Source Water Assessment

A Hydrogeologic Susceptibility and Vulnerability Assessment for Glennallen Heights Drinking Water System, Glennallen, Alaska

PWSID # 291504.002

July 2004

DRINKING WATER PROTECTION PROGRAM REPORT 1362
Alaska Department of Environmental Conservation

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The Drinking Water Protection Program (DWPP) is producing Source Water Assessments in compliance with the Safe Drinking Water Act Amendments of 1996. Each assessment includes a delineation of the source water area, an inventory of potential and existing contaminant sources that may impact the water, a risk ranking for each of these contaminants, and an evaluation of the potential vulnerability of these drinking water sources.

These assessments are intended to provide public water systems owners/operators, communities, and local governments with the best available information that may be used to protect the quality of their drinking water. The assessments combine information obtained from various sources, including the U.S. Environmental Protection Agency, Alaska Department of Environmental Conservation (ADEC), public water system owners/operators, and other public information sources. The results of this assessment are subject to change if additional data becomes available. It is anticipated this assessment will be updated every five years to reflect any changes in the vulnerability and/or susceptibility of public drinking water source. If you have any additional information that may affect the results of this assessment, please contact the Program Coordinator of DWPP, (907) 269-7521.

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Source Water Assessment for Glennallen Heights Source of Public Drinking Water, Glennallen, Alaska

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

Glennallen Heights has two Public Water System (PWS) wells. This report exclusively pertains to the second of the two wells (PWS No. 291504.002). It can be assumed that the well has been used as a drinking water source since it was drilled in November of 1976.

The well is a Class A (community and non-transient/non-community) water system located west of the well house in Glennallen Heights, which is in Glennallen, Alaska. The 2002 sanitary survey indicates that there is a storage tank with a 1200-gallon capacity. Records also indicate that the drinking water source is untreated. This system operates year round and serves approximately 37 residents and 0 non-residents through 11 service connections. The wellhead received a susceptibility rating of **Low** and the aquifer received a susceptibility rating of **Very High**. Combining these two ratings produce a **High** rating for the natural susceptibility of the well.

Identified potential and current sources of contaminants for the public drinking water source include: aboveground fuel storage tanks, septic systems, roads, pipelines (oil and gas), and electric power generation (fossil fuels). A detailed inventory of potential or existing contamination sources can be found in Appendix B, Table 1. These identified potential and existing sources of contamination are considered as sources of bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, cyanide and other inorganic chemicals, synthetic organic chemicals, and other organic chemicals contaminant categories.

Overall, the water well received a vulnerability rating of **Very High** for heavy metals, cyanide and other inorganic chemicals, a vulnerability rating of **High** for volatile organic chemicals, other organic chemicals; a vulnerability rating of **Medium** for bacteria and viruses, nitrates and nitrites; and synthetic organic chemicals.

PUBLIC DRINKING WATER SYSTEM

The Glennallen Heights well is a Class A (community/non-transient/non-community) public water system. The system is located south of the well house in Glennallen Heights, which is in Glennallen, Alaska. (Sec. 23, T004N, R002W, Copper River Meridian; see Map A of Appendix A). Glennallen is located at the junction of the Glenn and Richardson Highways, approximately 189 miles east of Anchorage. The community has a population of 574 (ADCED, 2003). Average annual precipitation for Glennallen is 9 inches, including approximately 39 inches of snowfall. Temperatures typically range between –10 in January to 56°F in July.

Households in Glennallen have individual wells and septic systems. Almost all homes are fully plumbed, and refuse is collected by a private firm, Copper Valley Construction, and is transported to the landfill operated by a private operator, Copper Basin Sanitation (ADCED, 2003). Copper Valley Electric Association, a REA cooperative, provides electricity. Power-generating facilities are hydro powered with diesel backups (ADCED, 2003).

According to information supplied by ADEC for the Glennallen Heights PWS, the depth of the primary water well is 174.5 feet below the ground surface. Based on available well construction details, the well is screened, but the depth is unknown. The well is completed in an unconfined aquifer and is not located within a floodplain.

Information acquired from an April 2002 sanitary survey for the public water system indicated that the land surface was sloped away from the well. Generally, land surfaces that slope away from the wellhead promote surface water drainage, which reduces the potential of contaminant migration down the well casing annulus. The sanitary survey indicates that the well is not grouted according to ADEC regulations. Proper grouting provides added protection against contaminants traveling along the well casing annulus and into source waters.

The Glennallen area is in the southeastern portion of the Copper River basin, in southeastern Interior Alaska. The Copper River basin, ranging from 500 to over 4,000 feet above sea level, is an intermontane basin rimmed by peaks of the Chugach, Alaska, Talkeetna, and Wrangell mountains. The terrain of the basin can be divided into two physiographic sub-units: the rolling, hummocky Copper River basin piedmont surface, and the Copper River basin trough. The Copper River basin trough is generally flat and lacks the hummocky, rolling character of the piedmont surface (Nichols 1956).

The terrain, geology of the unconsolidated deposits, and foundation materials of the Copper River basin are related to Pleistocene and recent events. Glaciers from the Chugach, Wrangell, Talkeetna, and Alaska Ranges repeatedly invaded the basin, perhaps at times filling it and flowing across the divides to the north, west, east, and south. Such extensive glaciation has resulted in the deposition of large thicknesses of coarse glacial boulder clays (till) and coarse outwash gravel and sand on the piedmont surface, with finer till and outwash interbedded with lake deposits in the basin trough (Nichols 1956).

The Glennallen area is within the discontinuous permafrost zone (Nichols 1956).

Surface soils in the area generally consist of silt and clay with pebbles underlain by boulder clay with till, underlain by glacial outwash sand and gravel, underlain by boulder clay or till (Nichols 1956).

DRINKING WATER PROTECTION AREA

In order to evaluate whether a drinking water source is at risk, we must first evaluate what the most likely pathways for surface contamination to reach the groundwater are. These areas are determined by looking at the characteristics of the soil, groundwater, aquifer, and well.

The most probable area for contamination to reach the drinking water well is the area that contributes water to the well, the groundwater recharge area. This area is designated as the drinking water protection area (DWPA). Because releases of contaminants within the protection area are most likely to impact the drinking water well, this area will serve as the focus for voluntary protection efforts. An analytical calculation was used to determine the size and shape of the DWPA for the Glennallen Heights PWS. The input parameters describing the attributes of the aquifer in this calculation were adopted from Groundwater (Freeze and Cherry, 1979). Available geology and groundwater contours were also considered to take into account any uncertainties in groundwater flow and aquifer characteristics to arrive at a meaningful protection area.

The protection areas established for wells by the ADEC are usually separated into four zones, limited by the watershed. These zones correspond to differences in the time-of-travel (TOT) of the water moving through the aquifer to the well (Please refer to the Guidance Manual for Class A Public Water Systems for additional information).

The time of travel for contaminants within the water varies and is dependent on the physical and chemical characteristics of each contaminant. The following is a summary of the four protection area zones for wells and the calculated time-of-travel for each:

Table 1. Definition of Zones

Zone	Definition
A	¼ the distance for the 2-yr. time-of-travel
B	Less than the 2 year time-of-travel
C	Less Than the 5 year time-of-travel
D	Less than the 10 year time-of-travel

The DWPA for the Glennallen Heights PWS was determined using an analytical calculation and includes Zones A, B, C, and D (See Map A of Appendix A).

INVENTORY OF POTENTIAL AND EXISTING CONTAMINANT SOURCES

The Drinking Water Protection Program has completed an inventory of potential and existing sources of contamination within the Glennallen Heights DWPA. This inventory was completed through a search of agency records and other publicly available information. Potential sources of contamination to the drinking water aquifer include 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 all Class A public water system assessments, six categories of drinking water contaminants were inventoried. They include:

- Bacteria and viruses,
- Nitrates and/or nitrites,
- Volatile organic chemicals,

- Heavy metals, cyanide and other inorganic chemicals,
- Synthetic organic chemicals,
- Other organic chemicals.

The sources are displayed on Map C of Appendix C and summarized in Table 1 of Appendix B.

RANKING OF CONTAMINANT RISKS

Once the potential and existing sources of contamination have been identified, they are assigned a ranking 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. Rankings include:

- Low,
- Medium,
- High, and
- Very High.

The time-of-travel for contaminants within the water varies and is dependent on the physical and chemical characteristics of each contaminant. Bacteria and Viruses are only inventoried in Zones A and B because of their short life span. Only "Very High" and "High" rankings are inventoried within the outer Zone D due to the probability of contaminant dilution by the time the contaminants get to the well. Tables 2 through 7 in Appendix B 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, cyanide and other inorganic chemicals, synthetic organic chemicals, and other organic chemicals.

VULNERABILITY OF THE DRINKING WATER SYSTEM

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 analyzes the 'Susceptibility of the Wellhead' to contamination by looking at the construction of the well and its surrounding area. Chart 2 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 3 analyzes 'Contaminant Risks' for the drinking water source with respect to bacteria and viruses. The 'Contaminant Risks' portion of the analysis considers potential sources of contaminants as well as a review of contamination that has or may have occurred, but has not arrived or been detected at the well. Chart 4 contains the 'Vulnerability Analysis for Bacteria and Viruses'. Charts 5 through 14 contain the Contaminant Risks and Vulnerability Analyses for nitrates and nitrites, volatile organic chemicals, heavy metals, cyanide and other inorganic chemicals, synthetic organic chemicals, and other organic chemicals, respectively.

A score for the Natural Susceptibility is reached by considering the properties of the well and the aquifer.

Susceptibility of the Wellhead (0 – 25 Points)
(Chart 1 of Appendix D)

+

Susceptibility of the Aquifer (0 – 25 Points)
(Chart 2 of Appendix D)

=

Natural Susceptibility (Susceptibility of the Well)
(0 – 50 Points)

A ranking is assigned for the Natural Susceptibility according to the point score:

Natural Susceptibility Ratings	
40 to 50 pts	Very High
30 to < 40 pts	High
20 to < 30 pts	Medium
< 20 pts	Low

The Glennallen Heights water well is completed in an unconfined aquifer. Unconfined aquifers are more susceptible to potential groundwater quality impacts posed by the migration of surface water contaminants downward from the surface. Table 2 shows the susceptibility scores and ratings for this PWS.

Table 2. Susceptibility

	Score	Rating
Susceptibility of the Wellhead	5	Low
Susceptibility of the Aquifer	25	Very High
Natural Susceptibility	30	High

Contaminant risks to a drinking water source depend on the type, number or density, and distribution of contaminant sources. This score has been derived from an examination of existing and historical contamination that has been detected at the drinking water source through routine sampling. It also evaluates potential sources of contamination. Flow charts are used to assign a point score, and ratings are assigned in the same way as for the natural susceptibility:

Contaminant Risk Ratings	
40 to 50 pts	Very High
30 to < 40 pts	High
20 to < 30 pts	Medium
< 20 pts	Low

Table 3 summarizes the Contaminant Risks for each category of drinking water contaminants.

Table 3. Contaminant Risks

Category	Score	Rating
Bacteria and Viruses	12	Low
Nitrates and/or Nitrites	12	Low
Volatile Organic Chemicals	35	High
Heavy Metals, Cyanide and Other Inorganic Chemicals	50	Very High
Synthetic Organic Chemicals	12	Low
Other Organic Chemicals	44	Very High

Finally, an overall vulnerability score is assigned for each water system by combining each of the contaminant risk scores with the natural susceptibility score:

Natural Susceptibility (0 – 50 points)

+

Contaminant Risks (0 – 50 points)

=

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

Again, rankings are assigned according to a point score:

Overall Vulnerability Ratings	
80 to 100 pts	Very High
60 to < 80 pts	High
40 to < 60 pts	Medium
< 40 pts	Low

Table 4 contains the overall vulnerability scores (0 – 100) and ratings for each of the six categories of drinking water contaminants. Note: scores are rounded off to the nearest five.

Table 4. Overall Vulnerability

Category	Score	Rating
Bacteria and Viruses	40	Medium
Nitrates and Nitrites	40	Medium
Volatile Organic Chemicals	65	High
Heavy Metals, Cyanide and Other Inorganic Chemicals	80	Very High
Synthetic Organic Chemicals	40	Medium
Other Organic Chemicals	75	High

Bacteria and Viruses

The contaminant risk for bacteria and viruses is **Low**. The risk is primarily attributed to the presence of septic systems and roads in Zone A (see Table 2 – Appendix B).

Coliform (a bacteria) are found naturally in the environment and although they aren't necessarily a health threat, they are an indicator of other potentially harmful bacteria in the water, more specifically, fecal coliform and E. coli, which only come from human and animal fecal waste. Harmful bacteria can cause diarrhea, cramps, nausea, headaches, or other symptoms (EPA, 2003).

No positive bacteria counts have been reported in recent (within five years) sampling events (See Chart 3 – Contaminant Risks for Bacteria and Viruses in Appendix D). Only a small amount of bacteria and viruses are required to endanger public health.

After combining the contaminant risk for bacteria and viruses with the natural susceptibility of the well, the

overall vulnerability of the well to contamination is **Medium**.

Nitrates and Nitrites

The contaminant risk for nitrates and nitrites is **Low**. The risk to this source of public drinking water is primarily attributed to to the presence of septic systems and roads in Zone A (see Table 3 – Appendix B).

Nitrates are very mobile, moving at approximately the same rate as water. The sampling history for this well indicates nitrates have been below the detection level in recent sampling events.

Nitrate concentrations in uncontaminated groundwater are typically less than 2 mg/L; therefore, nitrate concentrations above 2 mg/L may be indicative of man-made sources (See Chart 5 - Contaminant Risks for Nitrates and/or Nitrites in Appendix D).

After combining the contaminant risk for nitrates and nitrites with the natural susceptibility of the well, the overall vulnerability of the well to nitrate and nitrite contamination is **Medium**.

Volatile Organic Chemicals

The contaminant risk for volatile organic chemicals is **High**. The risk is primarily attributed to the presence of above ground heating oil tanks located in Zone A. Other potential contaminant sources are also found within the protection area (see Table 4 – Appendix B).

There were no recent sampling data for VOCs for Glennallen Heights (See Chart 7 – Contaminant Risks for Volatile Organic Chemicals in Appendix D).

After combining the contaminant risk for volatile organic chemicals with the natural susceptibility of the well, the overall vulnerability of the well to contamination is **High**.

Heavy Metals, Cyanide and Other Inorganic Chemicals

The contaminant risk for heavy metals, cyanide and other inorganic chemicals is **Very High**. The risk is primarily attributed to the presence of copper in recent sampling events and an electric power generation facility using fossil fuels located in Zone B (see Table 5 – Appendix B).

Based on review of recent sampling records for this public water system, high levels of copper have been detected in recent sampling history, and have exceeded the MCL (1.3 mg/L and 0.015 mg/L, respectively) (see Chart 9 – Contaminant Risks for Heavy Metals, Cyanide, and Other Inorganic Chemicals in Appendix D).

The presence of copper is likely attributed to recent maintenance to the water distribution/conveyance system.

After combining the contaminant risk for heavy metals, cyanide and other inorganic chemicals with the natural susceptibility of the well, the overall vulnerability of the well to contamination is **Very High**.

