Source Water Assessment

A Hydrogeologic Susceptibility and Vulnerability Assessment for Bethel Water Complex Drinking Water System, Bethel, Alaska

PWSID # 271075.001

April 2004

DRINKING WATER PROTECTION PROGRAM REPORT 1118
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 Bethel Water Complex Source of Public Drinking Water, Bethel, Alaska

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

The Bethel Water Complex has one Public Water System (PWS) well. The well (PWS No. 271075.001) has been used as a drinking water source since it was drilled in 1979.

The well is a Class A (community and non-transient/non-community) water system located on Radio Road in Bethel, Alaska. Available records indicate that there is water storage with a capacity of 120,000-gallons, and that the drinking water is treated with calcium hypochlorite. This system operates year round and serves approximately 400 residents through thirteen service connections. The wellhead received a susceptibility rating of **Low** and the aquifer received a susceptibility rating of **Low**. Combining these two ratings produce a **Low** rating for the natural susceptibility of the well.

Identified potential and current sources of contaminants for the public drinking water source include: wastewater holding tanks, motor/motor vehicle repair shops, domestic wastewater collection systems, aboveground fuel tanks, monitoring wells, water supply wells, cemeteries, glycol storage/disposal, pipelines, electric power generation, medical/veterinary facilities, abandoned wells, firehouses, a domestic wastewater treatment plant disposal pond/lagoon, landfills, and a floatplane dock/ refueling area. 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 **Low** for bacteria and viruses, and a vulnerability rating of **Medium** for nitrates and nitrites, volatile organic chemicals, heavy metals, cyanide and other inorganic chemicals, synthetic organic chemicals, and other organic chemicals.

PUBLIC DRINKING WATER SYSTEM

The Bethel Water Complex well is a Class A (community/non-transient/non-community) public water system. The system is located on Radio Road in Bethel, Alaska (Sec. 8, T8N, R71W, Seward Meridian; see Map A of Appendix A). Bethel serves as the regional center for 56 villages in the Yukon-Kuskokwim Delta. Food, fuel, transportation, medical care, and other services for the region are provided by Bethel. Bethel is located at the mouth of the Kuskokwim River, 40-miles inland from the Bering Sea, and approximately 400-air miles west of Anchorage. The community has a population of 5,736 (ADCED, 2003). Average annual precipitation for Bethel is 16 inches, including approximately 50 inches of snowfall. Temperatures range from 42 to 62°F in summer and -2 to 19°F in winter.

The community of Bethel obtains a portion of their water supply from city wells. Some households are served by the central piped water and sewage collection system; however, approximately 75% of households have water delivered and sewage hauled by truck. Several facilities have individual wells and septic tanks (ADCED, 2003). Bethel receives electrical power from the Bethel Utilities Corporation. Power generating facilities are fueled by diesel. Refuse is collected by the City of Bethel and transported to the City operated landfill (ADCED, 2003).

According to information supplied by ADEC for the Bethel Water Complex PWS, the depth of the primary water well is 460 feet below the ground surface. Well construction details are unknown; however, it is assumed the well is screened in a confined aquifer based on available construction details for surrounding wells. The well is not located within a floodplain.

Information acquired from a March 2000 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 grouted according to ADEC regulations. Proper grouting provides added protection against contaminants traveling along the well casing annulus and into source waters.

The Bethel area is near the southern border of the continuous permafrost zone and the City, and most of the area west of the Kuskokwim River, appear to be underlain with permafrost. The permafrost generally extends to a depth of at least 300 feet bgs, with depths of over 600 feet bgs recorded in some areas. The geology in the area consists primarily of unconsolidated floodplain alluvium, silt deposits, and reworked silt. The Bethel area consists of poorly drained wetlands that have permanently ponded water in local depressions. Sloughs, small lakes, ponds, and marshes in meander scars surround Bethel (Dames & Moore, 1996).

DRINKING WATER PROTECTION AREA

In order to evaluate whether a drinking water source is at risk, we must first evaluate what are the most likely pathways for surface contamination to reach the groundwater. 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 Bethel Water Complex 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 Bethel Water Complex 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 Bethel Water Complex 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 4 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 Bethel Water Complex's water well is in a confined aquifer. Confined aquifers are less 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	0	Low
Susceptibility of the Aquifer	9	Low
Natural Susceptibility	9	Low

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	22	Medium
Nitrates and/or Nitrites	36	High
Volatile Organic Chemicals	46	Very High
Heavy Metals, Cyanide and Other Inorganic Chemicals	50	Very High
Synthetic Organic Chemicals	34	High
Other Organic Chemicals	50	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	30	Low
Nitrates and Nitrites	45	Medium
Volatile Organic Chemicals	55	Medium
Heavy Metals, Cyanide and Other Inorganic Chemicals	55	Medium
Synthetic Organic Chemicals	45	Medium
Other Organic Chemicals	55	Medium

Bacteria and Viruses

The contaminant risk for bacteria and viruses is **Medium**. The risk is primarily attributed to the presence of a domestic wastewater treatment plant disposal pond/lagoon and a landfill in Zone D (see Table 2 – Appendix B).

A positive bacteria count has not 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 **Low**.

Nitrates and Nitrites

The contaminant risk for nitrates and nitrites is **High**. The risk to this source of public drinking water is primarily attributed to the presence of an abandoned well, a domestic wastewater treatment plant disposal pond/lagoon, and a landfill in Zones C and D (see Table 3 – Appendix B).

Nitrates are very mobile, moving at approximately the same rate as water. The sampling history for this well indicates that nitrates have not been detected 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).

Nitrate levels are often derived from the decomposition of organic matter in soils. Although the nitrate source is unknown, such occurrences may be attributed to septic systems or other sources. 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 **Very High**. The risk is primarily attributed to the presence of an abandoned well and a landfill in Zones C and D. Numerous other potential contaminant sources are also found within the protection area (see Table 4 – Appendix B).

All recent sampling data for VOCs were below detection levels for the Bethel Water Complex (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 **Medium**.

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 an abandoned well and a landfill in Zones C and D. Numerous other potential contaminant sources are also found within the protection area (see Table 5 – Appendix B).

Based on review of recent sampling records for this public water system, moderate levels of copper and lead have been detected in recent sampling history, but have not exceeded their respective MCLs of 1.3 mg/L and 0.015 mg/L (see Chart 9 – Contaminant Risks for Heavy Metals, Cyanide, and Other Inorganic Chemicals in Appendix D).

The reported concentrations of copper and lead in recent sampling events are not likely to be representative of source water conditions. These two analytes are likely attributed to either the water treatment process or water distribution network; therefore, no risk points were assigned based on the presence of these analytes.

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 **Medium**.

Synthetic Organic Chemicals

The contaminant risk for synthetic organic chemicals is **High**. The risk is primarily attributed to the presence of an abandoned well and a landfill in Zones C and D (see Table 6 – Appendix B).

No recent sampling data was available in ADEC records for the Bethel Water Complex (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, electric power generation, an abandoned well, and landfills in Zones B, C, and D. Numerous 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 the Bethel Water Complex (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 **Medium**.

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 the community of Bethel 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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Dames & Moore, 1996. Final Water and Sewer Facilities Master Plan Update Report, City of Bethel.

Freeze, R. A., and Cherry, J.A. 1979, Groundwater, Prentice-Hall, Englewood Cliffs, New Jersey

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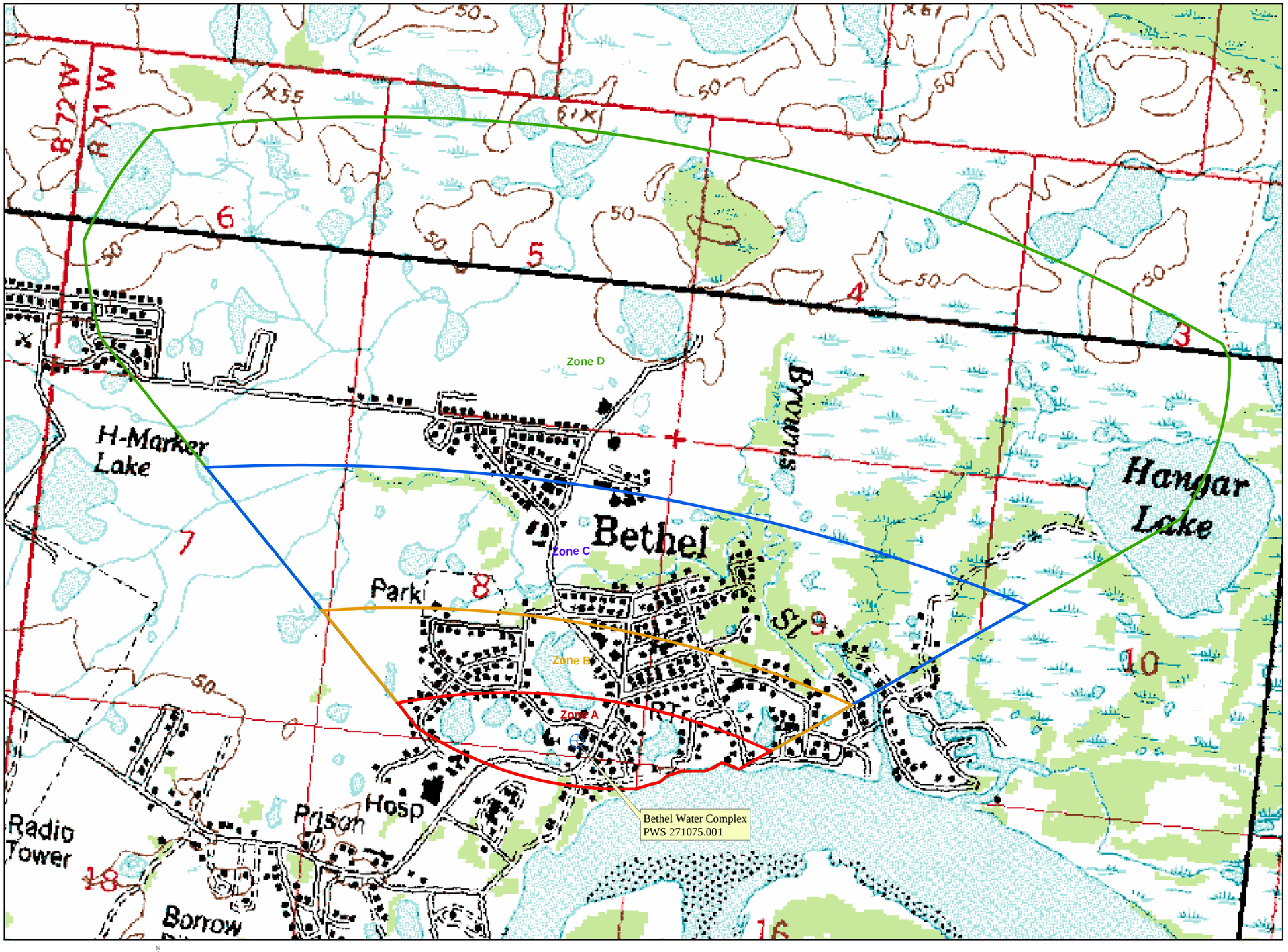
APPENDIX A

Drinking Water Protection Area Location Map
(Map A)

Public Water Well System for PWS #271075.001 Bethel Water Complex



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

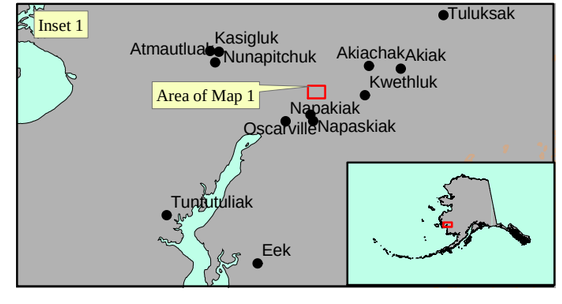
Data Sources:
Contaminant Sources, Public Water System Wells, Contours
Alaska Department of Environmental Conservation (ADEC)

Critical Facilities, Federal Emergency Management Agency (FEMA)

