SOURCES FOR OTHER SYNTHETIC ORGANIC CHEMICALS ARE WITHIN ZONE E AND F +0 POINTS	**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