Synthetic Organic Chemicals

The contaminant risk for synthetic organic chemicals is **Low**. The risk is primarily attributed to the presence of septic systems (for single family homes) in Zone A. (see Table 6 – Appendix B).

No recent sampling data was available in ADEC records for Glennallen Heights (See Chart 11 – Contaminant Risks for Synthetic Organic Chemicals in Appendix D).

After combining the contaminant risk for synthetic organic chemicals with the natural susceptibility of the well, the overall vulnerability of the well to contamination is **Medium**.

Other Organic Chemicals

The contaminant risk for other organic chemicals is **Very High**. The risk is primarily attributed to the presence of pipelines and an electric power generator (fossil fuels) in Zone B. Other potential contaminant sources are also found within the protection area (see Table 7 – Appendix B).

No recent sampling data was available in ADEC records for Glennallen Heights (See Chart 13 – Contaminant Risks for Other Organic Chemicals in Appendix D).

After combining the contaminant risk for other organic chemicals with the natural susceptibility of the well, the overall vulnerability of the well to contamination is **High.**

Using the Source Water Assessment

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 Glennallen Heights and the community of

Glennallen 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

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Nichols, Donald R. Permafrost and Groundwater Conditions in the Glennallen area, Alaska Open File Report 56-91, U.S. Geological Survey, dated January 1956.

United States Environmental Protection Agency (EPA), 2002 [WWW document]. URL http://www.epa.gov/safewater/mcl.html.

APPENDIX A

Drinking Water Protection Area Location Map
(Map A)

APPENDIX B

Contaminant Source Inventory and Risk Ranking (Tables 1-7)

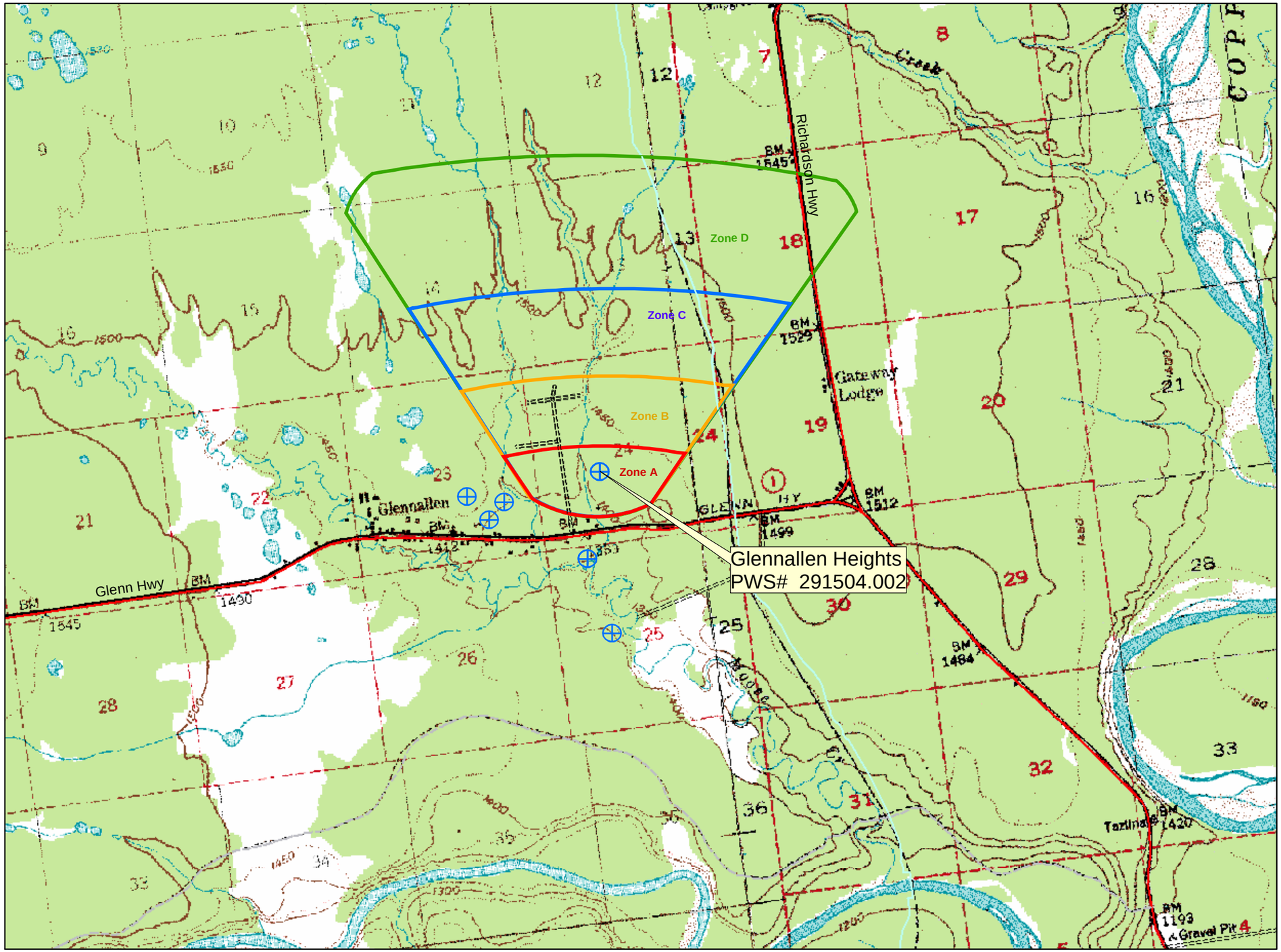
APPENDIX C

Drinking Water Protection Area
and Potential and Existing Contaminant Sources
(Map C)

APPENDIX D

Vulnerability Analysis for Public Drinking Water Source (Charts 1-14)

Public Water Well System for PWS #291504.002 Glennallen Heights



LEGEND

- Public Water System Well

Hydrography/Physical

- Parcels
- Stream
- Lake or Pond
- Contours

Transportation

- Primary Route (Class 1)
- Secondary Route (Class 2)
- Road (Class 3)
- Road (Class 4)
- Road (Class 5, Four-wheel drive)

Groundwater Protection Zones

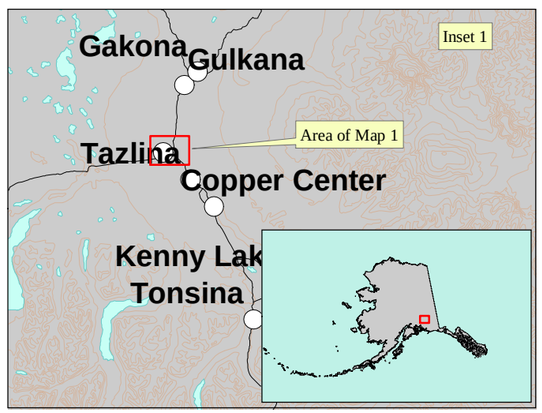
- Zone A Protection Area– Several Months Travel Time
- Zone B Protection Area– 2 Years Travel Time
- Zone C Protection Area– 5 Years Travel Time
- Zone D Protection Area– 10 Years Travel Time

Data Sources:
Contaminant Sources, Public Water System Wells, Contours
Alaska Department of Environmental Conservation (ADEC)

All other data:
United States Geological Survey (USGS)

Drinking Water Protection Areas based on "Alaska Drinking Water Protection Program - Guidance Manual for Class A Public Water Systems" published by ADEC

URS Corporation does not guarantee the accuracy or validity of the data provided.



0 0.375 0.75 1.5 2.25 3 Miles

Glennallen Heights
PWS# 291504.002
Appendix A Map A

Table 1

Contaminant Source Inventory for ***Glennallen Heights***

PWSID291504.002

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Map Number*	*Comments*
Septic systems (serves one single-family home)	R02	R02-01	A	C	Assume 5 septic tanks in Zone A
Tanks, heating oil, residential (above ground)	R08	R08-01	A	C	Assume 5 residential heating oil tanks in Zone A
Highways and roads, dirt/gravel	X24	X24-01	A	C	Assume 1-20 roads in Zone A
Septic systems (serves one single-family home)	R02	R02-02	B	C	Assume 5 septic tanks in Zone B
Tanks, heating oil, residential (above ground)	R08	R08-02	B	C	Assume 5 residential heating oil tanks in Zone B
Tanks, heating oil, nonresidential (aboveground)	T14	T14-01	B	C	COPPER VALLEY ELEC GLENNALLEN DIESEL PL
Highways and roads, dirt/gravel	X24	X24-02	B	C	Assume 1-20 roads in Zone B
Pipelines (oil and gas)	X28	X28-01	B	C	TRANS-ALASKA PIPELINE
Electric power generation (fossil fuels)	X36	X36-01	B	C	COPPER VALLEY ELEC GLENNALLEN DIESEL PL
Pipelines (oil and gas)	X28	X28-02	C	C	TRANS-ALASKA PIPELINE
Highways and roads, paved (cement or asphalt)	X20	X20-02	D	C	RICHARDSON HIGHWAY
Pipelines (oil and gas)	X28	X28-03	D	C	TRANS-ALASKA PIPELINE

Table 2

Contaminant Source Inventory and Risk Ranking for Glennallen Heights
Sources of Bacteria and Viruses

PWSID 291504.002

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Septic systems (serves one single-family home)	R02	R02-01	A	Low	C	Assume 5 septic tanks in Zone A
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Septic systems (serves one single-family home)	R02	R02-02	B	Low	C	Assume 5 septic tanks in Zone B
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B

Table 3

Contaminant Source Inventory and Risk Ranking for Glennallen Heights
Sources of Nitrates/Nitrites

PWSID 291504.002

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Septic systems (serves one single-family home)	R02	R02-01	A	Low	C	Assume 5 septic tanks in Zone A
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Septic systems (serves one single-family home)	R02	R02-02	B	Low	C	Assume 5 septic tanks in Zone B
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B

Table 4

Contaminant Source Inventory and Risk Ranking for Glennallen Heights
Sources of Volatile Organic Chemicals

PWSID 291504.002

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Septic systems (serves one single-family home)	R02	R02-01	A	Low	C	Assume 5 septic tanks in Zone A
Tanks, heating oil, residential (above ground)	R08	R08-01	A	Medium	C	Assume 5 residential heating oil tanks in Zone A
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Septic systems (serves one single-family home)	R02	R02-02	B	Low	C	Assume 5 septic tanks in Zone B
Tanks, heating oil, nonresidential (aboveground)	T14	T14-01	B	Low	C	COPPER VALLEY ELEC GLENNALLEN DIESEL PL
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B
Pipelines (oil and gas)	X28	X28-01	B	Medium	C	TRANS-ALASKA PIPELINE
Electric power generation (fossil fuels)	X36	X36-01	B	Medium	C	COPPER VALLEY ELEC GLENNALLEN DIESEL PL
Pipelines (oil and gas)	X28	X28-02	C	Medium	C	TRANS-ALASKA PIPELINE

Table 5

Contaminant Source Inventory and Risk Ranking for Glennallen Heights

Sources of Heavy Metals, Cyanide and Other Inorganic Chemicals

PWSID 291504.002

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Septic systems (serves one single-family home)	R02	R02-01	A	Low	C	Assume 5 septic tanks in Zone A
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Septic systems (serves one single-family home)	R02	R02-02	B	Low	C	Assume 5 septic tanks in Zone B
Tanks, heating oil, nonresidential (aboveground)	T14	T14-01	B	Low	C	COPPER VALLEY ELEC GLENNALLEN DIESEL PL
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B
Pipelines (oil and gas)	X28	X28-01	B	Low	C	TRANS-ALASKA PIPELINE
Electric power generation (fossil fuels)	X36	X36-01	B	Medium	C	COPPER VALLEY ELEC GLENNALLEN DIESEL PL
Pipelines (oil and gas)	X28	X28-02	C	Low	C	TRANS-ALASKA PIPELINE

Table 6

Contaminant Source Inventory and Risk Ranking for Glennallen Heights
Sources of Synthetic Organic Chemicals

PWSID 291504.002

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Septic systems (serves one single-family home)	R02	R02-01	A	Low	C	Assume 5 septic tanks in Zone A
Septic systems (serves one single-family home)	R02	R02-02	B	Low	C	Assume 5 septic tanks in Zone B

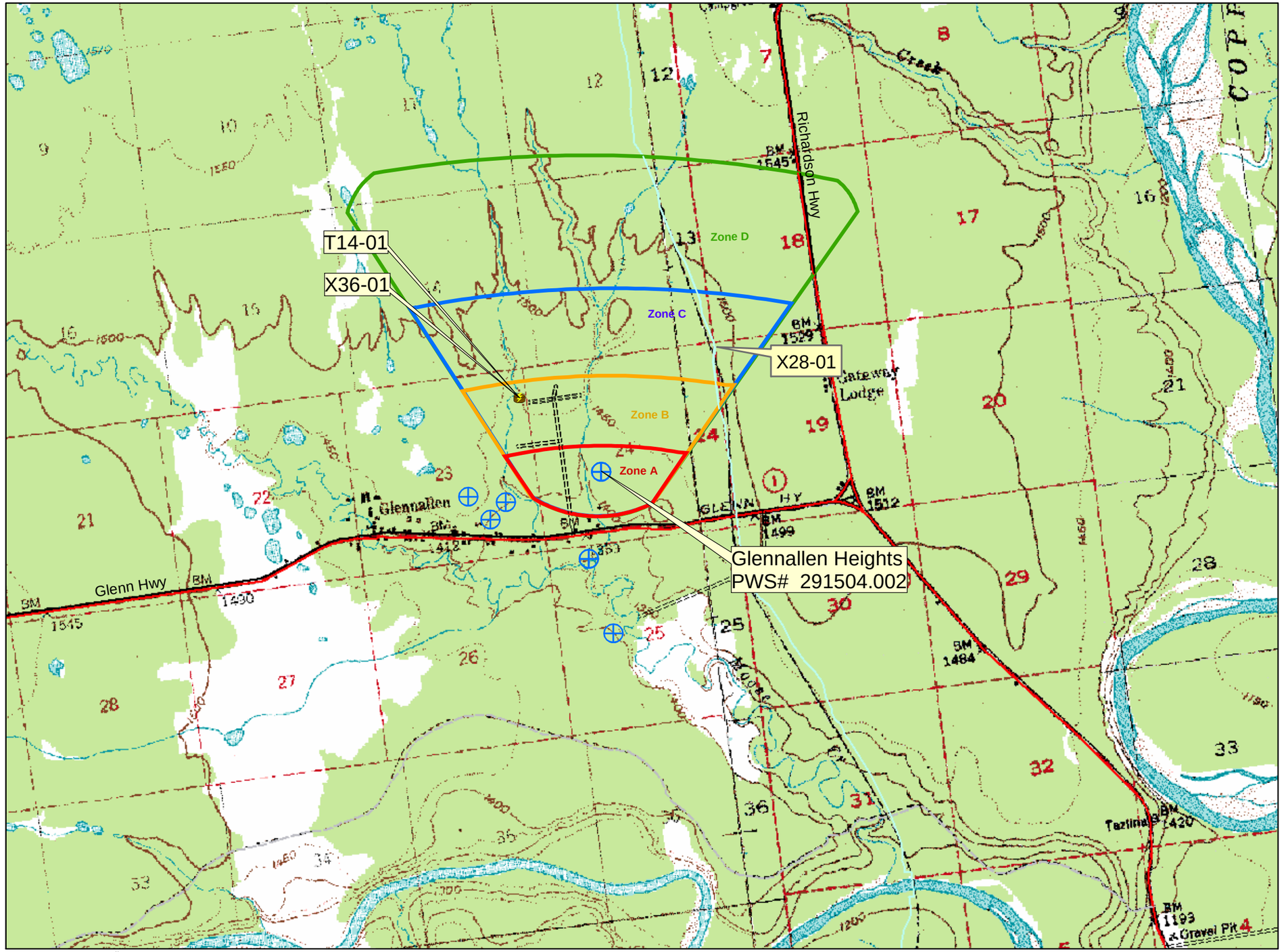
Table 7

Contaminant Source Inventory and Risk Ranking for Glennallen Heights
Sources of Other Organic Chemicals