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 0.25 0.5 1 1.5 2 Miles

Bethel Water Complex
PWS 271075.001

Appendix A Map A

APPENDIX B

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

Table 1

Contaminant Source Inventory for ***Bethel Water Complex***

PWSID 271075.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Map Number*	*Comments*
Wastewater Holding Tank	T22	T22-01	A	C	
Wastewater Holding Tank	T22	T22-02	A	C	
Wastewater Holding Tank	T22	T22-03	A	C	
Motor /motor vehicle repair shops	C31	C31-01	B	C	
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-02	B	C	
Tanks, diesel (above ground)	T06	T06-02	B	C	
Wastewater Holding Tank	T22	T22-04	B	C	
Monitoring wells	W06	W06-01	B	C	
Water supply wells	W09	W09-01	B	C	6 water supply wells in Zone B
Cemeteries	X01	X01-01	B	C	
Glycol (disposal or storage)	X07	X07-01	B	C	
Glycol (disposal or storage)	X07	X07-02	B	C	
Pipelines (oil and gas)	X28	X28-01	B	C	
Electric power generation (fossil fuels)	X36	X36-01	B	C	
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-01	B	C	BERING SEA ANIMAL CLINIC
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-02	B	C	
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-03	C	C	
Tanks, diesel (above ground)	T06	T06-01	C	C	
Tanks, heating oil, nonresidential (aboveground)	T14	T14-01	C	C	
Tanks, heating oil, nonresidential (aboveground)	T14	T14-02	C	C	
Tanks, heating oil, nonresidential (aboveground)	T14	T14-03	C	C	United Pentacostal Church
Wastewater Holding Tank	T22	T22-05	C	C	

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Map Number*	*Comments*
Wastewater Holding Tank	T22	T22-06	C	C	United Pentacostal Church
Abandoned wells	W01	W01-01	C	C	
Water supply wells	W09	W09-02	C	C	5 water supply wells in Zone C
Glycol (disposal or storage)	X07	X07-03	C	C	
Firehouses	X38	X38-01	C	C	
Domestic wastewater collection systems (sewer lines or lift stations)	D01	D01-01	D	C	
Domestic wastewater treatment plant disposal ponds/lagoons	D02	D02-01	D	C	
Landfills (municipal; Class II)	D50	D50-01	D	C	Bethel Landfill
Landfills (industrial; type of industrial waste?)	D52	D52-01	D	C	Bethel Asbestos Landfill
Floatplane dock/refueling area	X17	X17-01	D	C	

Table 2

Contaminant Source Inventory and Risk Ranking for Bethel Water Complex Sources of Bacteria and Viruses

PWSID 271075.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Wastewater Holding Tank	T22	T22-01	A	Low	C	
Wastewater Holding Tank	T22	T22-02	A	Low	C	
Wastewater Holding Tank	T22	T22-03	A	Low	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-02	B	Medium	C	
Wastewater Holding Tank	T22	T22-04	B	Low	C	
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-01	B	Medium	C	BERING SEA ANIMAL CLINIC
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-02	B	Medium	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-03	C	Medium	C	
Wastewater Holding Tank	T22	T22-05	C	Low	C	
Wastewater Holding Tank	T22	T22-06	C	Low	C	United Pentacostal Church
Abandoned wells	W01	W01-01	C	Medium	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-01	D	Medium	C	
Domestic wastewater treatment plant disposal ponds/lagoons	D02	D02-01	D	High	C	
Landfills (municipal; Class II)	D50	D50-01	D	High	C	Bethel Landfill

Table 3

Contaminant Source Inventory and Risk Ranking for Bethel Water Complex Sources of Nitrates/Nitrites

PWSID 271075.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Wastewater Holding Tank	T22	T22-01	A	Low	C	
Wastewater Holding Tank	T22	T22-02	A	Low	C	
Wastewater Holding Tank	T22	T22-03	A	Low	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-02	B	Medium	C	
Wastewater Holding Tank	T22	T22-04	B	Low	C	
Cemeteries	X01	X01-01	B	Medium	C	
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-01	B	Low	C	BERING SEA ANIMAL CLINIC
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-02	B	Low	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-03	C	Medium	C	
Wastewater Holding Tank	T22	T22-05	C	Low	C	
Wastewater Holding Tank	T22	T22-06	C	Low	C	United Pentacostal Church
Abandoned wells	W01	W01-01	C	High	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-01	D	Medium	C	
Domestic wastewater treatment plant disposal ponds/lagoons	D02	D02-01	D	High	C	
Landfills (municipal; Class II)	D50	D50-01	D	Very High	C	Bethel Landfill

Table 4

Contaminant Source Inventory and Risk Ranking for Bethel Water Complex
Sources of Volatile Organic Chemicals

PWSID 271075.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Wastewater Holding Tank	T22	T22-01	A	Medium	C	
Wastewater Holding Tank	T22	T22-02	A	Medium	C	
Wastewater Holding Tank	T22	T22-03	A	Medium	C	
Motor /motor vehicle repair shops	C31	C31-01	B	Medium	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-02	B	Low	C	
Tanks, diesel (above ground)	T06	T06-02	B	Medium	C	
Wastewater Holding Tank	T22	T22-04	B	Medium	C	
Pipelines (oil and gas)	X28	X28-01	B	Medium	C	
Electric power generation (fossil fuels)	X36	X36-01	B	Medium	C	
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-01	B	Low	C	BERING SEA ANIMAL CLINIC
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-02	B	Low	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-03	C	Low	C	
Tanks, diesel (above ground)	T06	T06-01	C	Medium	C	
Tanks, heating oil, nonresidential (aboveground)	T14	T14-01	C	Low	C	
Tanks, heating oil, nonresidential (aboveground)	T14	T14-02	C	Low	C	
Tanks, heating oil, nonresidential (aboveground)	T14	T14-03	C	Low	C	United Pentacostal Church
Wastewater Holding Tank	T22	T22-05	C	Medium	C	
Wastewater Holding Tank	T22	T22-06	C	Medium	C	United Pentacostal Church
Abandoned wells	W01	W01-01	C	High	C	
Firehouses	X38	X38-01	C	Low	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-01	D	Low	C	

Contaminant Source Inventory and Risk Ranking for Bethel Water Complex

Sources of Volatile Organic Chemicals

Contaminant Source Type	***Contaminant Source ID***	***CS ID tag***	***Zone***	***Risk Ranking for Analysis***	***Map Number***	***Comments***
Domestic wastewater treatment plant disposal ponds/lagoons	D02	D02-01	D	Low	C	
Landfills (municipal; Class II)	D50	D50-01	D	High	C	Bethel Landfill
Floatplane dock/refueling area	X17	X17-01	D	Low	C	

Table 5

Contaminant Source Inventory and Risk Ranking for Bethel Water Complex

Sources of Heavy Metals, Cyanide and Other Inorganic Chemicals

PWSID 271075.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Wastewater Holding Tank	T22	T22-01	A	Medium	C	
Wastewater Holding Tank	T22	T22-02	A	Medium	C	
Wastewater Holding Tank	T22	T22-03	A	Medium	C	
Motor /motor vehicle repair shops	C31	C31-01	B	Medium	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-02	B	Low	C	
Wastewater Holding Tank	T22	T22-04	B	Medium	C	
Monitoring wells	W06	W06-01	B	Medium	C	
Cemeteries	X01	X01-01	B	Low	C	
Glycol (disposal or storage)	X07	X07-01	B	Low	C	
Glycol (disposal or storage)	X07	X07-02	B	Low	C	
Pipelines (oil and gas)	X28	X28-01	B	Low	C	
Electric power generation (fossil fuels)	X36	X36-01	B	Medium	C	
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-01	B	Low	C	BERING SEA ANIMAL CLINIC
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-02	B	Low	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-03	C	Low	C	
Tanks, heating oil, nonresidential (aboveground)	T14	T14-01	C	Low	C	
Tanks, heating oil, nonresidential (aboveground)	T14	T14-02	C	Low	C	
Tanks, heating oil, nonresidential (aboveground)	T14	T14-03	C	Low	C	United Pentacostal Church
Wastewater Holding Tank	T22	T22-05	C	Medium	C	
Wastewater Holding Tank	T22	T22-06	C	Medium	C	United Pentacostal Church
Abandoned wells	W01	W01-01	C	Very High	C	
Glycol (disposal or storage)	X07	X07-03	C	Low	C	

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Firehouses	X38	X38-01	C	Low	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-01	D	Low	C	
Domestic wastewater treatment plant disposal ponds/lagoons	D02	D02-01	D	Low	C	
Landfills (municipal; Class II)	D50	D50-01	D	High	C	Bethel Landfill
Floatplane dock/refueling area	X17	X17-01	D	Low	C	

Table 6

Contaminant Source Inventory and Risk Ranking for Bethel Water Complex
Sources of Synthetic Organic Chemicals

PWSID 271075.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-02	B	Low	C	
Cemeteries	X01	X01-01	B	Medium	C	
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-01	B	Low	C	BERING SEA ANIMAL CLINIC
Medical/veterinary facilities (doctor or dentist offices, hospitals, nursing homes)	X40	X40-02	B	Low	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-03	C	Low	C	
Abandoned wells	W01	W01-01	C	High	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-01	D	Low	C	
Domestic wastewater treatment plant disposal ponds/lagoons	D02	D02-01	D	Low	C	
Landfills (municipal; Class II)	D50	D50-01	D	Very High	C	Bethel Landfill

Table 7

Contaminant Source Inventory and Risk Ranking for Bethel Water Complex
Sources of Other Organic Chemicals

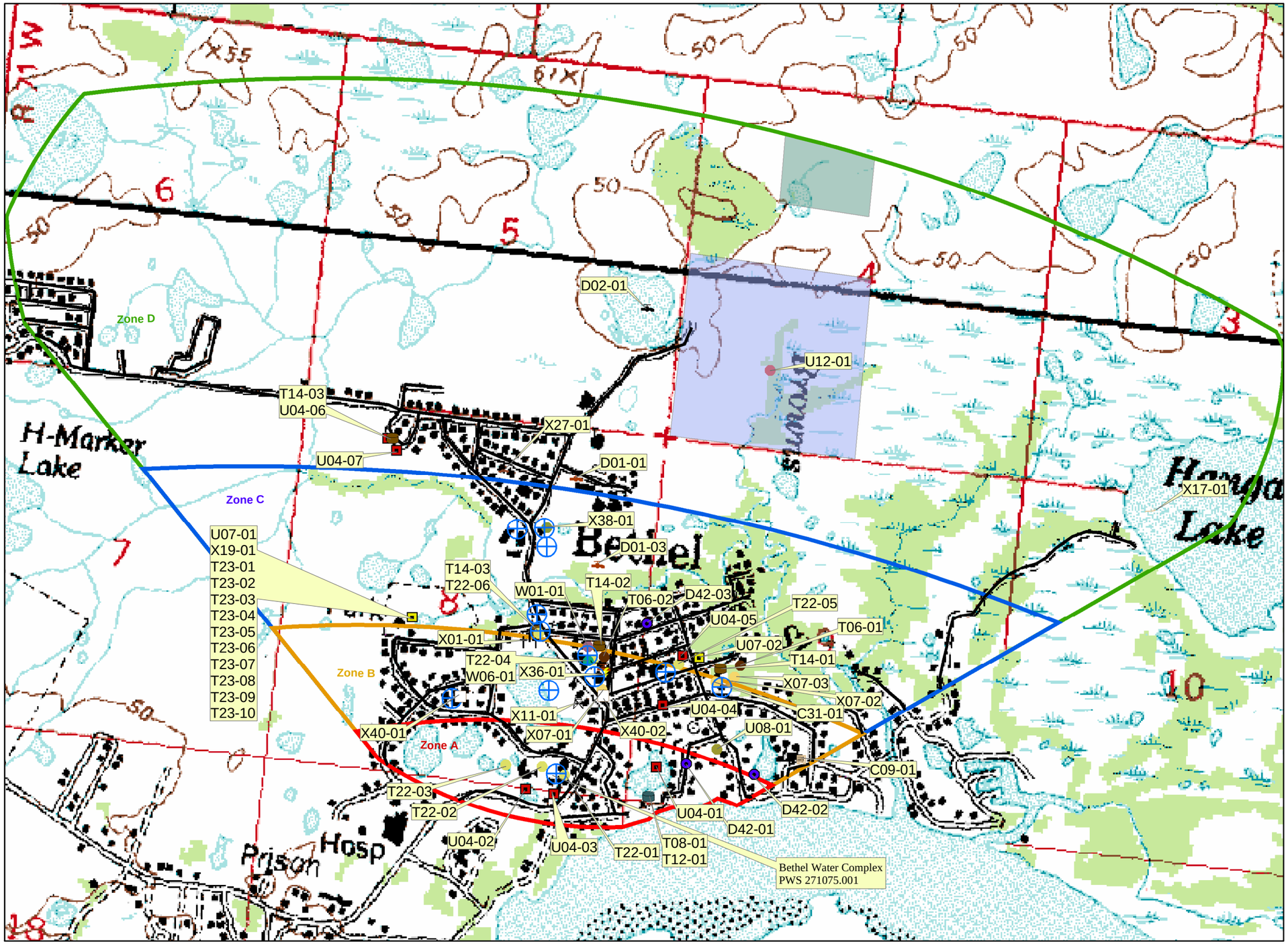
PWSID 271075.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Wastewater Holding Tank	T22	T22-01	A	Medium	C	
Wastewater Holding Tank	T22	T22-02	A	Medium	C	
Wastewater Holding Tank	T22	T22-03	A	Medium	C	
Motor /motor vehicle repair shops	C31	C31-01	B	Medium	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-02	B	Low	C	
Wastewater Holding Tank	T22	T22-04	B	Medium	C	
Pipelines (oil and gas)	X28	X28-01	B	High	C	
Electric power generation (fossil fuels)	X36	X36-01	B	High	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-03	C	Low	C	
Wastewater Holding Tank	T22	T22-05	C	Medium	C	
Wastewater Holding Tank	T22	T22-06	C	Medium	C	United Pentacostal Church
Abandoned wells	W01	W01-01	C	High	C	
Domestic wastewater collection systems (sewer line or lift stations)	D01	D01-01	D	Low	C	
Domestic wastewater treatment plant disposal ponds/lagoons	D02	D02-01	D	Low	C	
Landfills (municipal; Class II)	D50	D50-01	D	Very High	C	Bethel Landfill
Landfills (industrial; type of industrial waste?)	D52	D52-01	D	Very High	C	Bethel Asbestos Landfill

APPENDIX C

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

Public Water Well System for PWS #271075.001 Bethel Water Complex
Showing Potential and Existng Sources of Contamination



0 0.25 0.5 1 1.5 2 Miles

LEGEND

- Public Water System Well

Transportation

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

Hydrography/Physical

- Parcels
- Stream
- Lake or Pond
- Contours

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

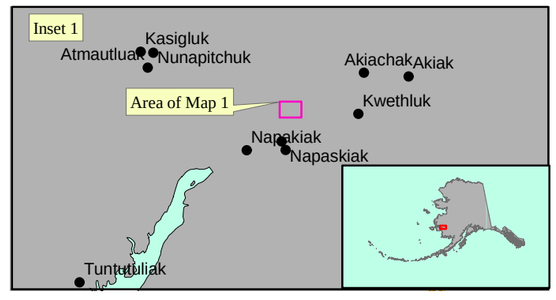
Existing or Potential Contaminant Sources

- Construction trade areas and materials (C09)
- Motor vehicle repair shop (C31)
- Domestic wastewater collection systems (sewer lines) (D01)
- Domestic wastewater treatment plant disosal pond (D02)
- Injection wells (Class V) Motor vehicle waste disposal well (D42)
- Aboveground diesel tank (T06)
- Underground diesel tank (T08)
- Underground gasoline tank (T12)
- Nonresidential aboveground heating oil tank (T14)
- Wastewater holding tank (T22)
- Closed wastewater holding tank (T23)
- Contam. sites, DEC recog., non-Superfund, non-RCRA (U04)
- Open leaking underground fuel storage tank (LUST) (U07)
- Closed leaking underground fuel storage tank (LUST) (U08)
- Closed leaking undergound fuel storage tank (LUST) (aviation) (U12)
- Abandoned well (W01)
- Monitoring well (W06)
- Cemetery (X01)
- Glycol (X07)
- Petroleum product bulk station/terminal (X11)
- Floatplane dock/refueling area (X17)
- Government vehicle maintenance facility (X19)
- Motor vehicle/general storage yards/facilities (X27)
- Oil and gas pipelines (X28)
- Electric power generation (fossil fuels) (X36)
- Firehouse (X38)
- Medical/veterinary facility(X40)
- Landfills (municipal; Class II) (D50)
- Landfills (industrial) (D52)

Data Sources: Contaminant Sources, Public Water System Wells, Contours, Alaska Department of Environmental Conservation (ADEC) Critical Facilities, Federal Emergency Management Agency (FEMA)

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.



Bethel Water Complex
PWS 271075.001

Appendix C Map C

APPENDIX D

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

Chart 1. Susceptibility of the wellhead - Bethel Water Complex (PWS No. 271075.001)

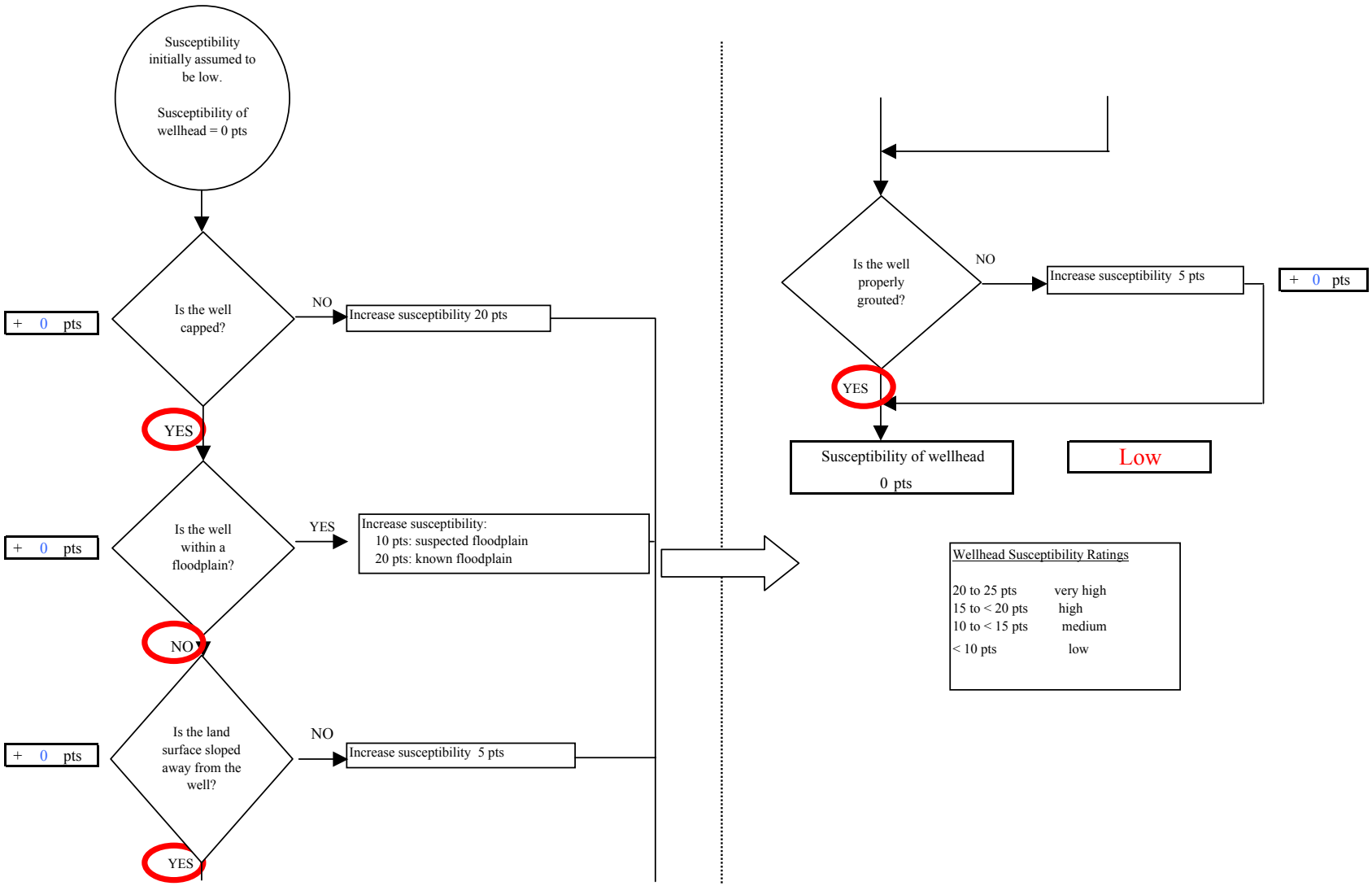


Chart 2. Susceptibility of the aquifer Bethel Water Complex (PWS No. 271075.001)

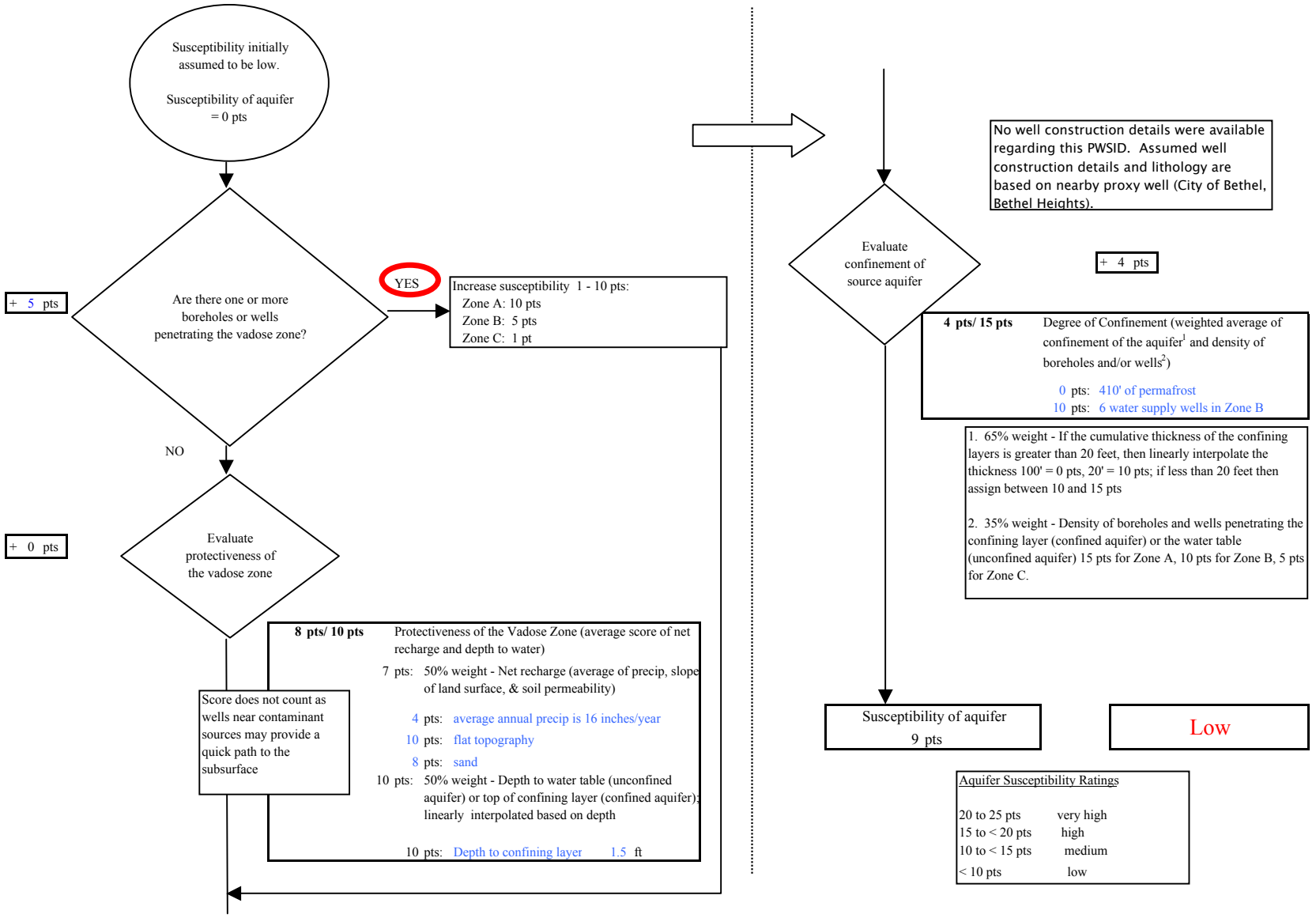
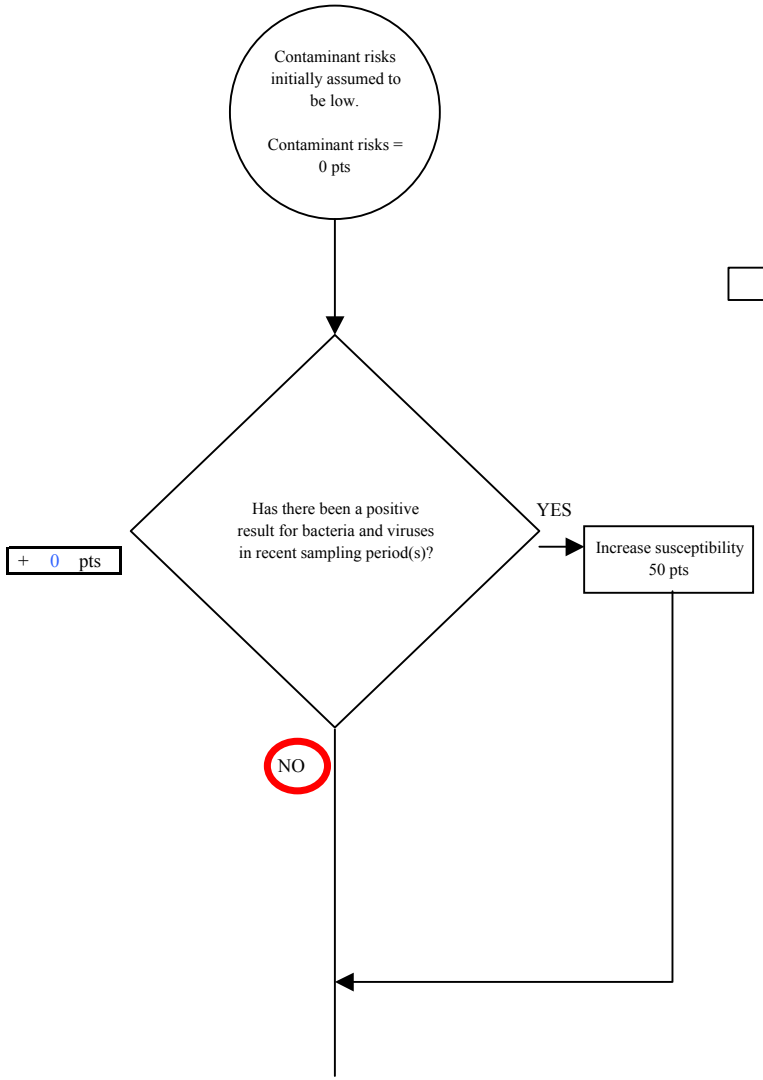
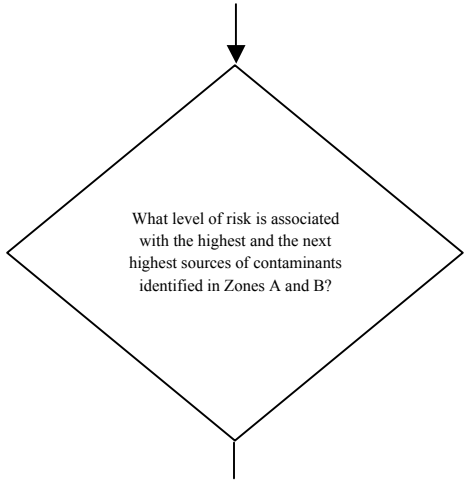