PWSID 291504.002

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Septic systems (serves one single-family home)	R02	R02-01	A	Low	C	Assume 5 septic tanks in Zone A
Highways and roads, dirt/gravel	X24	X24-01	A	Low	C	Assume 1-20 roads in Zone A
Septic systems (serves one single-family home)	R02	R02-02	B	Low	C	Assume 5 septic tanks in Zone B
Highways and roads, dirt/gravel	X24	X24-02	B	Low	C	Assume 1-20 roads in Zone B
Pipelines (oil and gas)	X28	X28-01	B	High	C	TRANS-ALASKA PIPELINE
Electric power generation (fossil fuels)	X36	X36-01	B	High	C	COPPER VALLEY ELEC GLENNALLEN DIESEL PL
Pipelines (oil and gas)	X28	X28-02	C	High	C	TRANS-ALASKA PIPELINE
Pipelines (oil and gas)	X28	X28-03	D	High	C	TRANS-ALASKA PIPELINE

Public Water Well System for PWS #291504.002 Glennallen Heights
Showing Potential and Exsisting Sources of Contamination



LEGEND

- Public Water System Well

Hydrography/Physical

- Parcels
- Stream
- Lake or Pond
- Contours

Transportation

- Primary Route (Class 1)
- Secondary Route (Class 2)
- Road (Class 3)
- Road (Class 4)
- Road (Class 5, Four-wheel drive)

Groundwater Protection Zones

- Zone A Protection Area– Several Months Travel Time
- Zone B Protection Area– 2 Years Travel Time
- Zone C Protection Area– 5 Years Travel Time
- Zone D Protection Area– 10 Years Travel Time

Existing or Potential Contaminant Sources

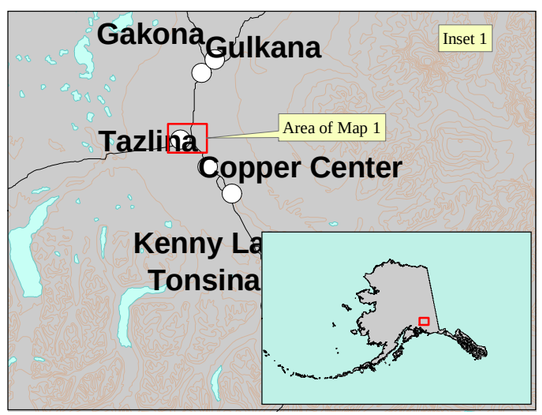
- Nonresidential aboveground heating oil tank (T14)
- Pipelines (oil and gas) (X28)
- Electric power generation (fossil fuels) (X36)

Data Sources:
Contaminant Sources, Public Water System Wells, Contours
Alaska Department of Environmental Conservation (ADEC)

All other data:
United States Geological Survey (USGS)

Drinking Water Protection Areas based on "Alaska Drinking Water Protection Program - Guidance Manual for Class A Public Water Systems" published by ADEC

URS Corporation does not guarantee the accuracy or validity of the data provided.



0 0.375 0.75 1.5 2.25 3 Miles

Glennallen Heights
PWS# 291504.002
Appendix C Map C

Chart 1. Susceptibility of the wellhead - Glennallen Heights (PWS No. 291504.002)

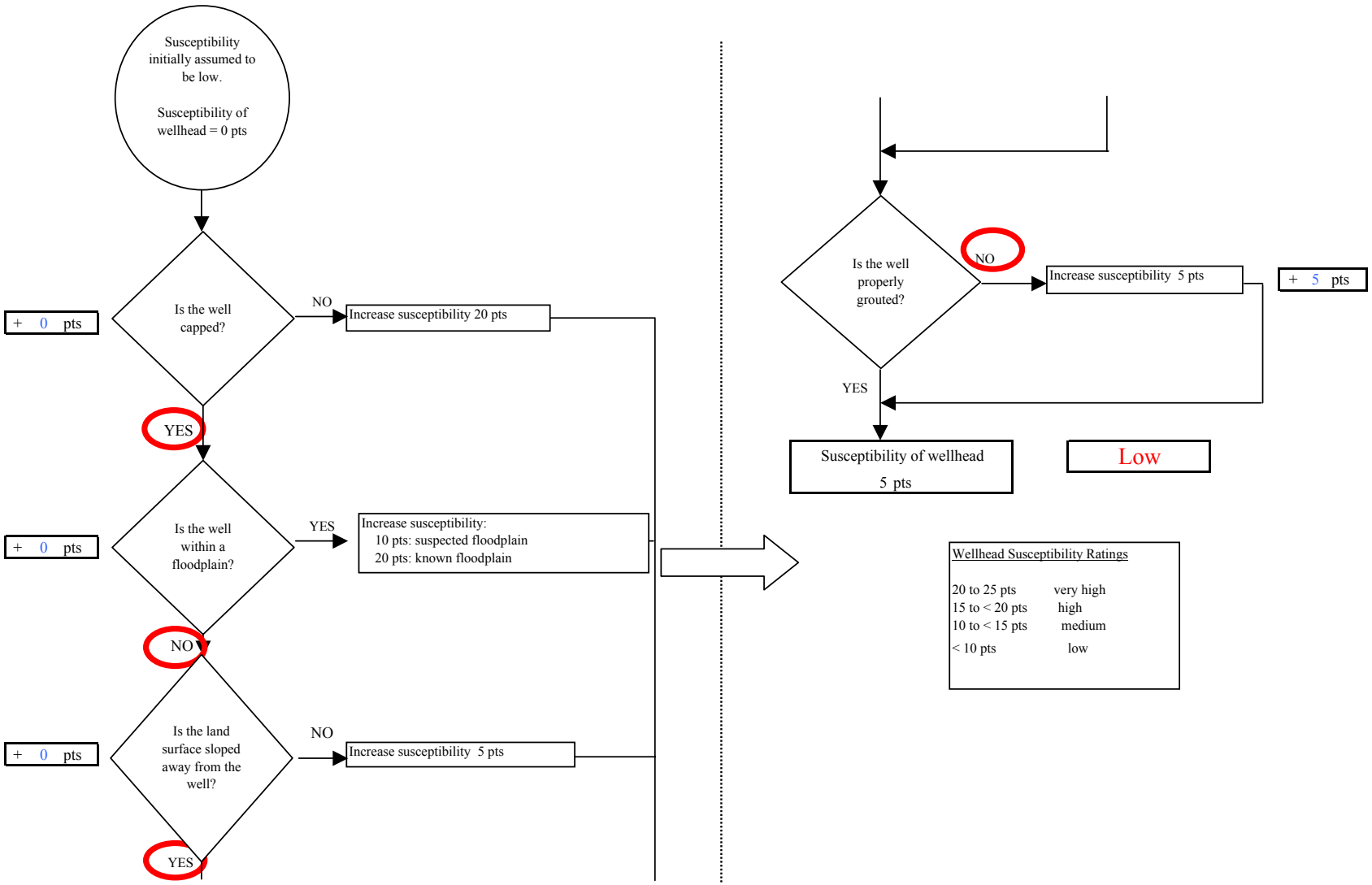


Chart 2. Susceptibility of the aquifer Glennallen Heights (PWS No. 291504.002)

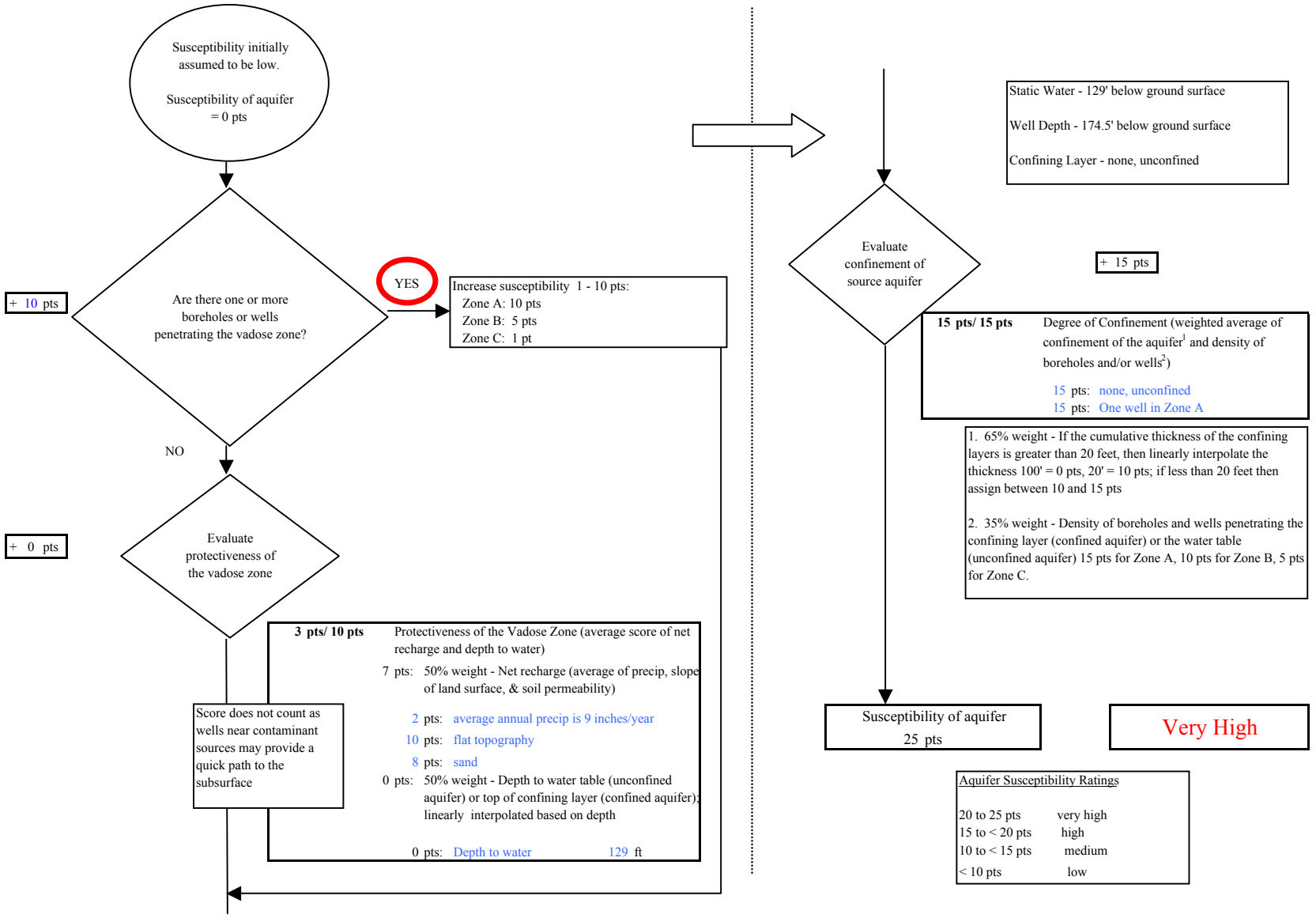
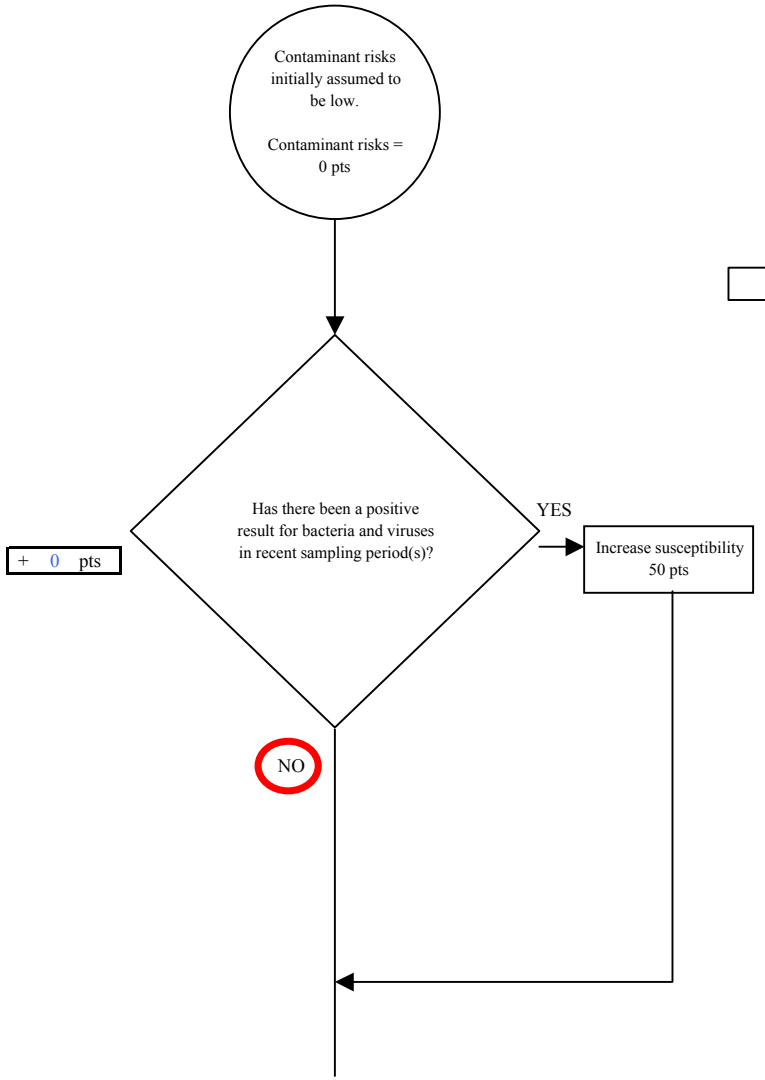
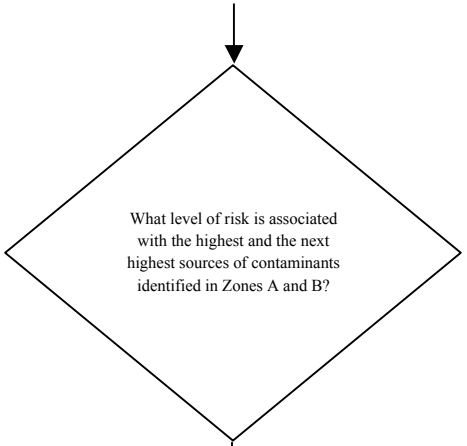


Chart 3. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Bacteria & Viruses





+ 10 pts

Risk Rankings for Contaminant Sources Identified in Zones A and B

	Zone A	Zone B	Total
Very Highs(s)	0	0	0
High(s)	0	0	0
Medium(s)	0	0	0
Low(s)	6	2	8

	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

Matrix Score 10

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.