Chart 3. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Bacteria & Viruses





+ 20 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	2	2
Low(s)	3	2	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 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 3. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Bacteria & Viruses

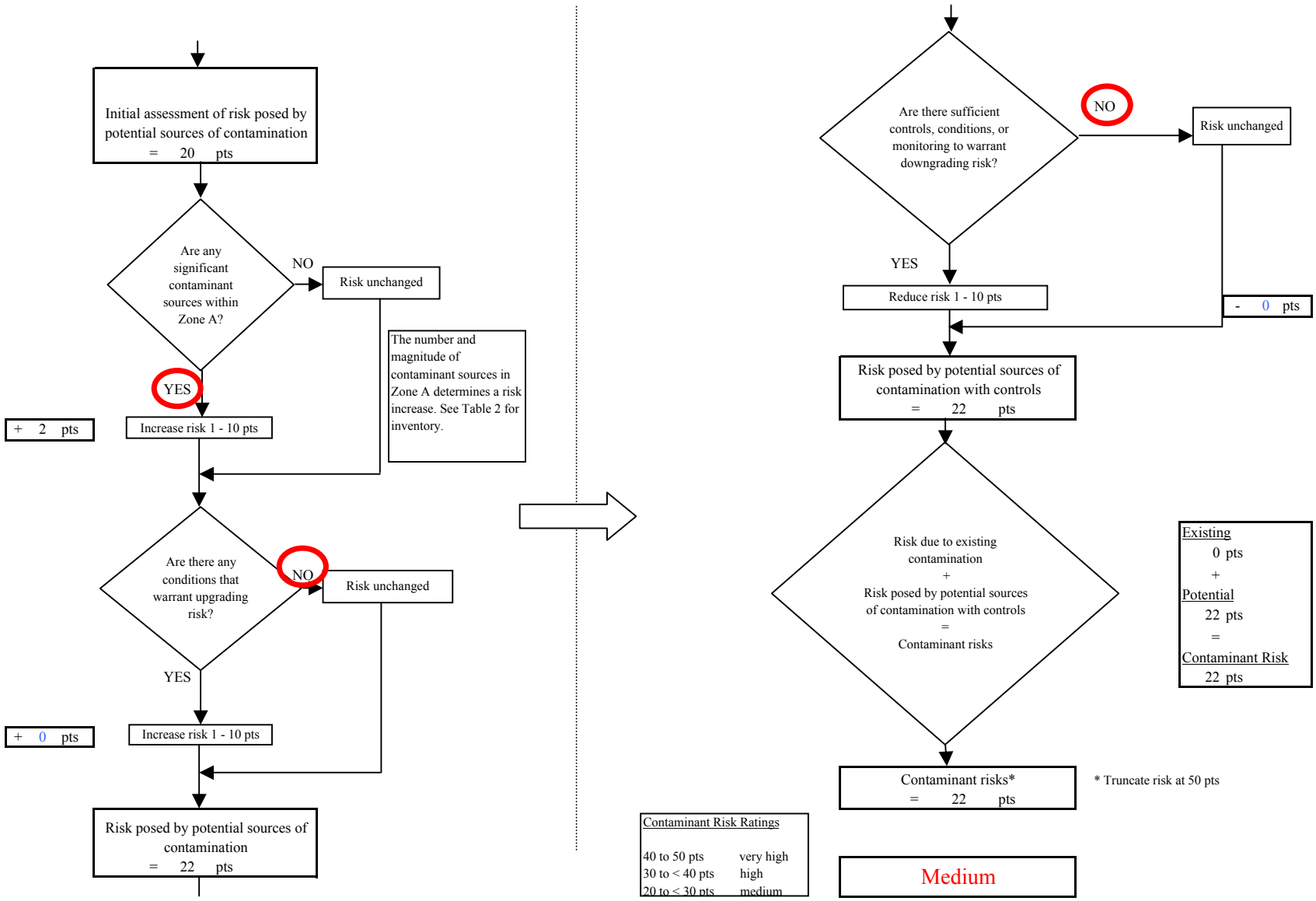


Chart 4. Vulnerability analysis for Bethel Water Complex (PWS No. 271075.001) - Bacteria & Viruses

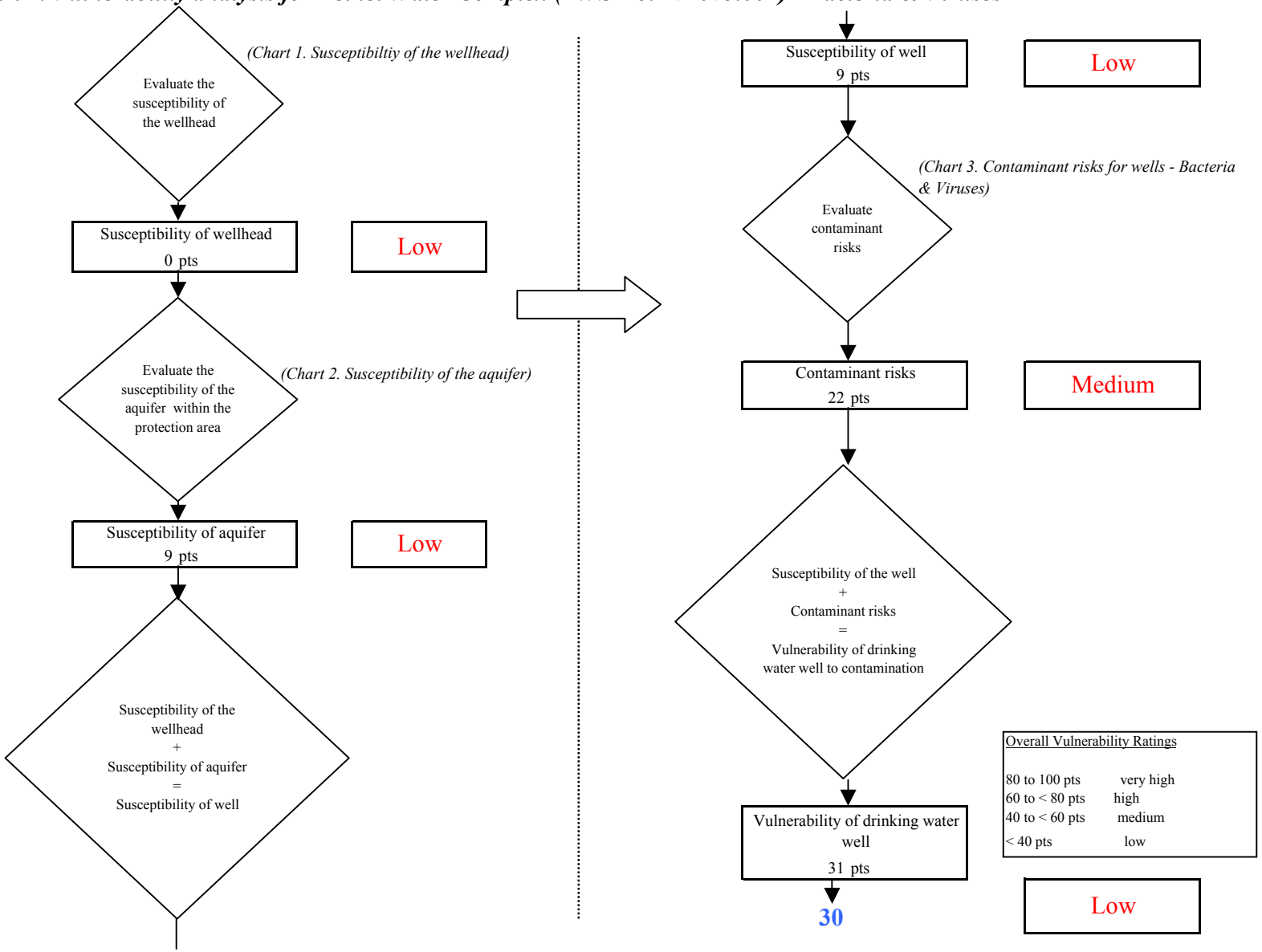


Chart 5. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Nitrates and Nitrites

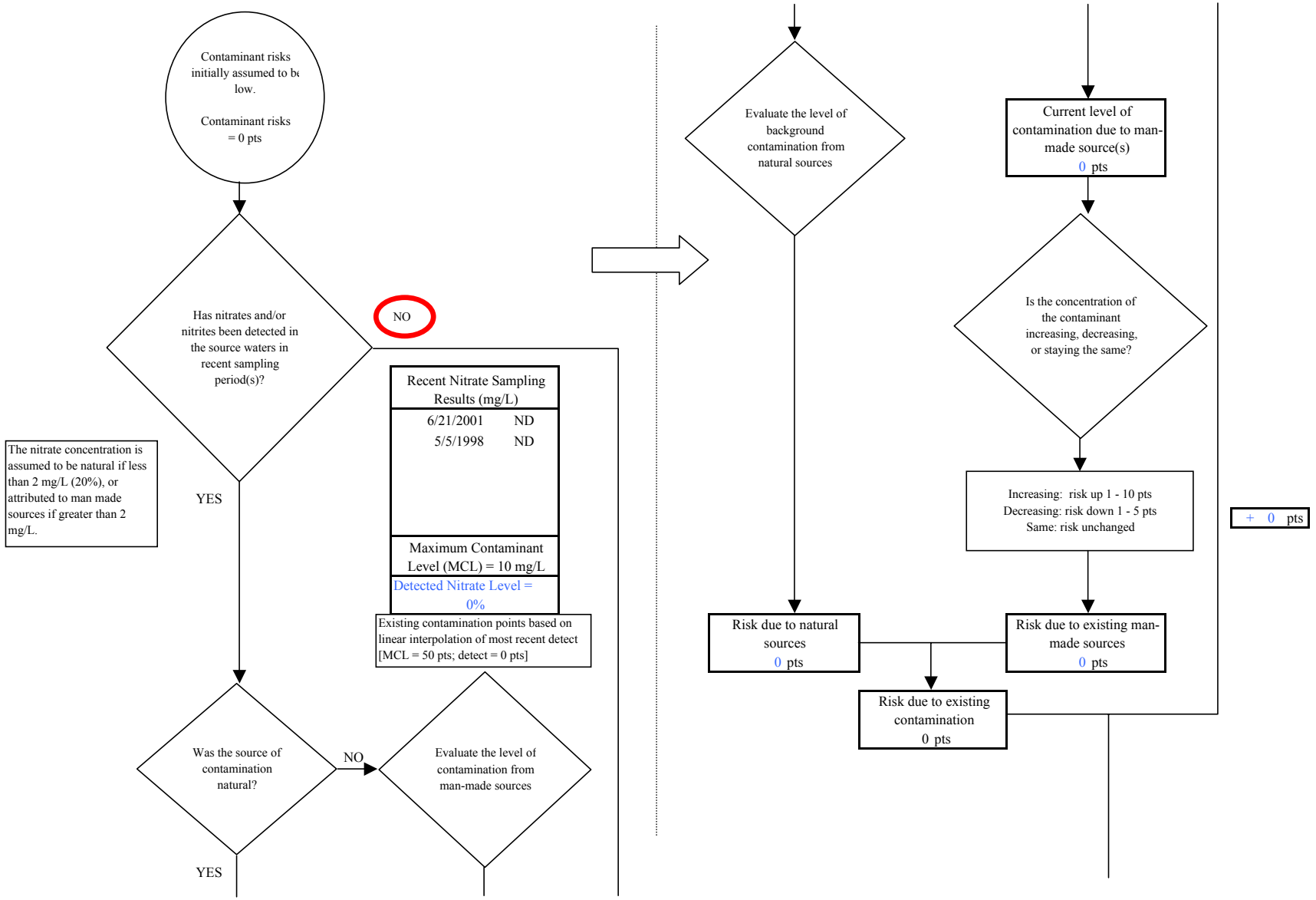


Chart 5. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Nitrates and Nitrites

+ 30 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	1	1
Medium(s)	0	1	1
Low(s)	3	6	9

	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 30

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 = 30 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

- 1 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 3 for inventory.

Chart 5. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Nitrates and Nitrites

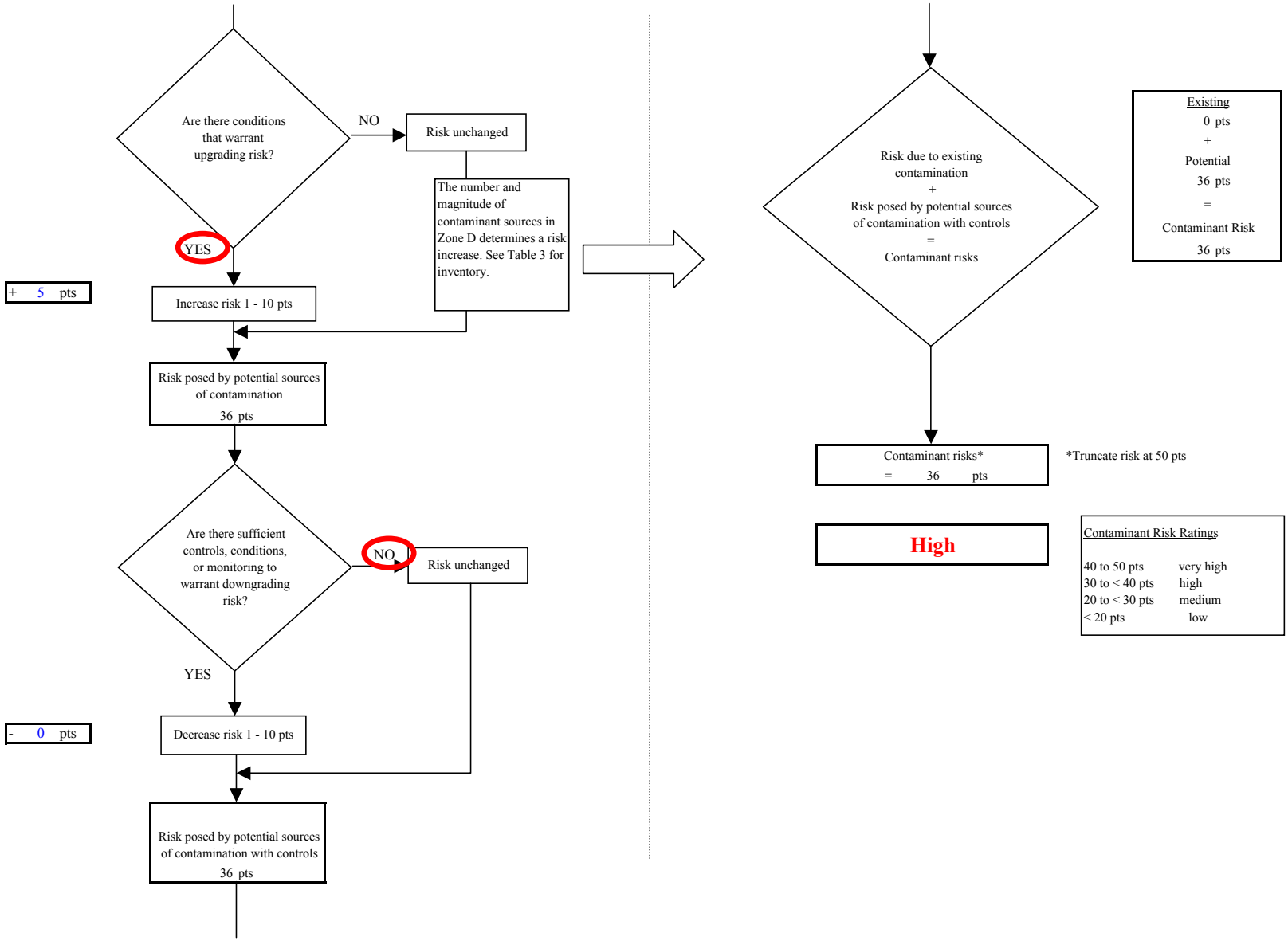


Chart 6. Vulnerability analysis for Bethel Water Complex (PWS No. 271075.001) - Nitrates and Nitrites

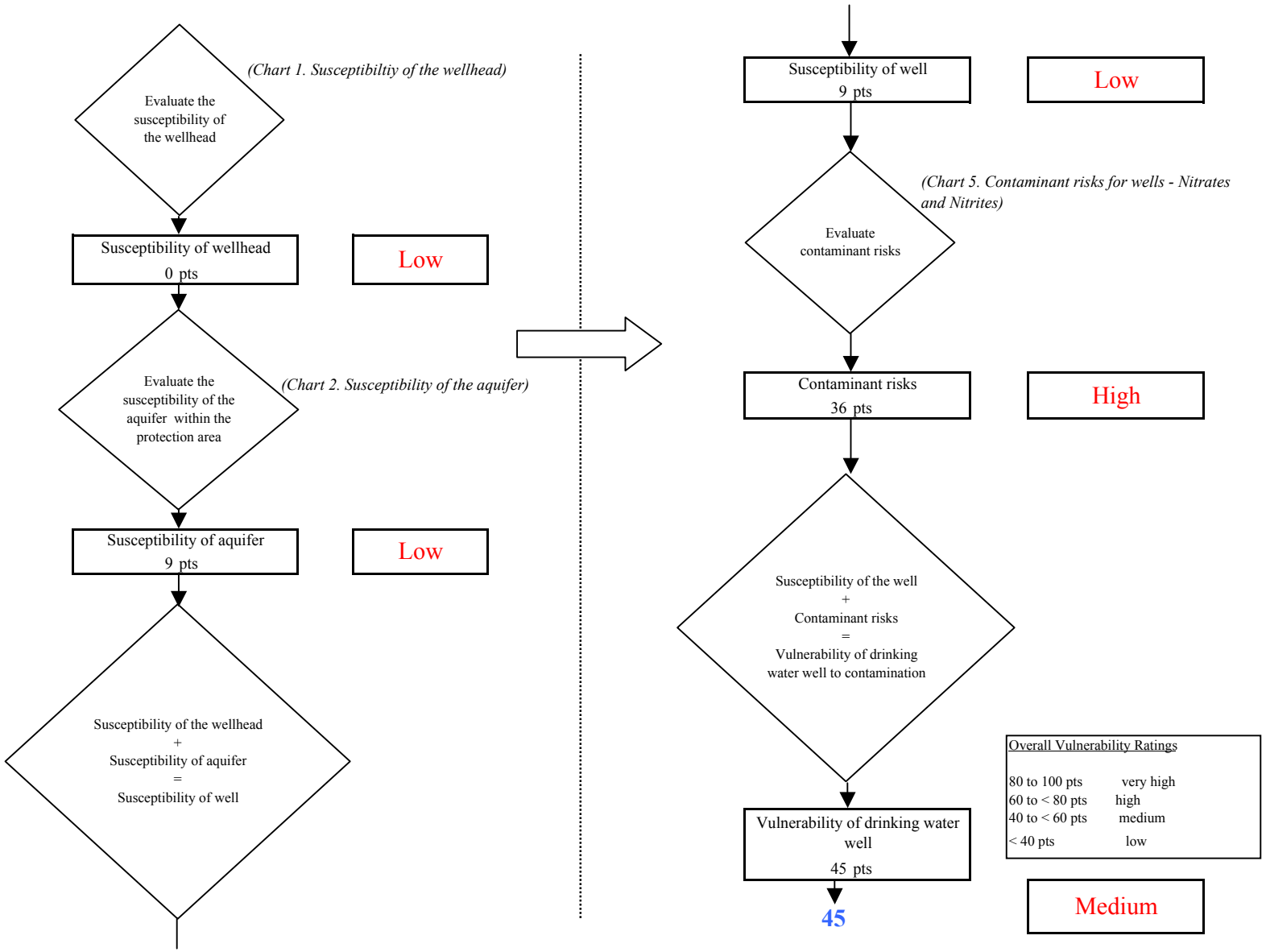


Chart 7. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Volatile Organic Chemicals