Chart 3. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Bacteria & Viruses

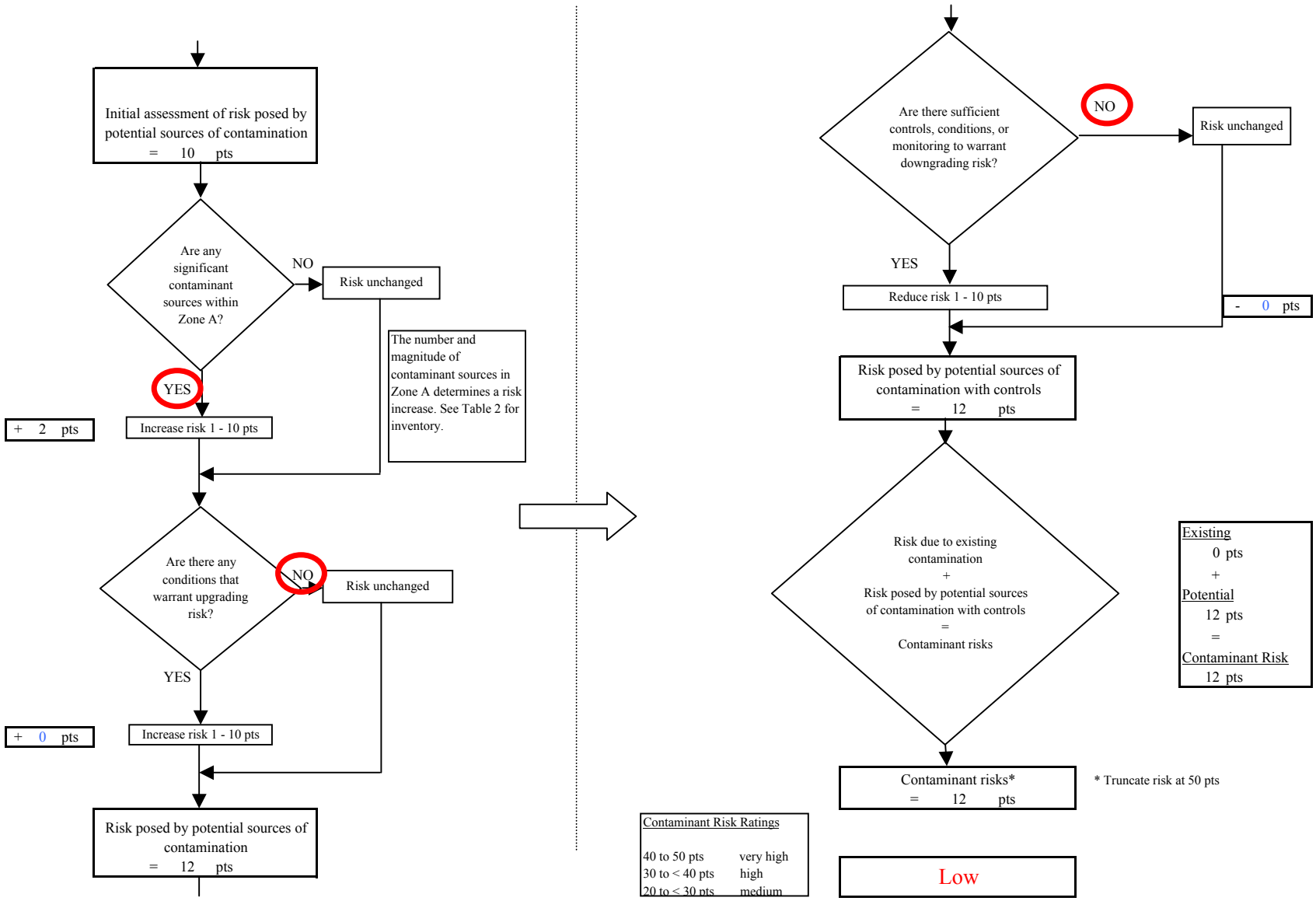


Chart 4. Vulnerability analysis for Glennallen Heights (PWS No. 291504.002) - Bacteria & Viruses

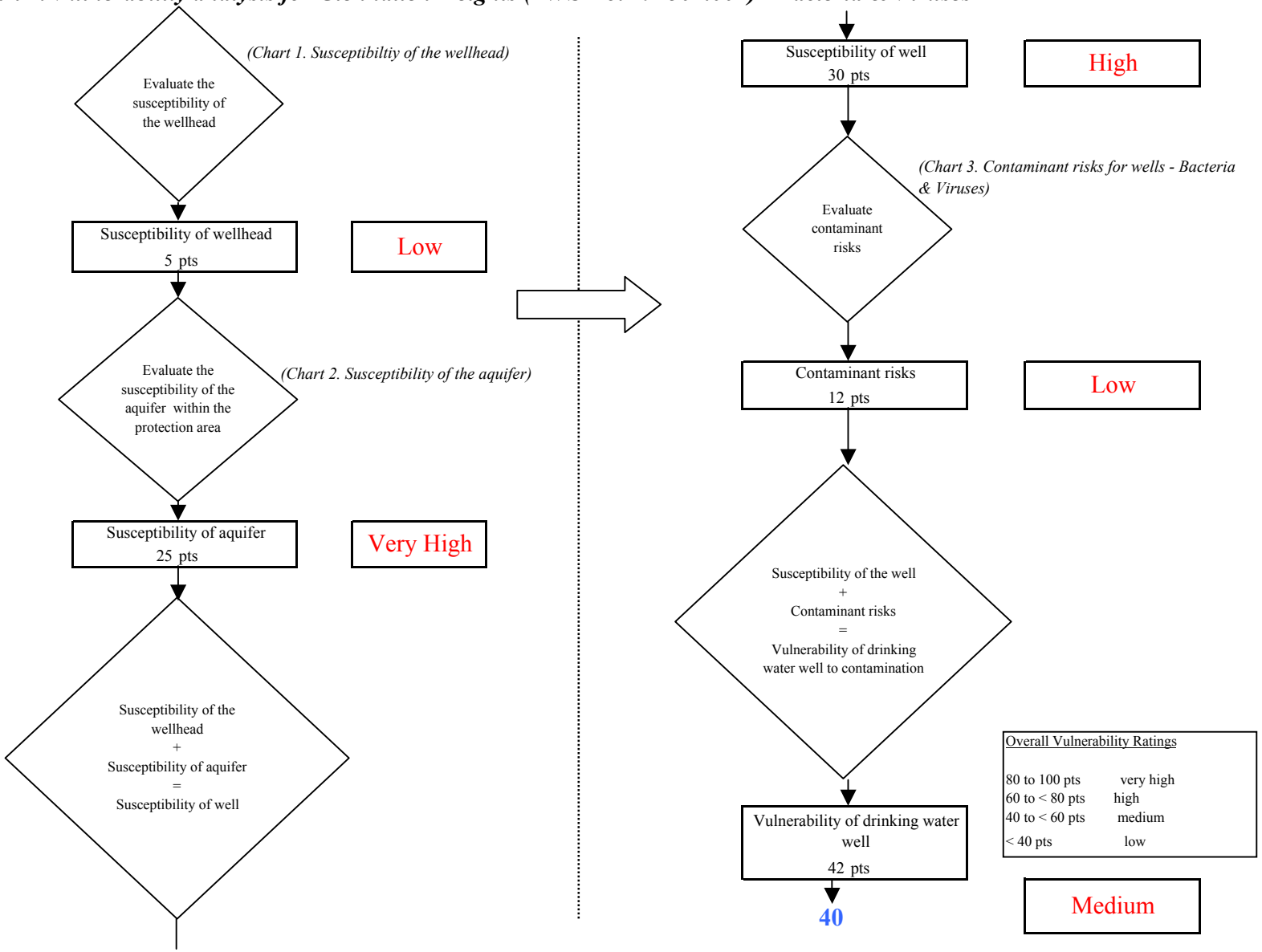


Chart 5. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Nitrates and Nitrites

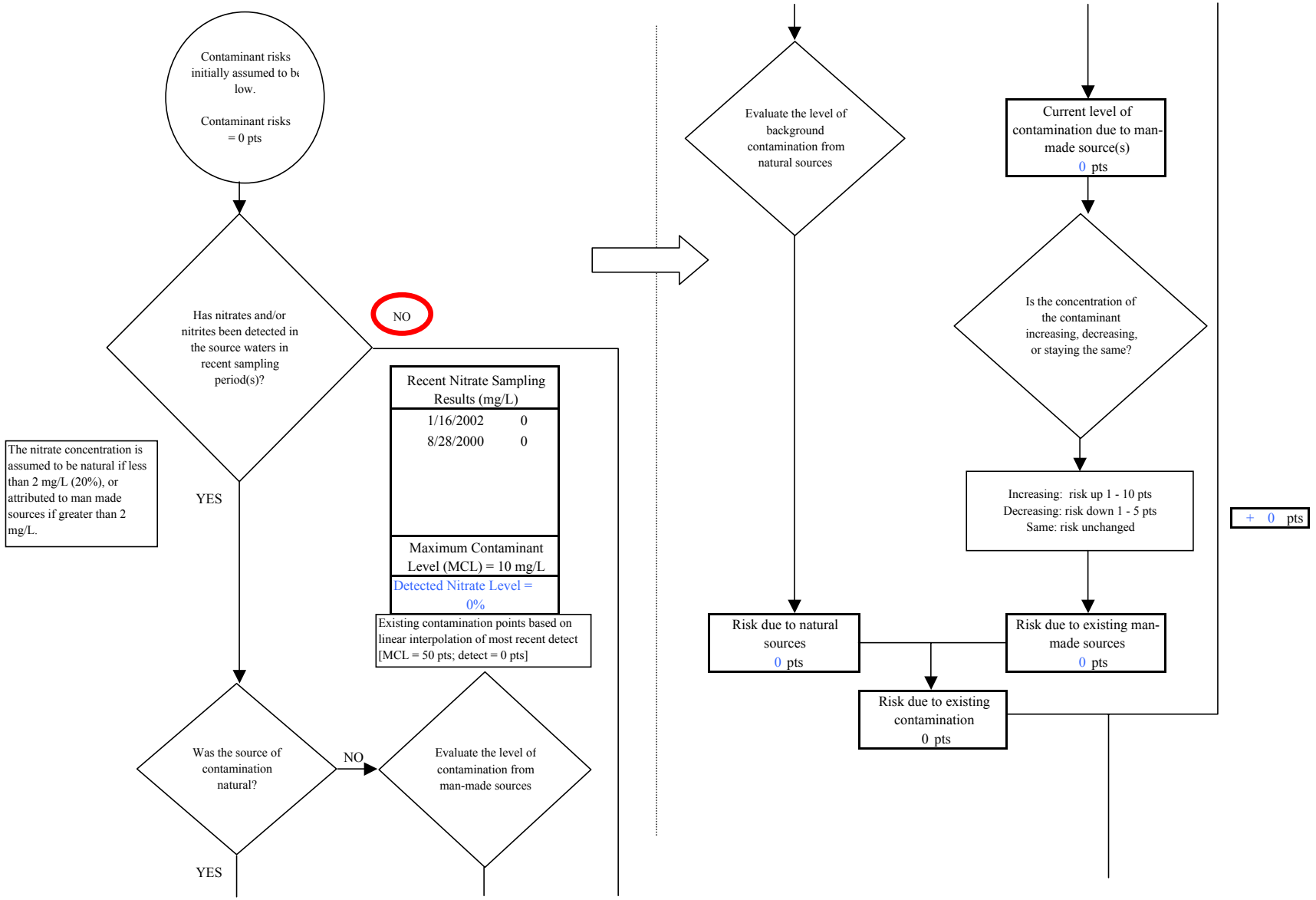
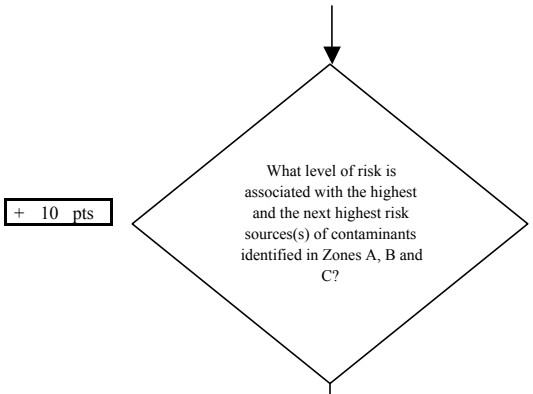


Chart 5. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Nitrates and Nitrites



+ 10 pts

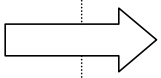
Risk Levels for Contaminant Sources identified in Zones A, B and C

	Zone A	Zones B&C	Total
Very Highs(s)	0	0	0
High(s)	0	0	0
Medium(s)	0	0	0
Low(s)	6	2	8

	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

Matrix Score 10

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individua contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.



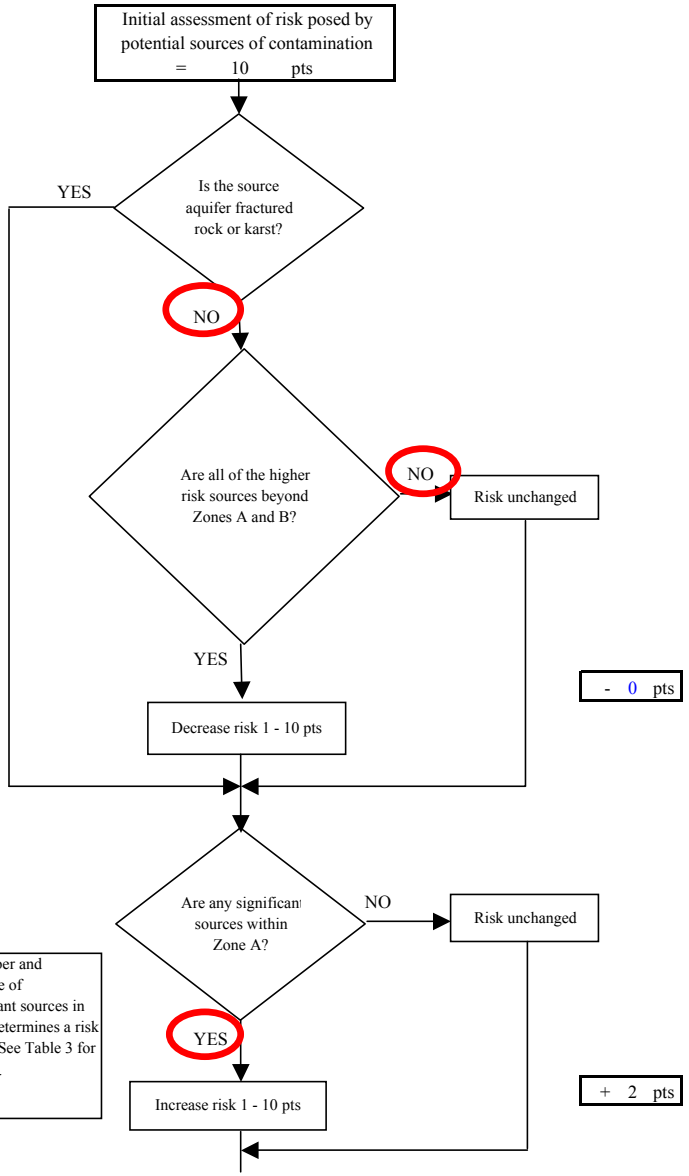


Chart 5. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Nitrates and Nitrites