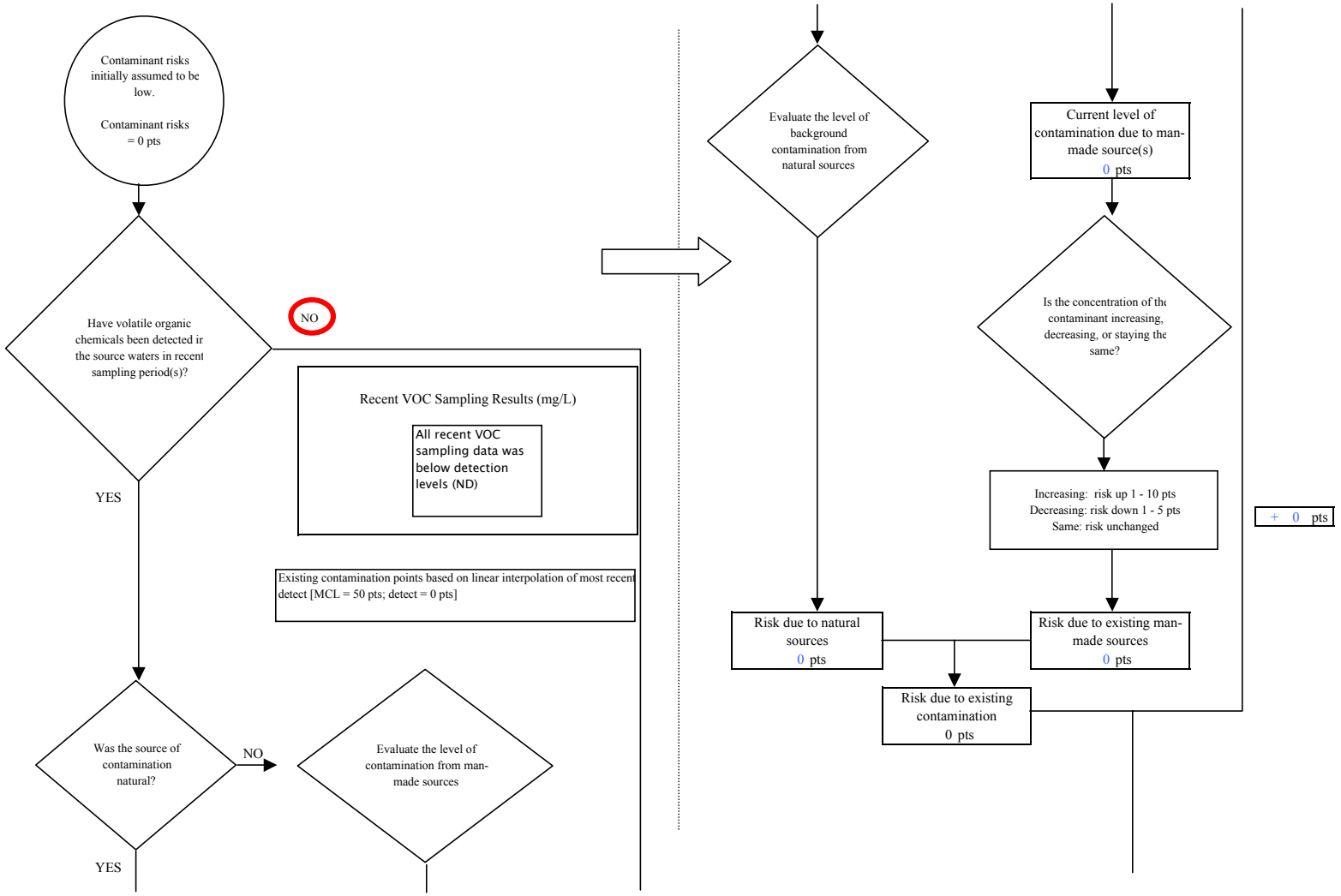
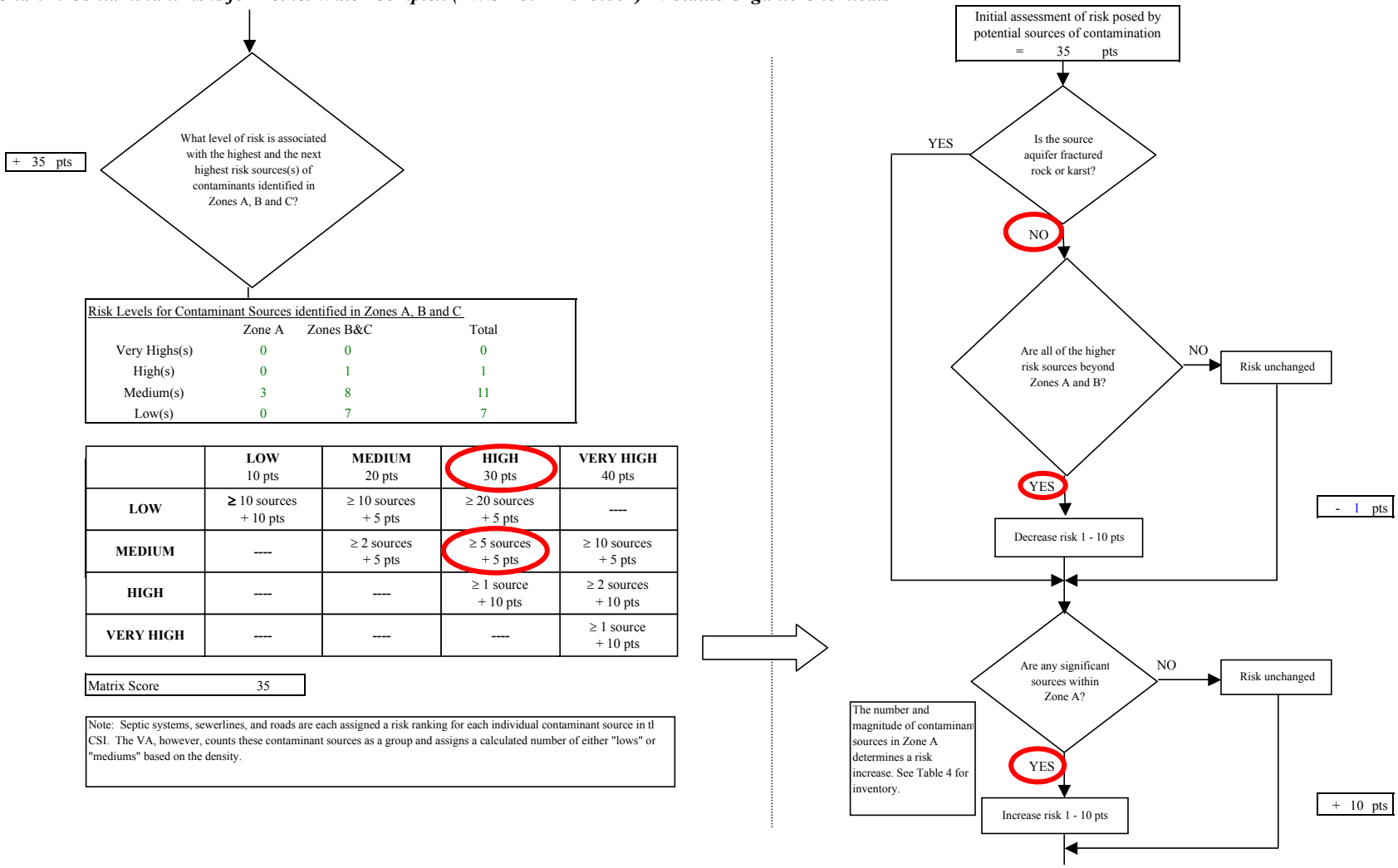


Chart 7. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Volatile Organic Chemicals



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	1	1
Medium(s)	3	8	11
Low(s)	0	7	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 35

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each individual contaminant source in tl 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 7. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Volatile Organic Chemicals

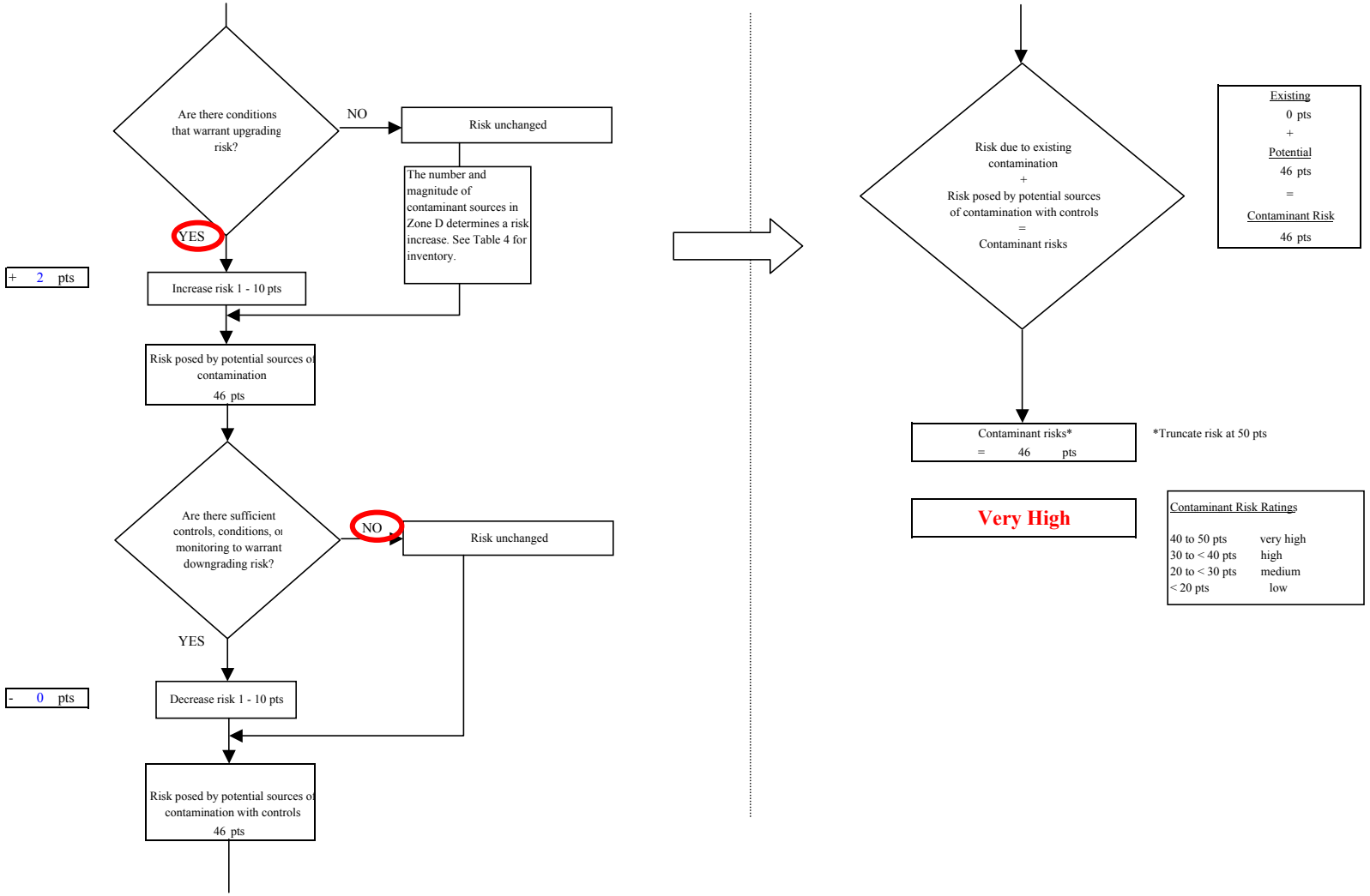


Chart 8. Vulnerability analysis for Bethel Water Complex (PWS No. 271075.001) - Volatile Organic Chemicals

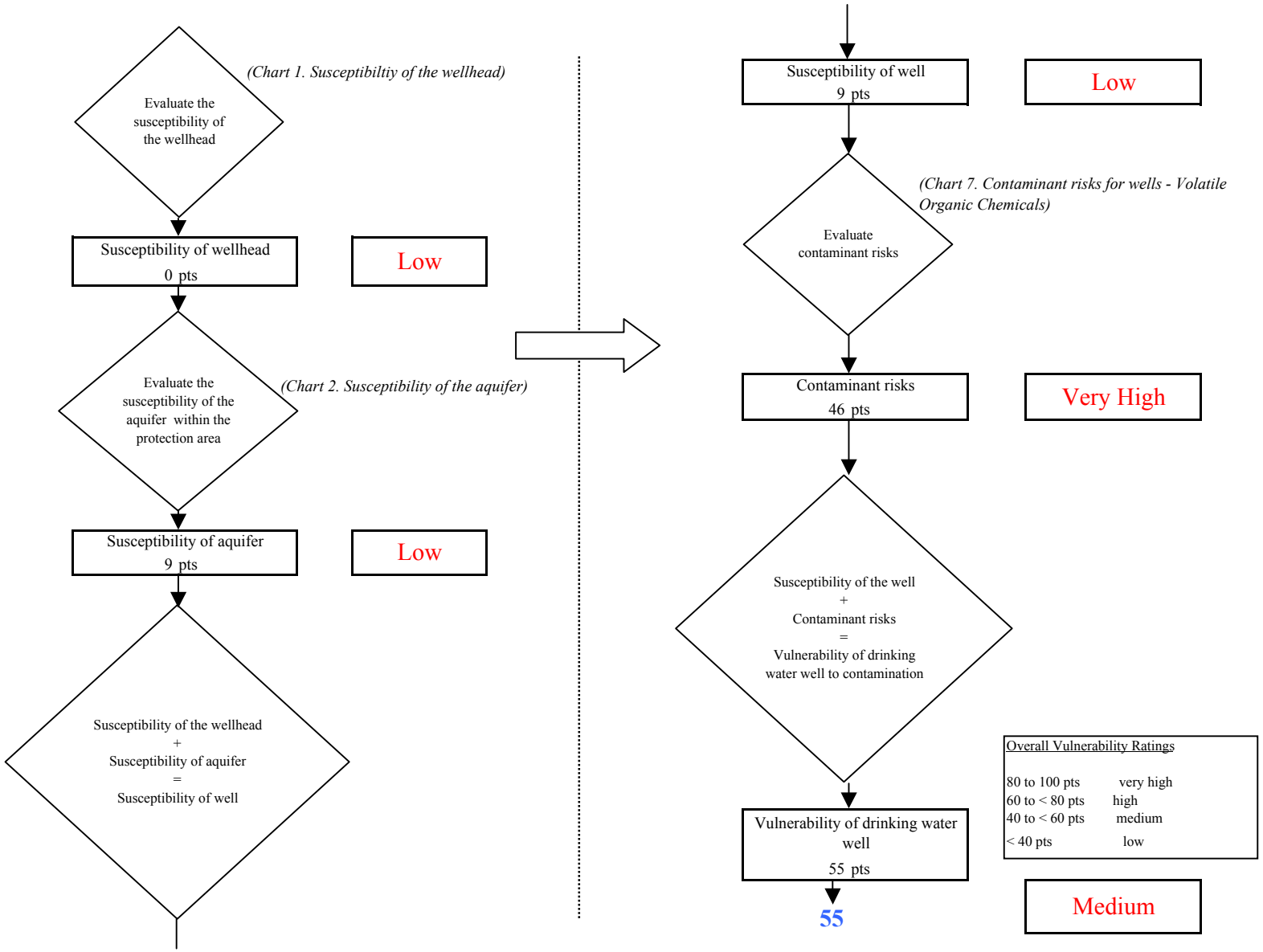


Chart 9. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Heavy Metals, Cyanide and Other Inorganic Chemicals