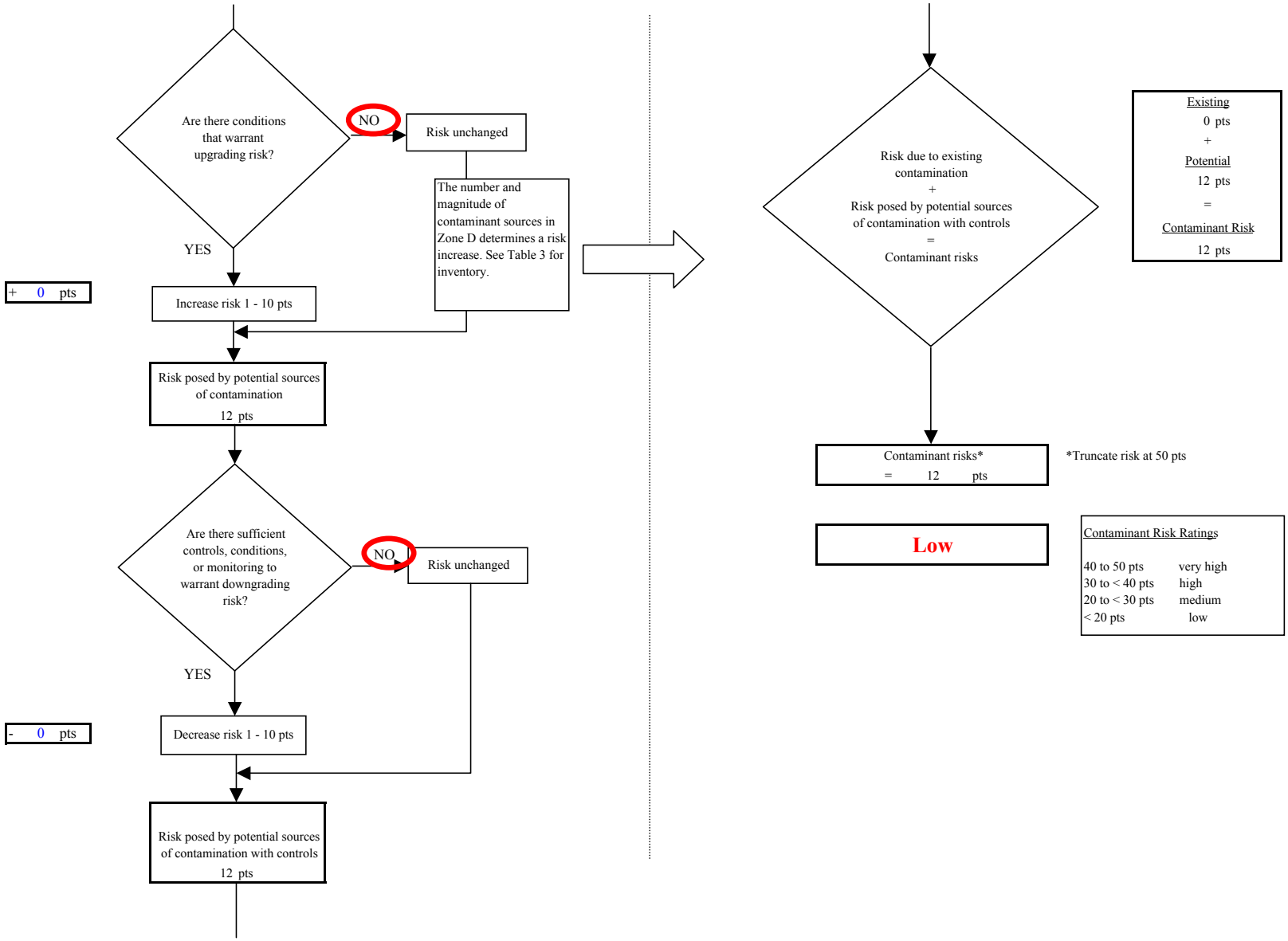


Chart 6. Vulnerability analysis for Glennallen Heights (PWS No. 291504.002) - Nitrates and Nitrites

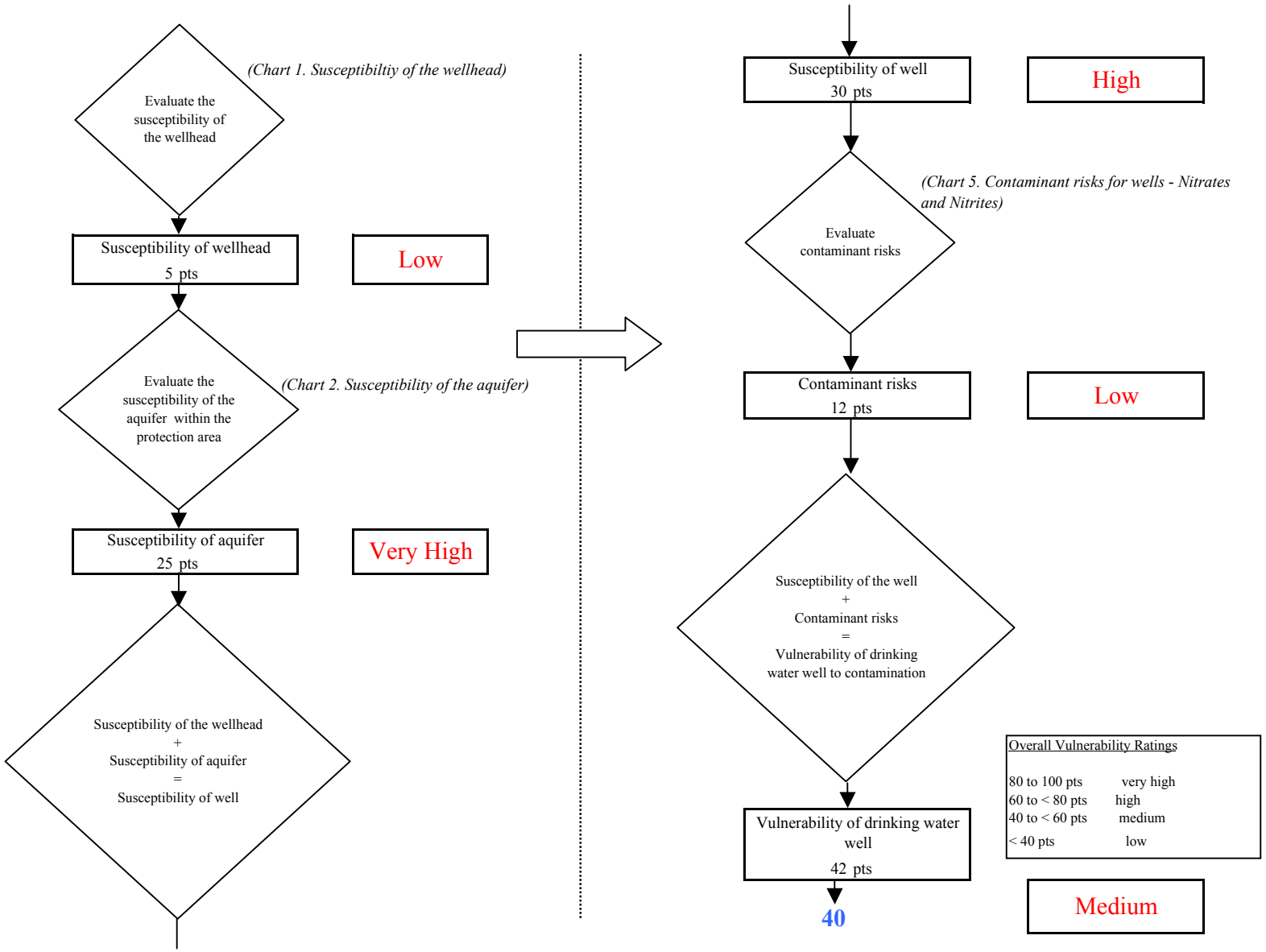


Chart 7. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Volatile Organic Chemicals

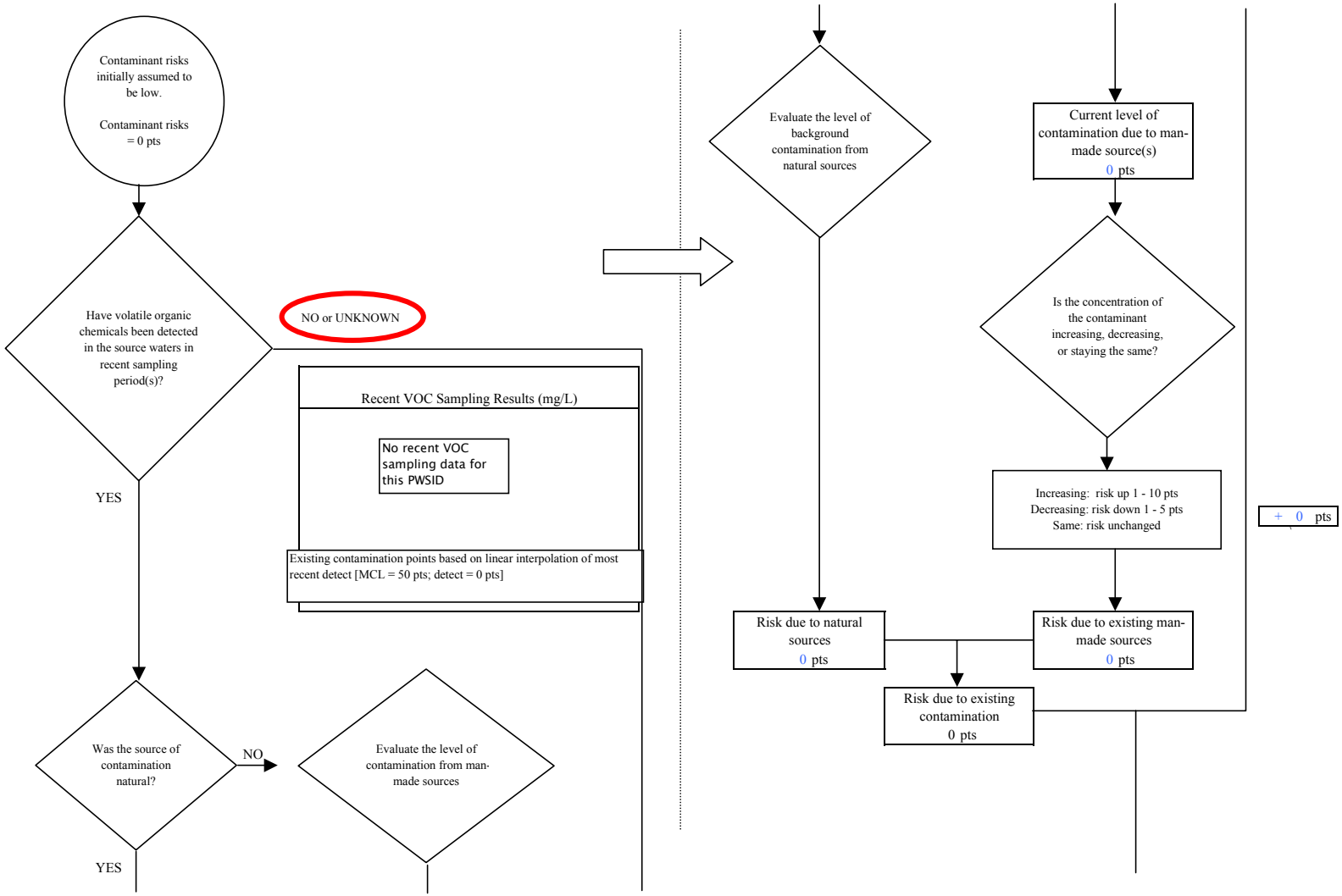


Chart 7. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Volatile Organic Chemicals

+ 25 pts

What level of risk is associated with the highest and the next highest risk sources(s) of contaminants identified in Zones A, B and C?

Risk Levels for Contaminant Sources identified in Zones A, B and C

	Zone A	Zones B&C	Total
Very Highs(s)	0	0	0
High(s)	0	0	0
Medium(s)	5	3	8
Low(s)	2	3	5

	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

Matrix Score 25

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.

Initial assessment of risk posed by potential sources of contamination = 25 pts

Is the source aquifer fractured rock or karst?

YES

NO

Are all of the higher risk sources beyond Zones A and B?

NO

Risk unchanged

YES

Decrease risk 1 - 10 pts

- 0 pts

Are any significant sources within Zone A?

NO

Risk unchanged

The number and magnitude of contaminant sources in Zone A determines a risk increase. See Table 4 for inventory.

YES

Increase risk 1 - 10 pts

+ 10 pts

Chart 7. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Volatile Organic Chemicals

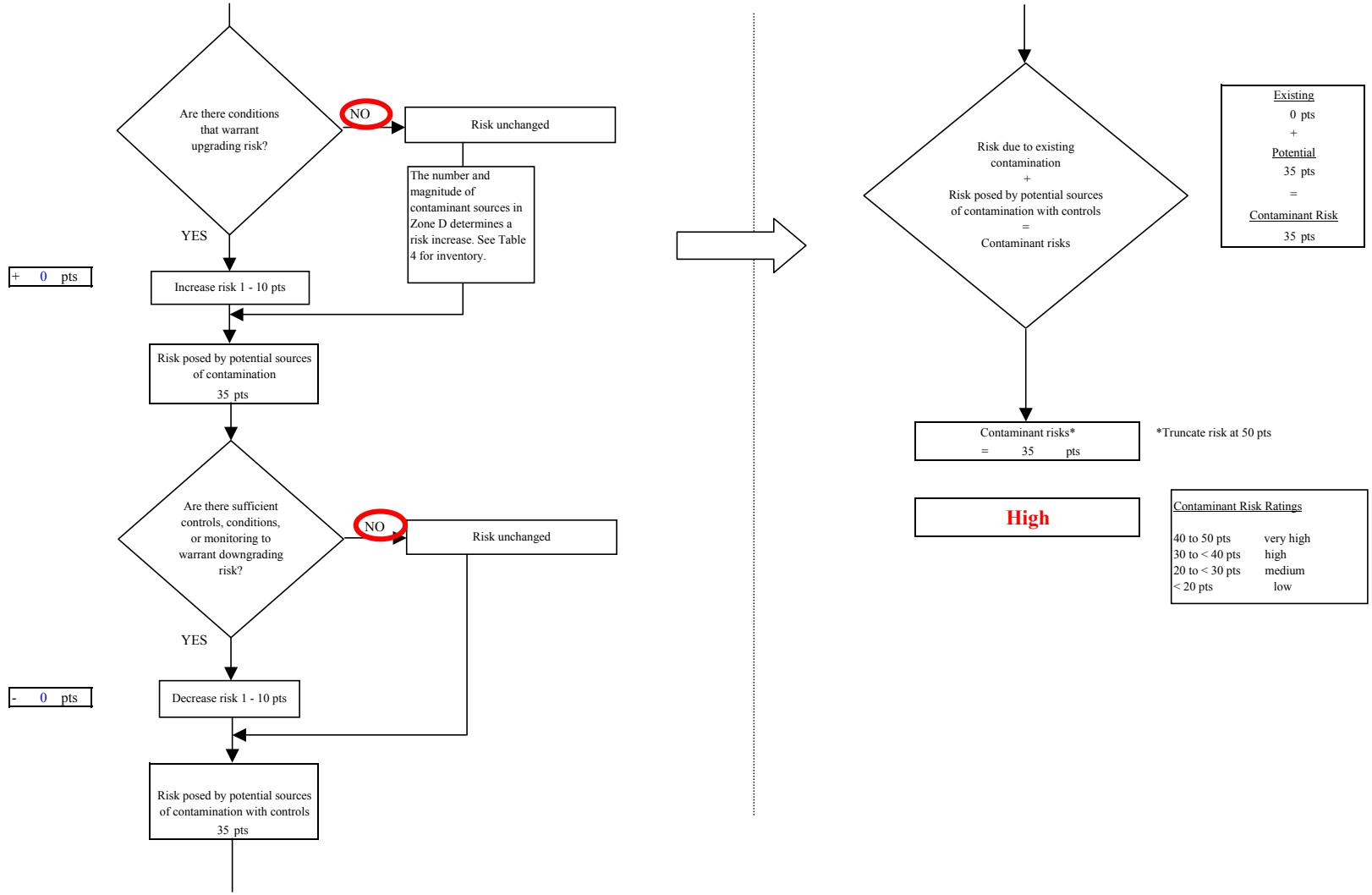


Chart 8. Vulnerability analysis for Glennallen Heights (PWS No. 291504.002) - Volatile Organic Chemicals