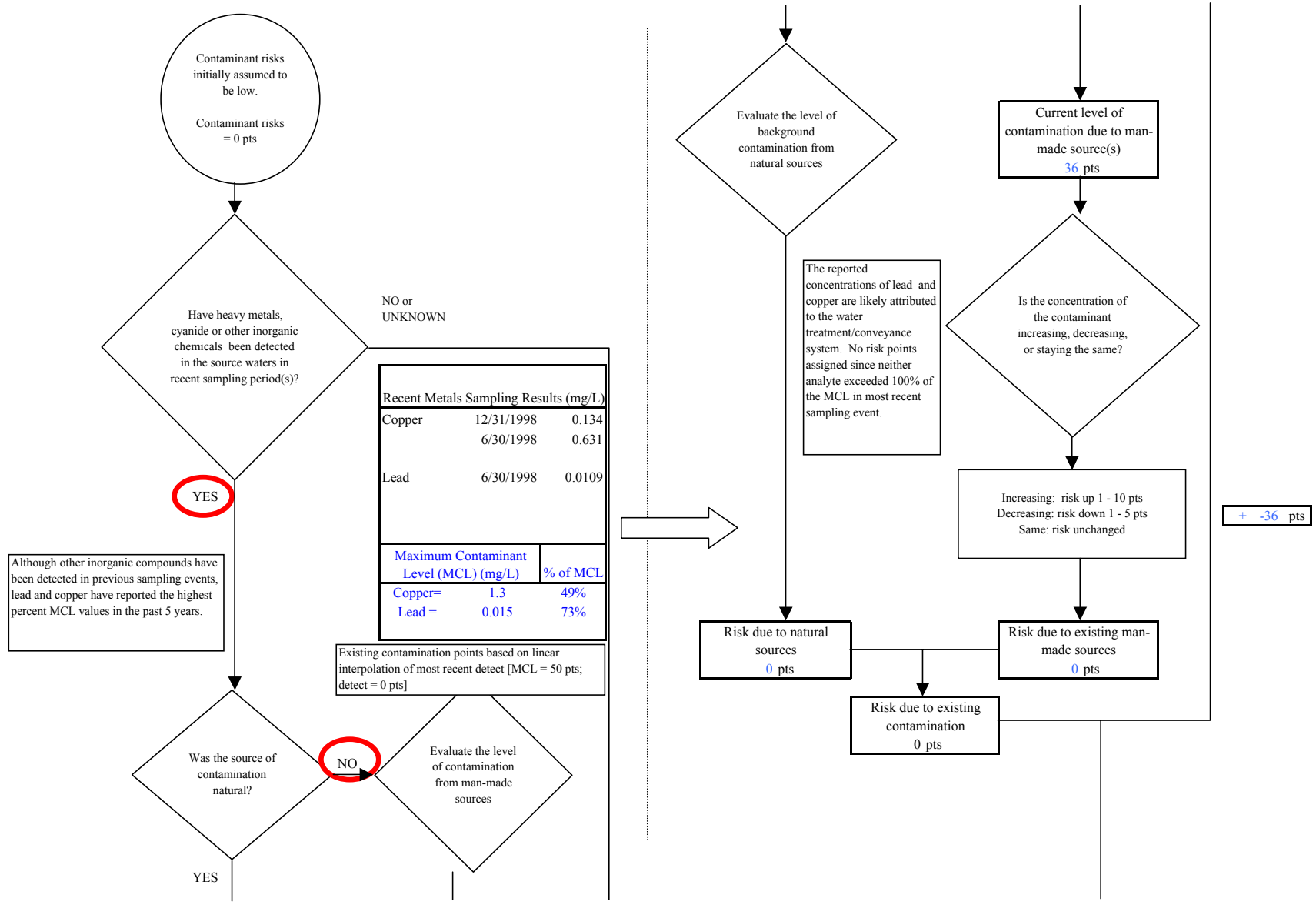


Chart 9. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Heavy Metals, Cyanide and Other Inorganic Chemicals

+ 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	1	1
High(s)	0	0	0
Medium(s)	3	6	9
Low(s)	0	12	12

	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 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 = 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

- 1 pts

Decrease risk 1 - 10 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 5 for inventory.

YES

+ 10 pts

Increase risk 1 - 10 pts

Chart 9. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Heavy Metals, Cyanide and Other Inorganic Chemicals

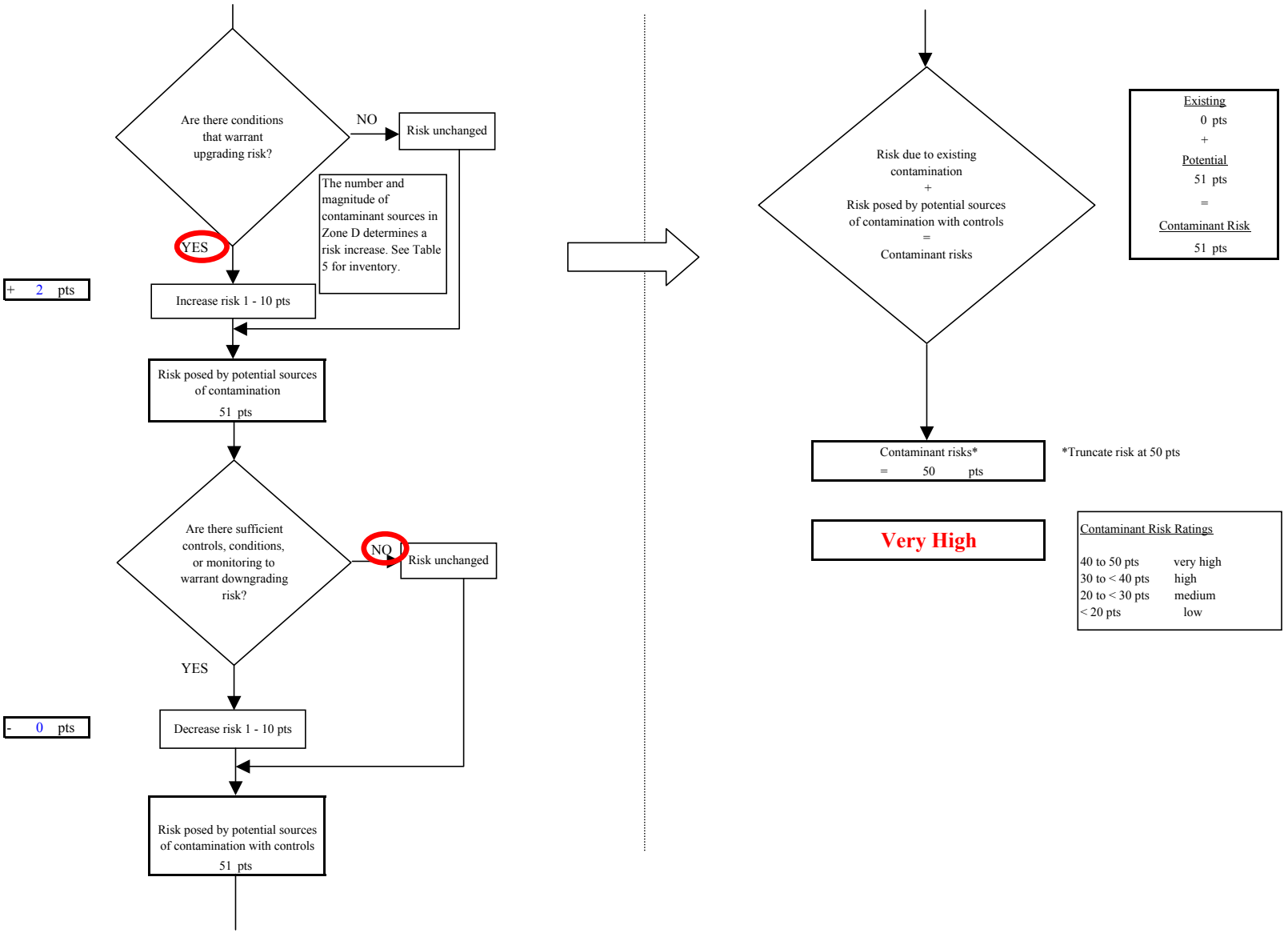


Chart 10. Vulnerability analysis for Bethel Water Complex (PWS No. 271075.001) - Heavy Metals, Cyanide and Other Inorganic Chemicals

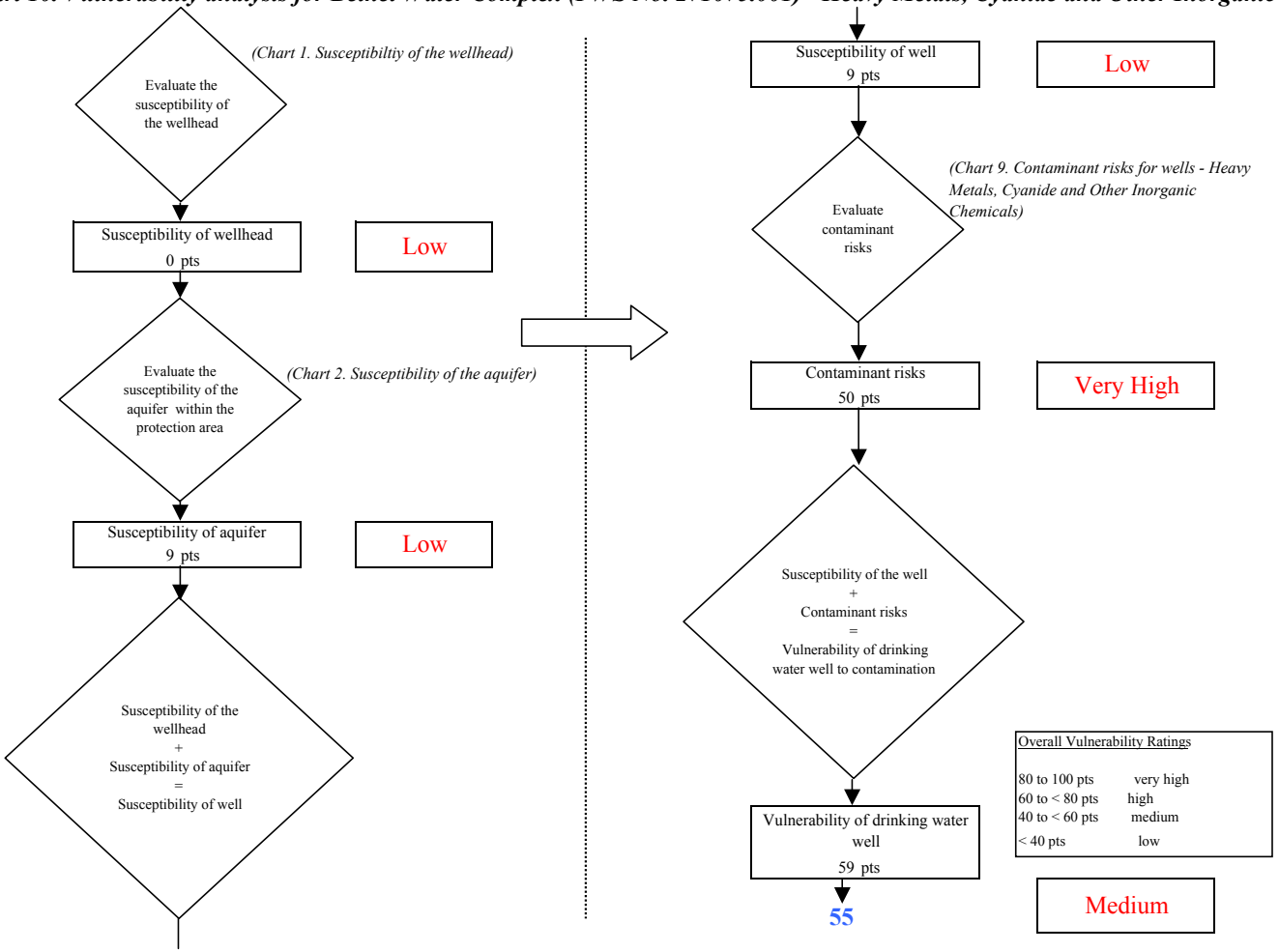


Chart 11. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Synthetic Organic Chemicals