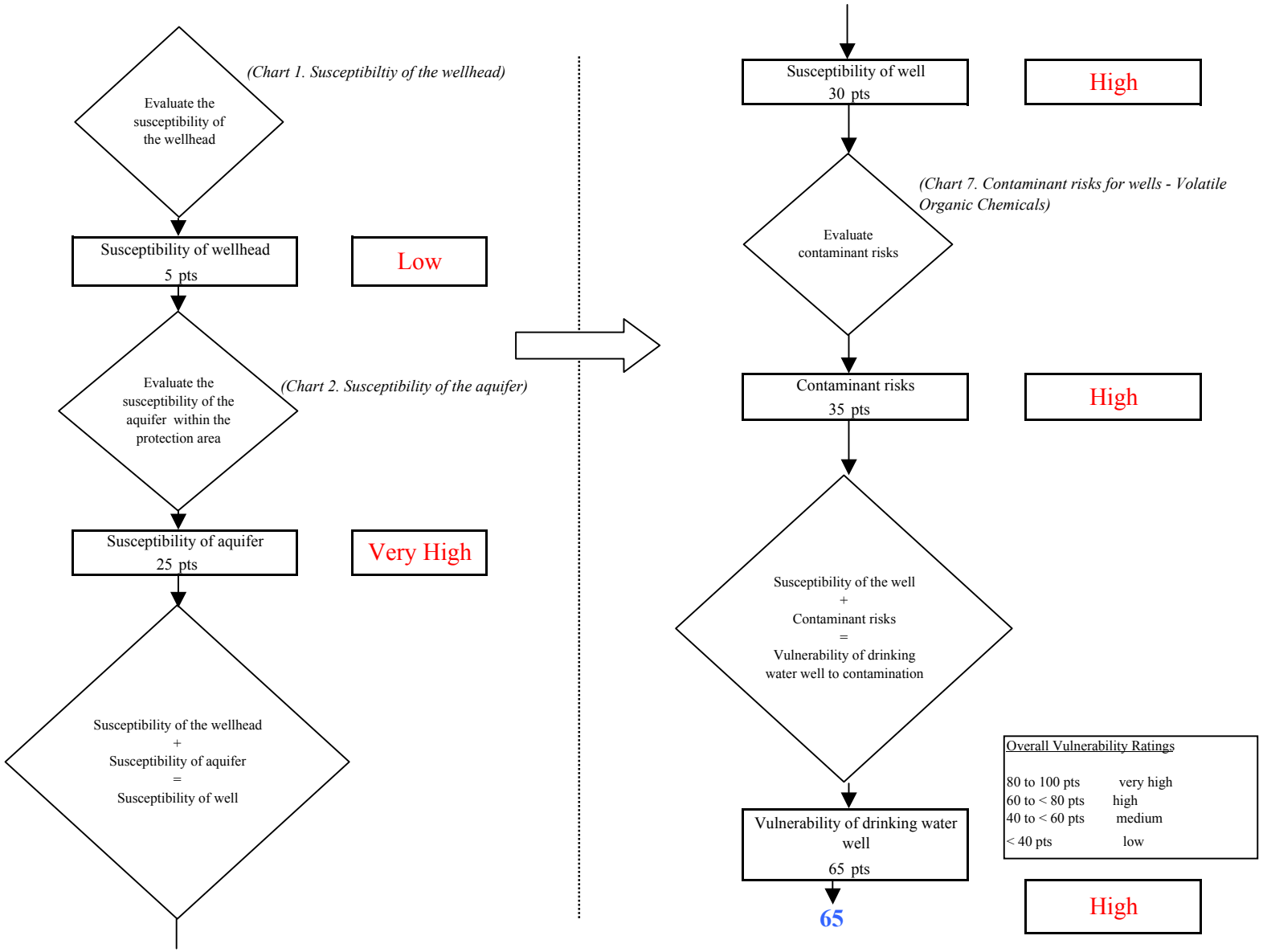


Chart 9. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Heavy Metals, Cyanide and Other Inorganic Chemicals

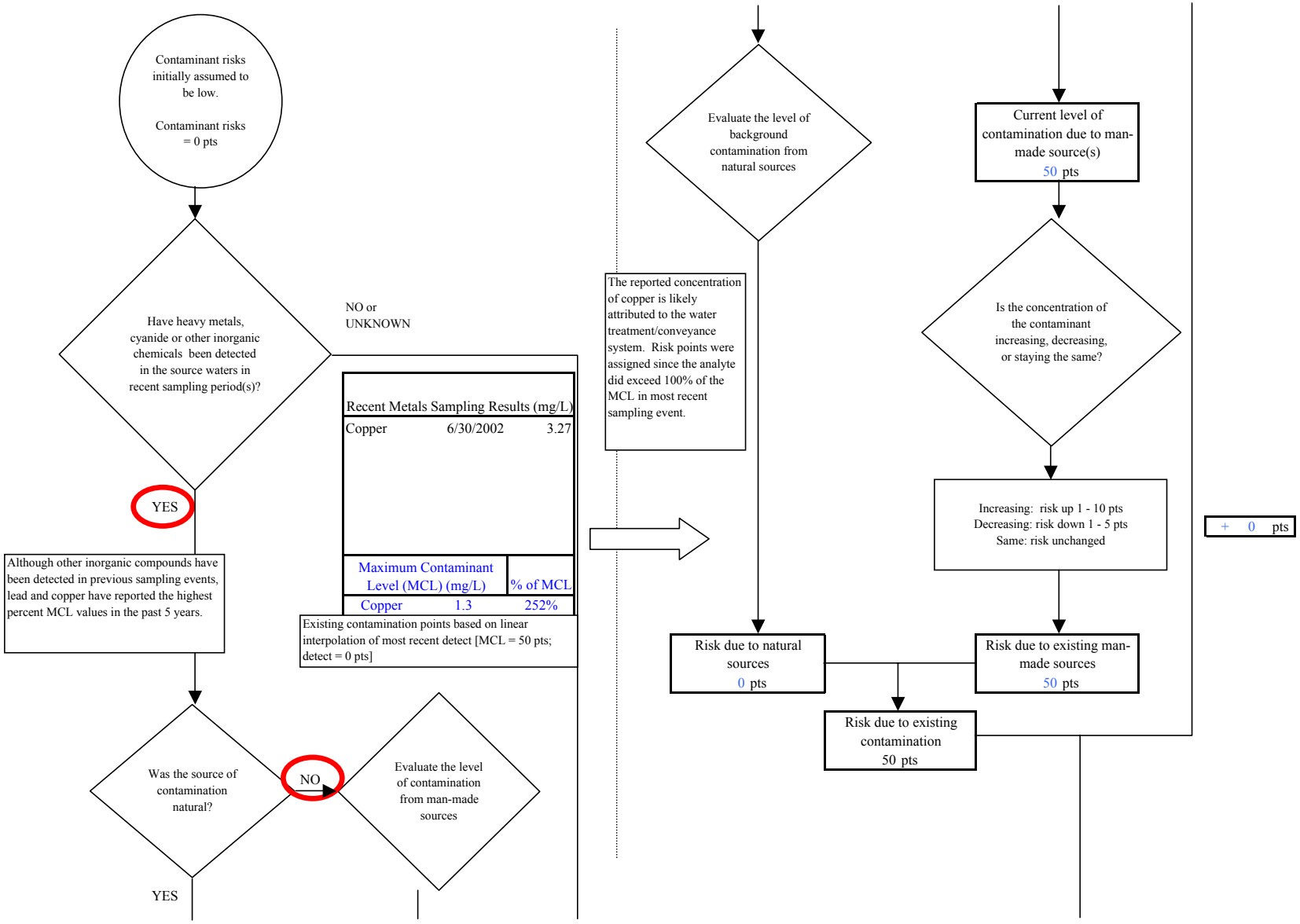
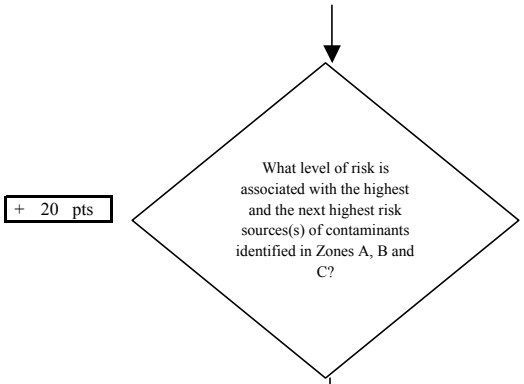


Chart 9. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Heavy Metals, Cyanide and Other Inorganic Chemicals



+ 20 pts

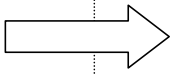
Risk Levels for Contaminant Sources identified in Zones A, B and C

	Zone A	Zones B&C	Total
Very Highs(s)	0	0	0
High(s)	0	0	0
Medium(s)	0	1	1
Low(s)	2	5	7

	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

Matrix Score 20

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.



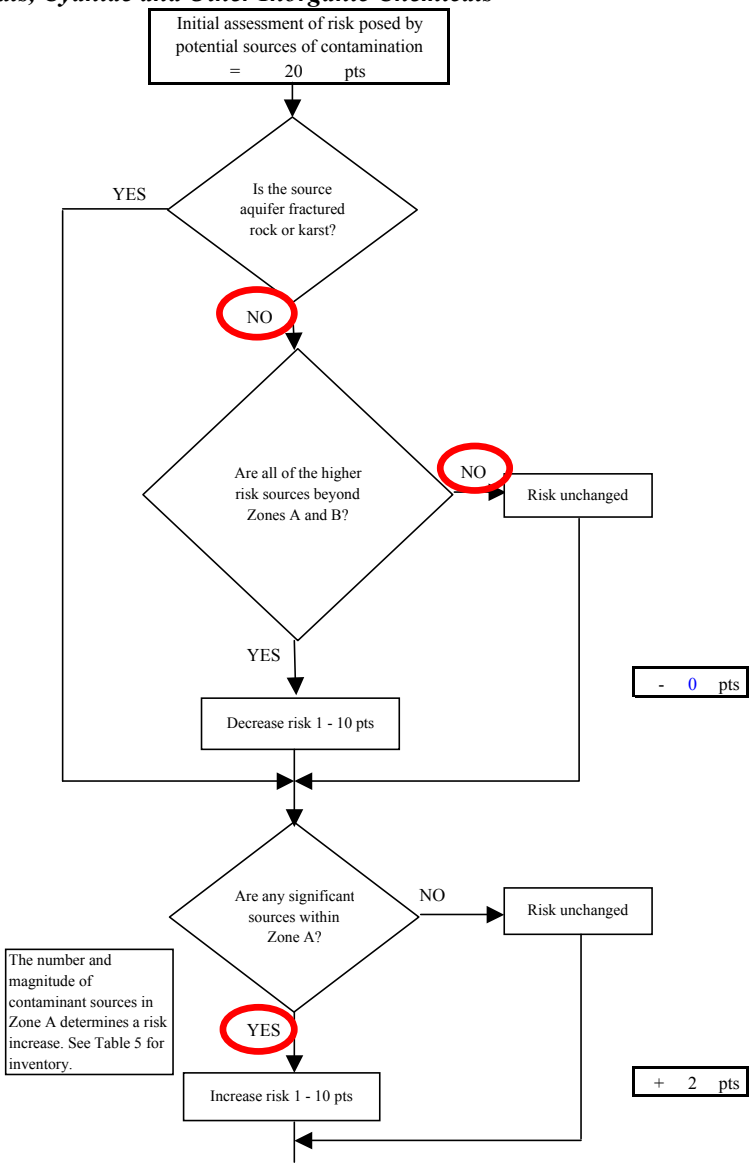


Chart 9. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Heavy Metals, Cyanide and Other Inorganic Chemicals

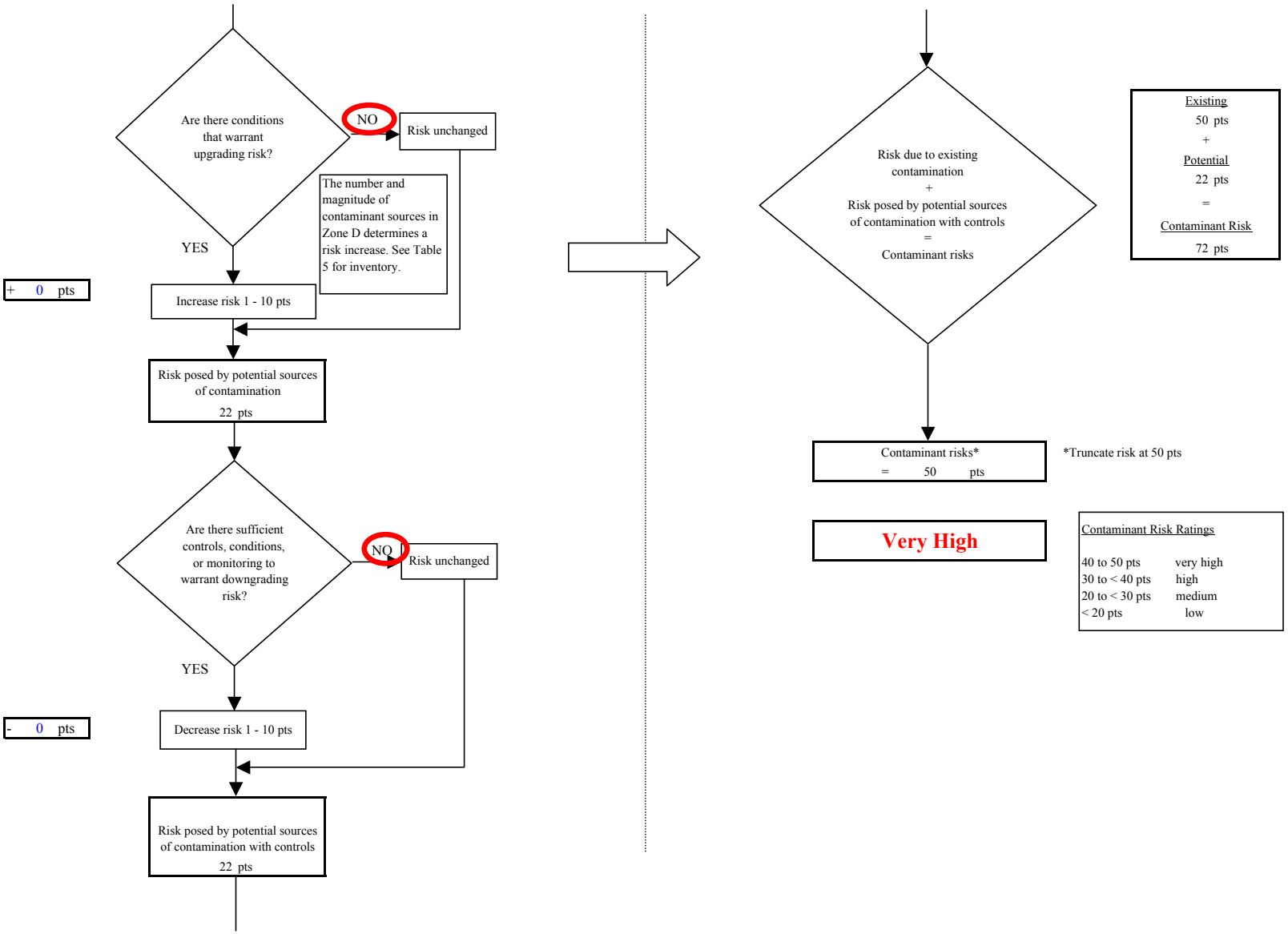


Chart 10. Vulnerability analysis for Glennallen Heights (PWS No. 291504.002) - Heavy Metals, Cyanide and Other Inorganic Chemicals

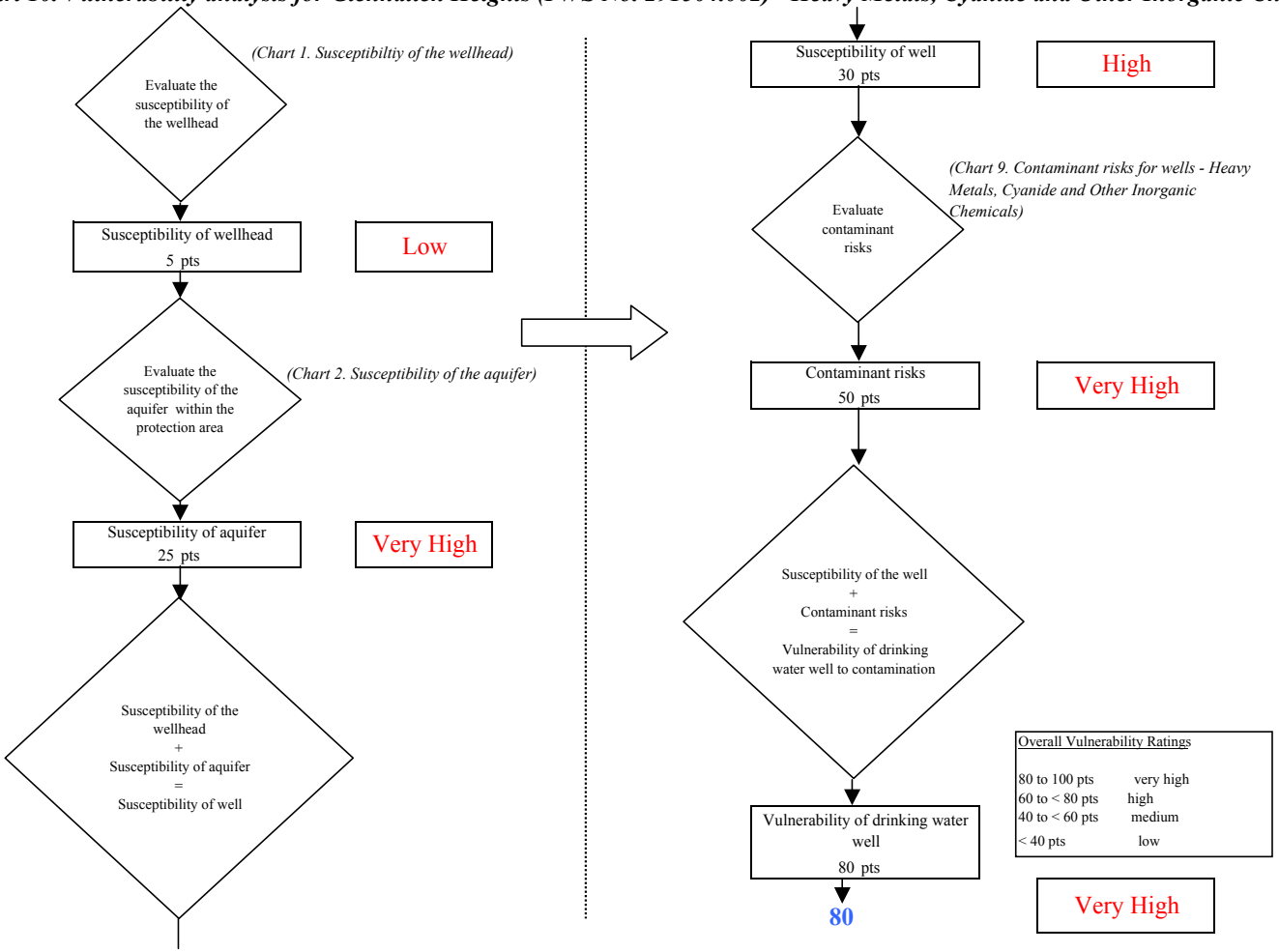


Chart 11. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Synthetic Organic Chemicals

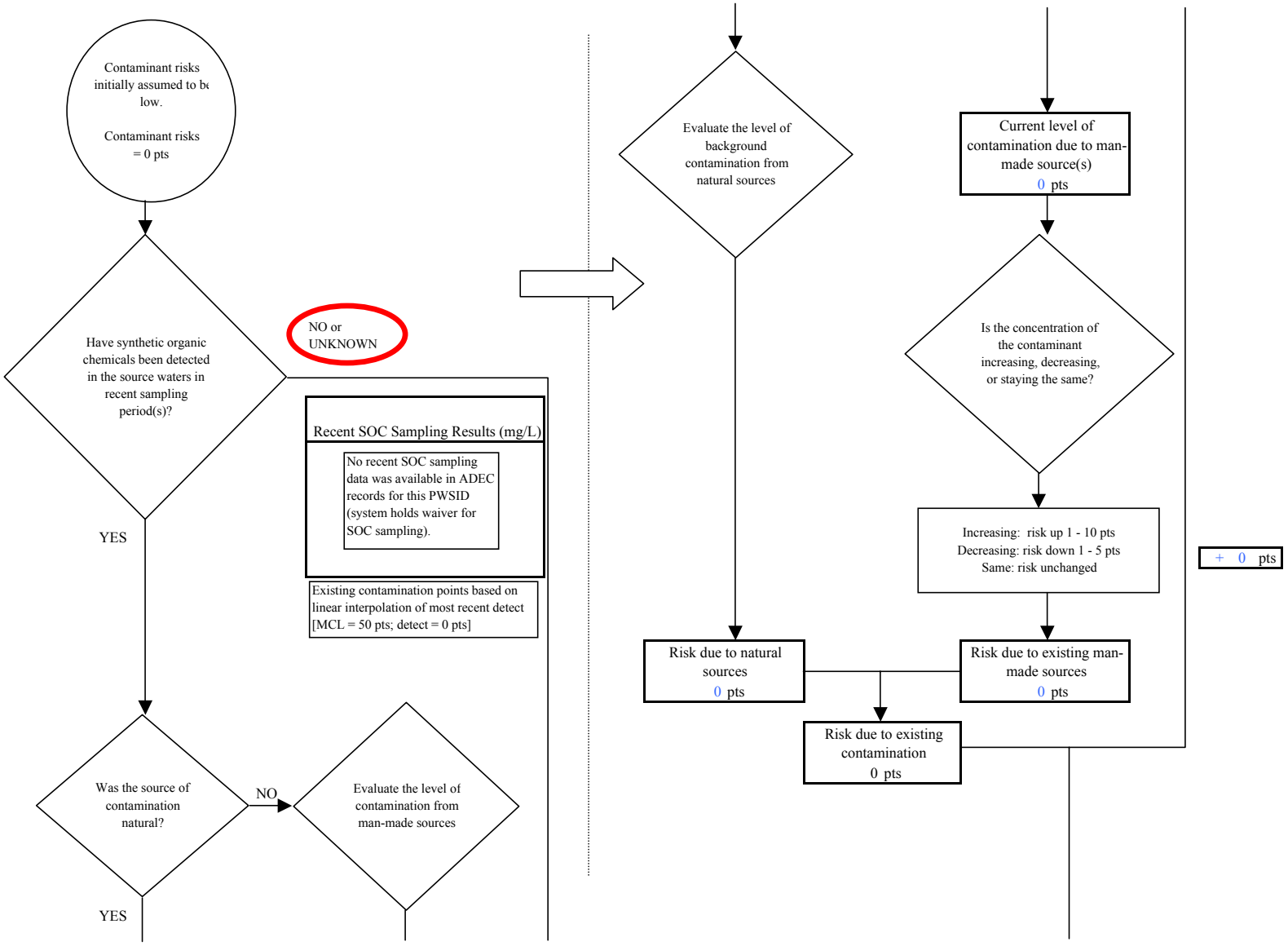
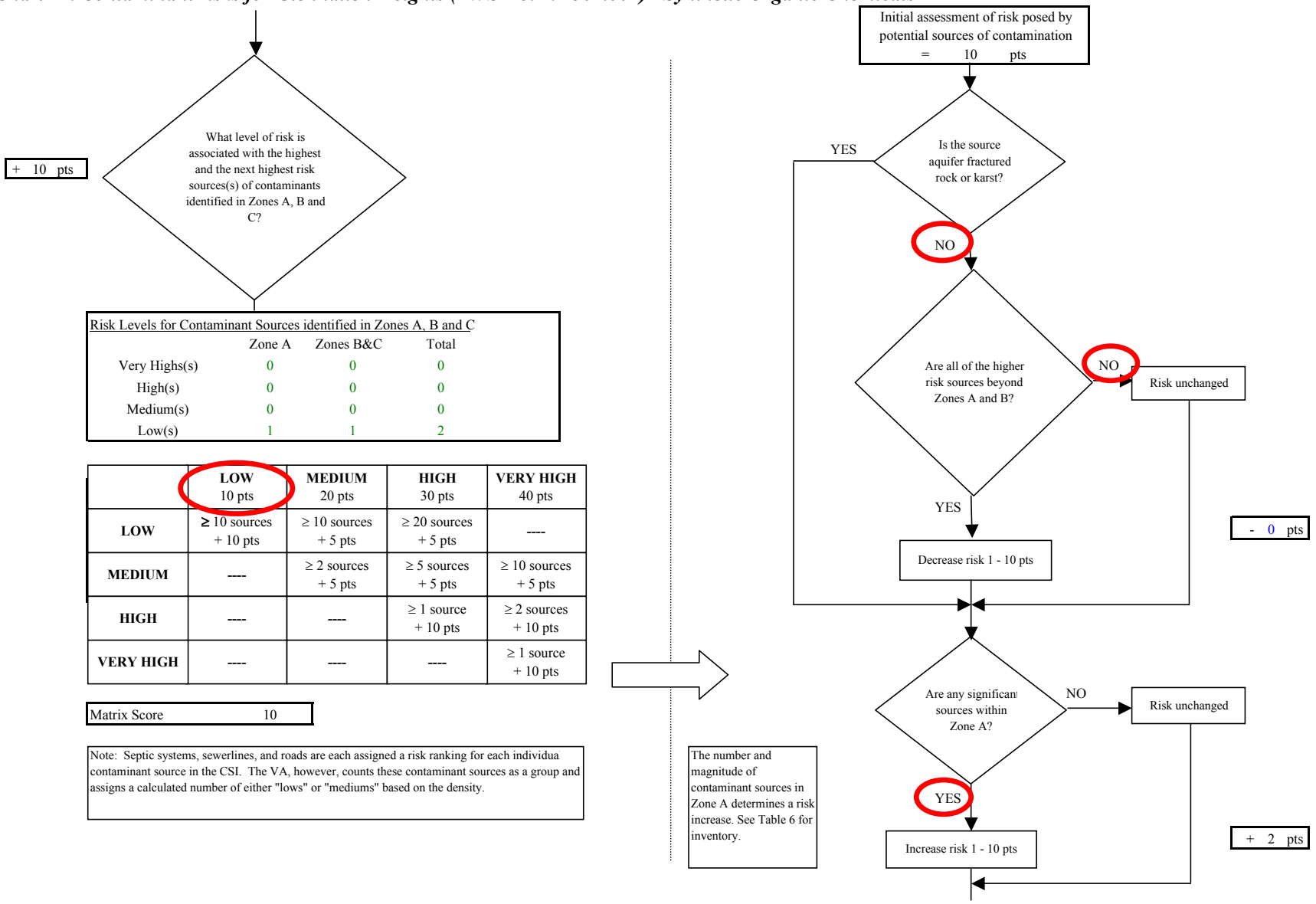


Chart 11. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Synthetic Organic Chemicals



Risk Levels for Contaminant Sources identified in Zones A, B and C

	Zone A	Zones B&C	Total
Very Highs(s)	0	0	0
High(s)	0	0	0
Medium(s)	0	0	0
Low(s)	1	1	2

	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

Matrix Score 10

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individua contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.

The number and magnitude of contaminant sources in Zone A determines a risk increase. See Table 6 for inventory.

Chart 11. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Synthetic Organic Chemicals

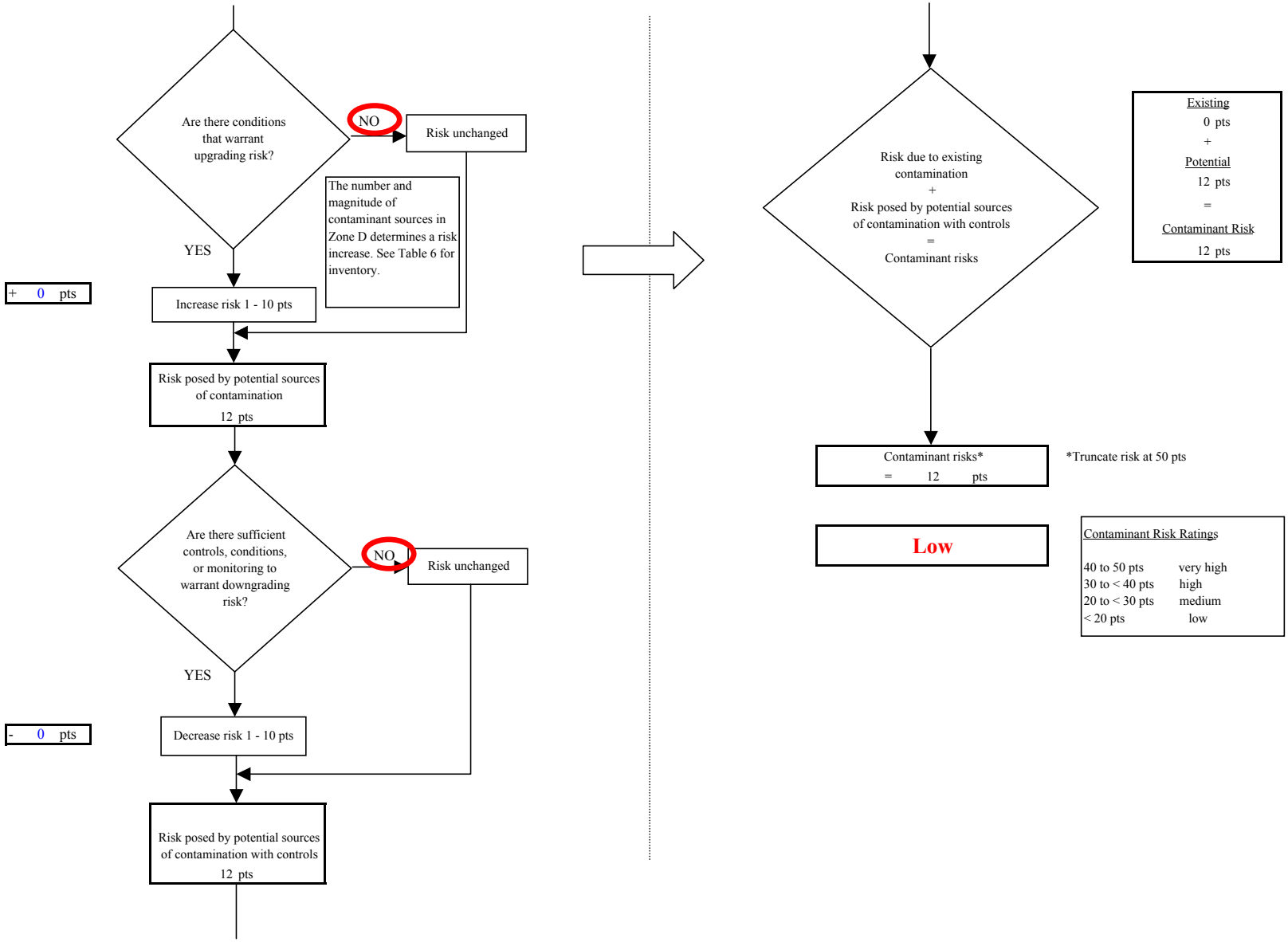


Chart 12. Vulnerability analysis for Glennallen Heights (PWS No. 291504.002) - Synthetic Organic Chemicals

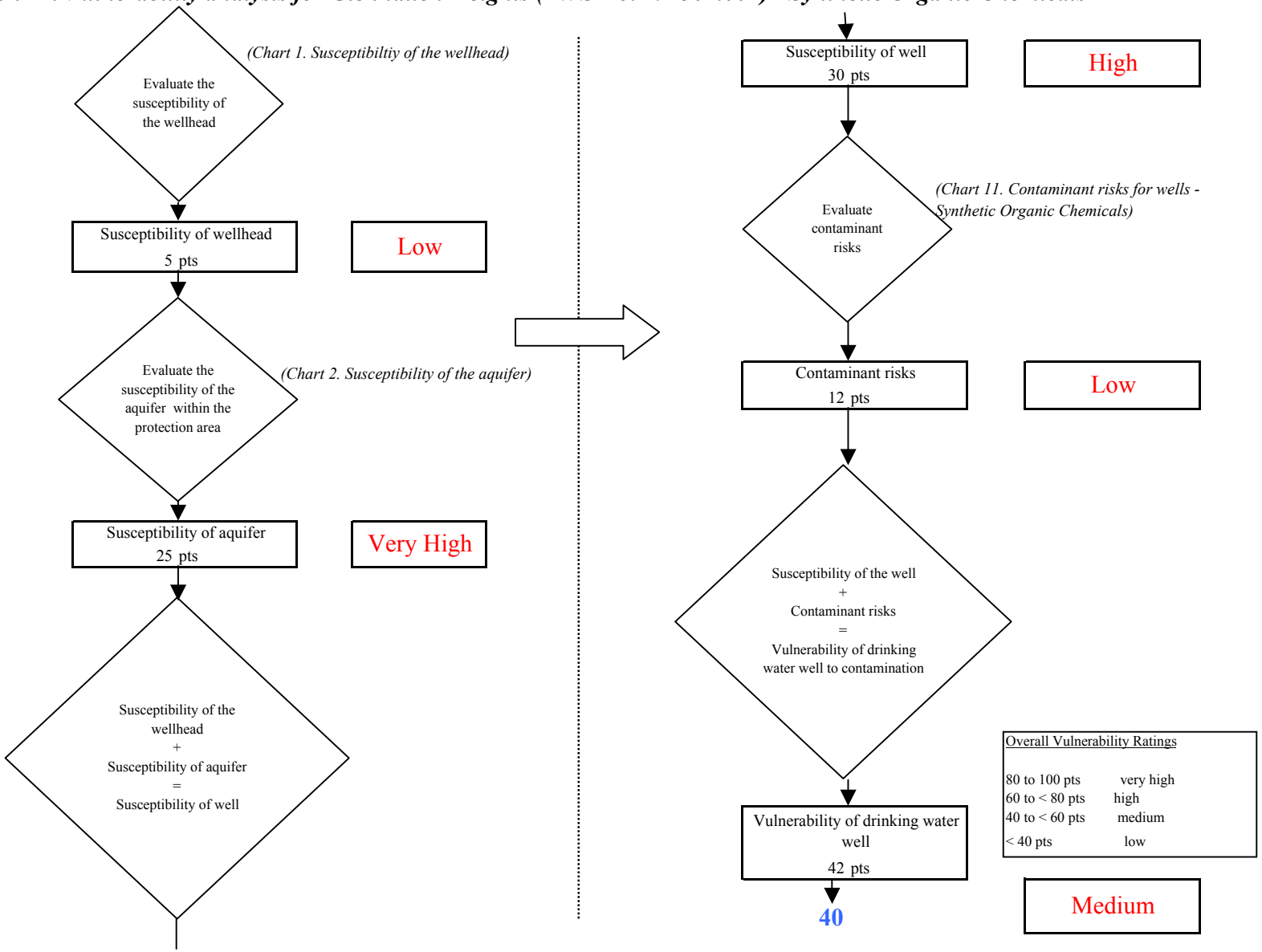


Chart 13. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Other Organic Chemicals

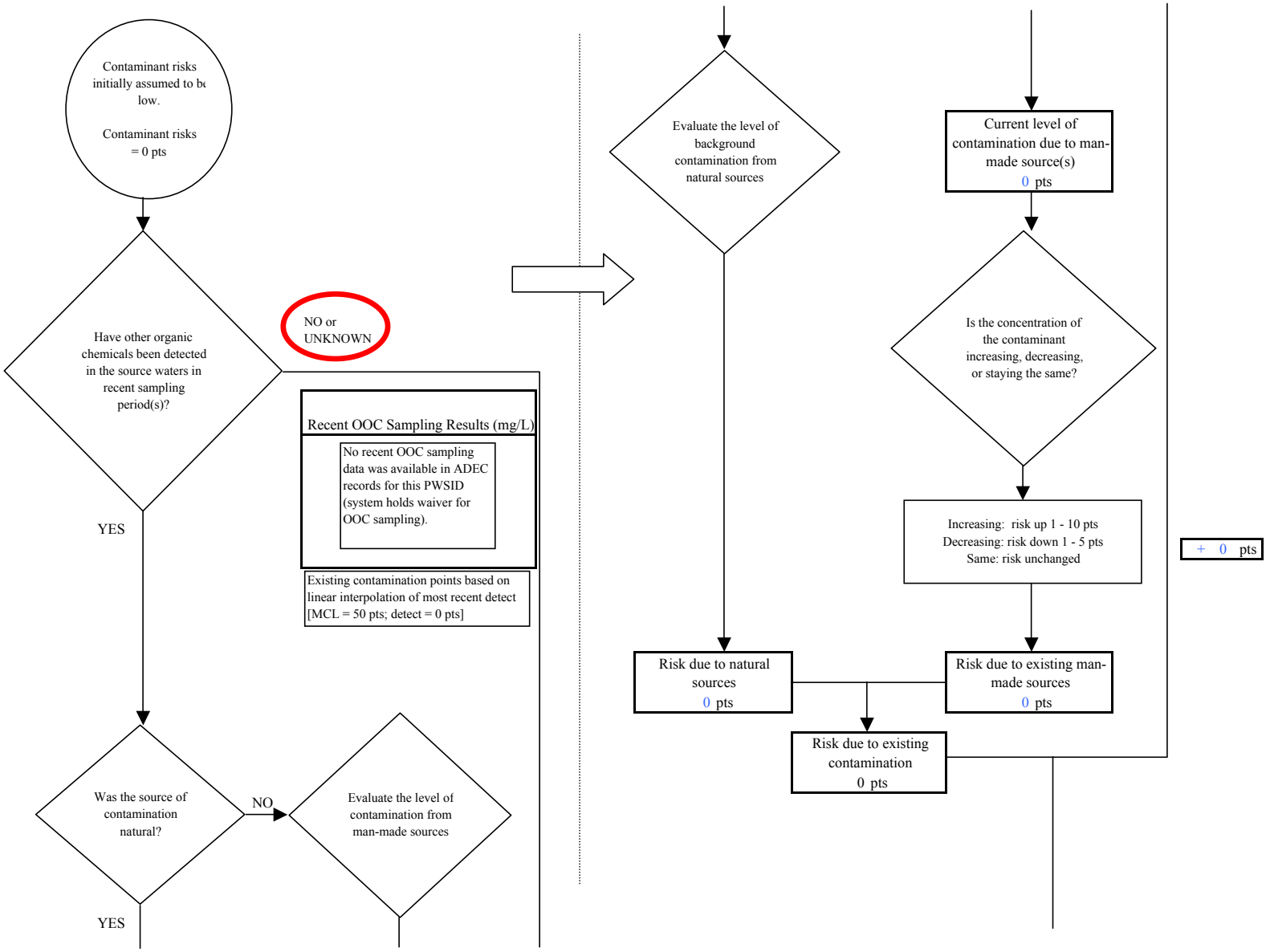


Chart 13. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Other Organic Chemicals

+ 40 pts

What level of risk is associated with the highest and the next highest risk sources(s) of contaminants identified in Zones A, B and C?

Risk Levels for Contaminant Sources identified in Zones A, B and C

	Zone A	Zones B&C	Total
Very Highs(s)	0	0	0
High(s)	0	3	3
Medium(s)	0	0	0
Low(s)	2	2	4

	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

Matrix Score 40

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individua contaminant source in the CSI. The VA, however, counts these contaminant sources as a group and assigns a calculated number of either "lows" or "mediums" based on the density.

Initial assessment of risk posed by potential sources of contamination = 40 pts

Is the source aquifer fractured rock or karst?

YES

NO

Are all of the higher risk sources beyond Zones A and B?

NO

Risk unchanged

YES

Decrease risk 1 - 10 pts

- 0 pts

Are any significant sources within Zone A?

NO

Risk unchanged

YES

Increase risk 1 - 10 pts

+ 2 pts

The number and magnitude of contaminant sources in Zone A determines a risk increase. See Table 7 for inventory.

Chart 13. Contaminant risks for Glennallen Heights (PWS No. 291504.002) - Other Organic Chemicals

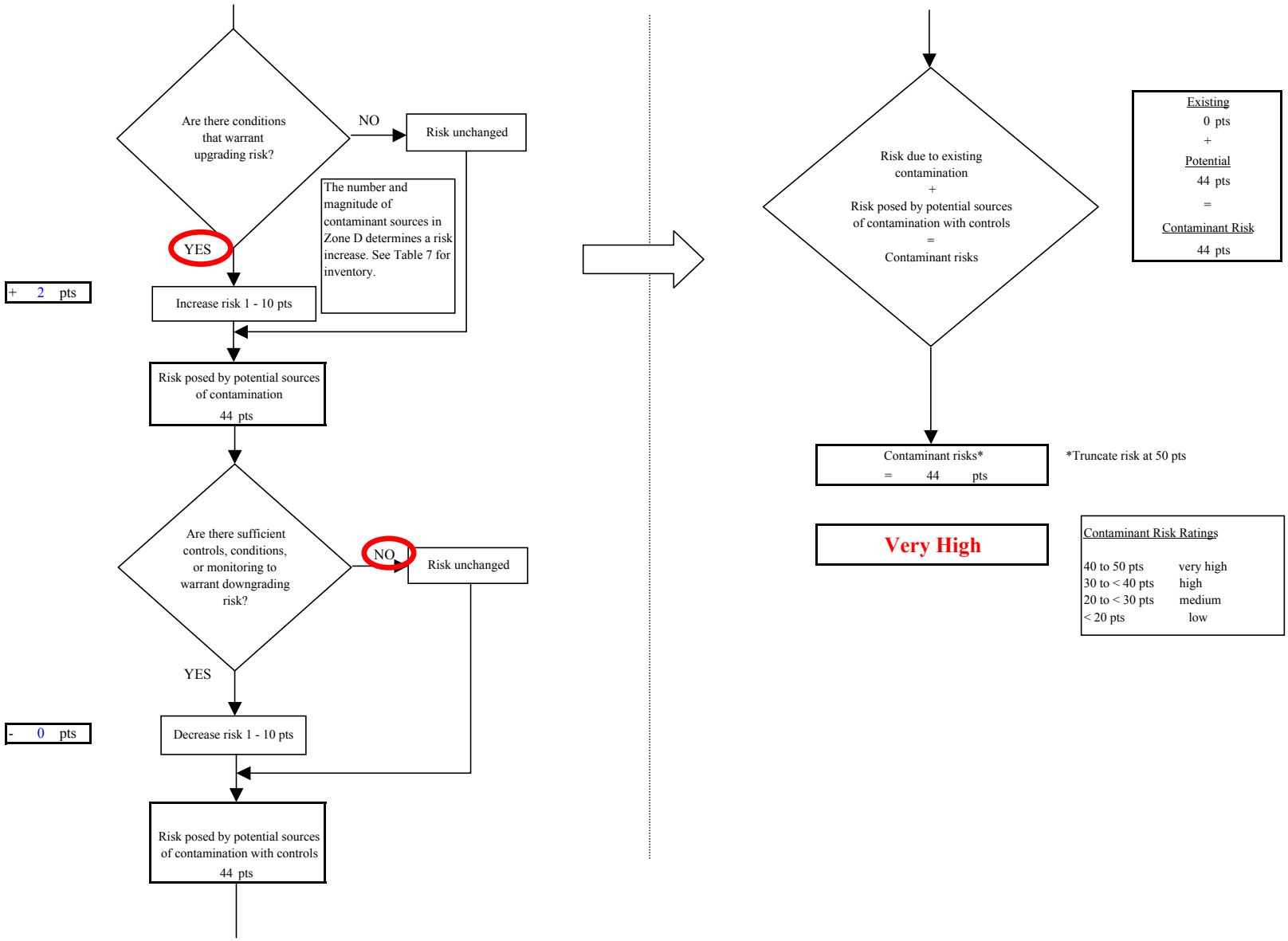


Chart 14. Vulnerability analysis for Glennallen Heights (PWS No. 291504.002) - Other Organic Chemicals