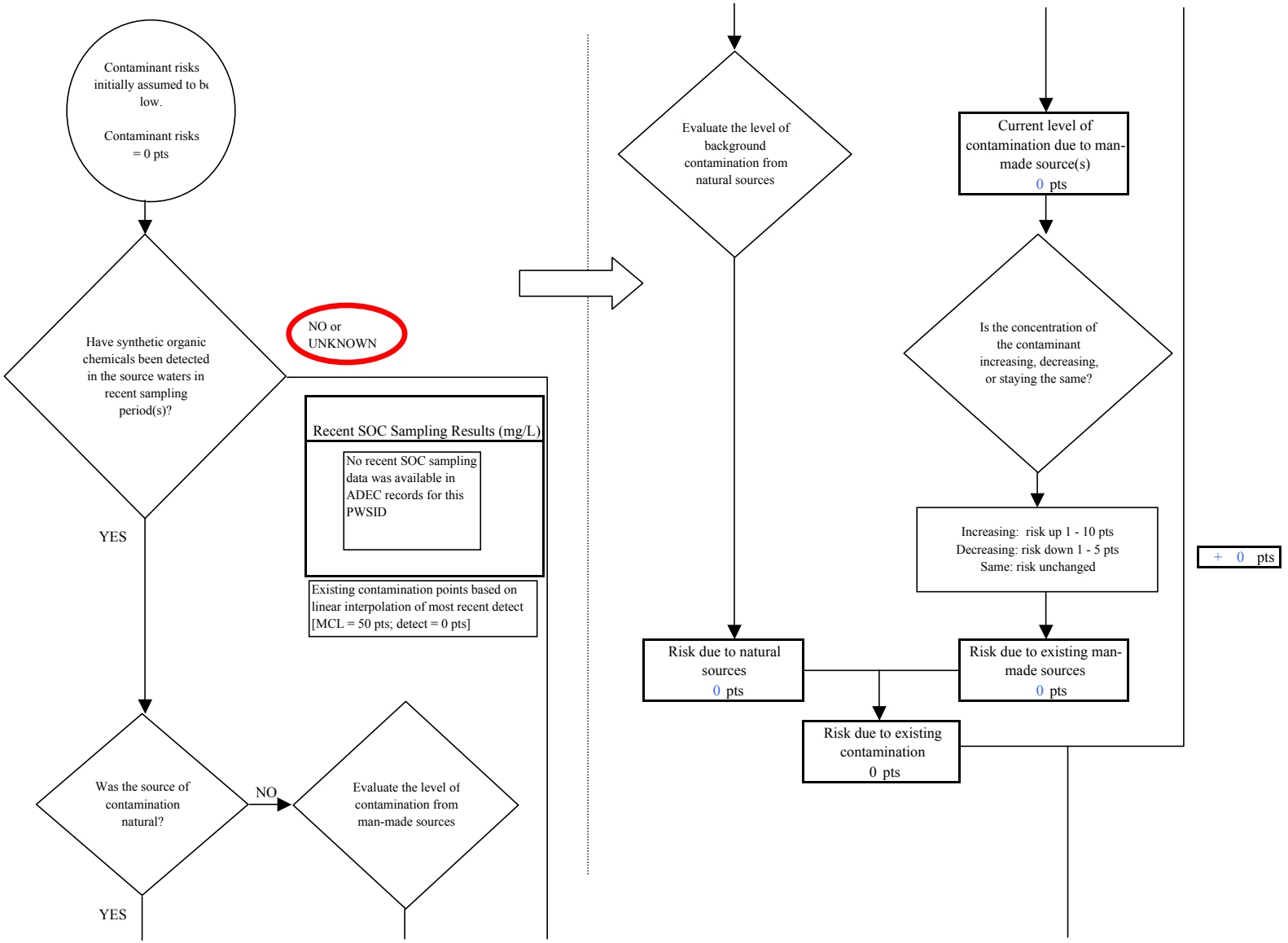
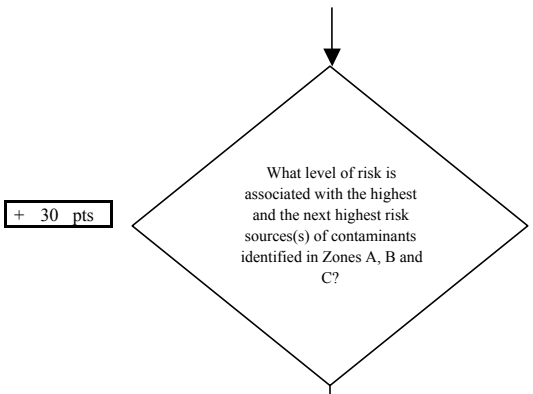


Chart 11. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Synthetic Organic Chemicals



+ 30 pts

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

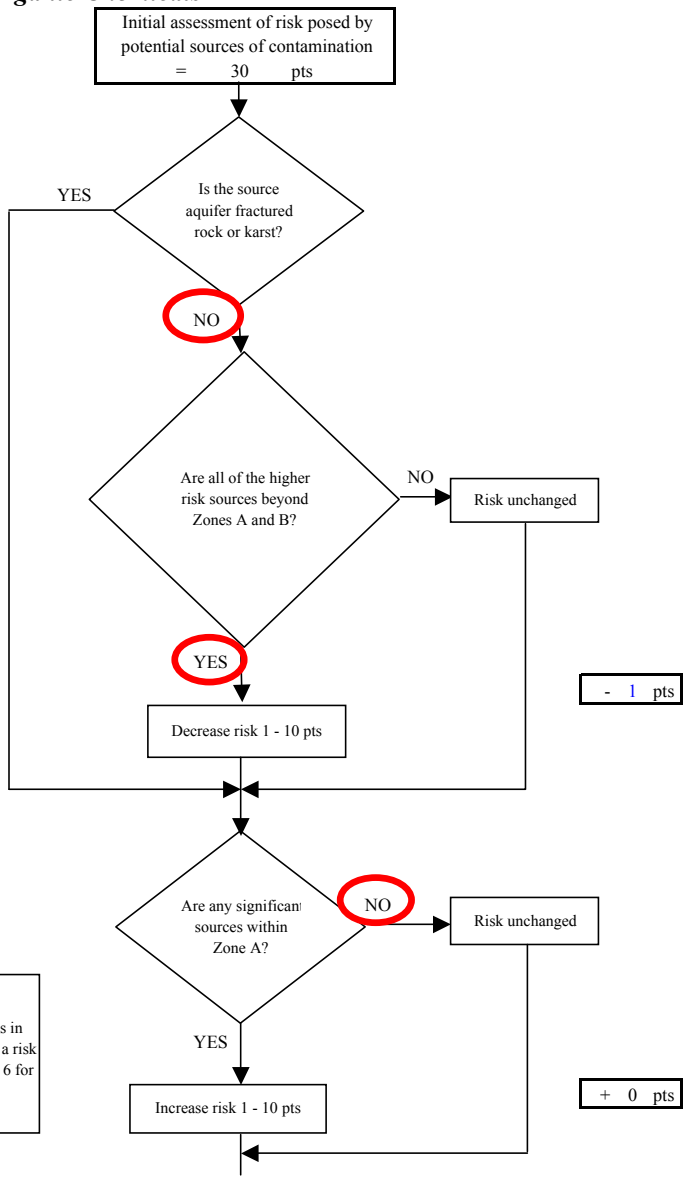
	Zone A	Zones B&C	Total
Very Highs(s)	0	0	0
High(s)	0	1	1
Medium(s)	0	1	1
Low(s)	0	3	3

	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 30

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.



- 1 pts

+ 0 pts

Chart 11. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Synthetic Organic Chemicals

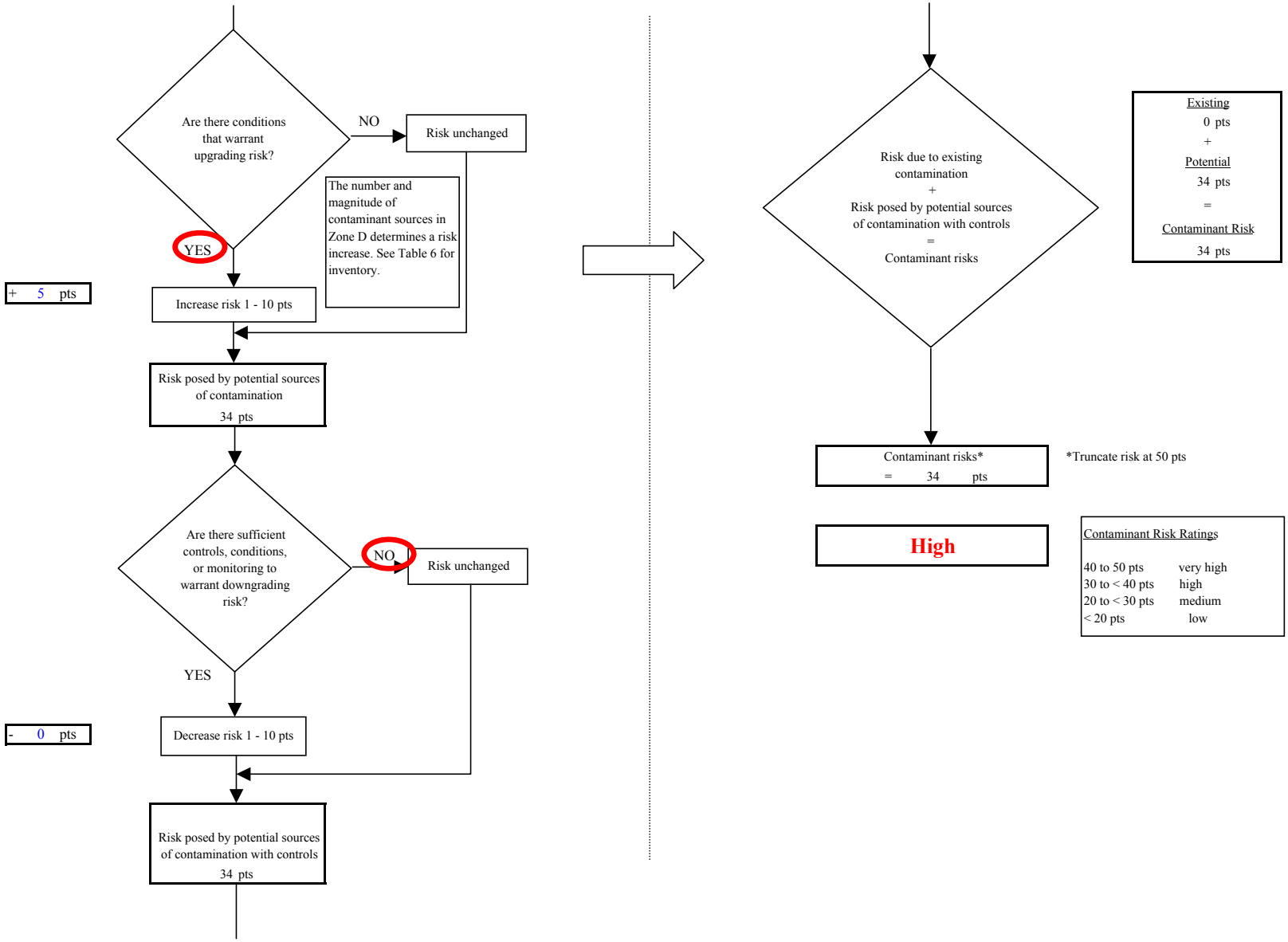


Chart 12. Vulnerability analysis for Bethel Water Complex (PWS No. 271075.001) - Synthetic Organic Chemicals

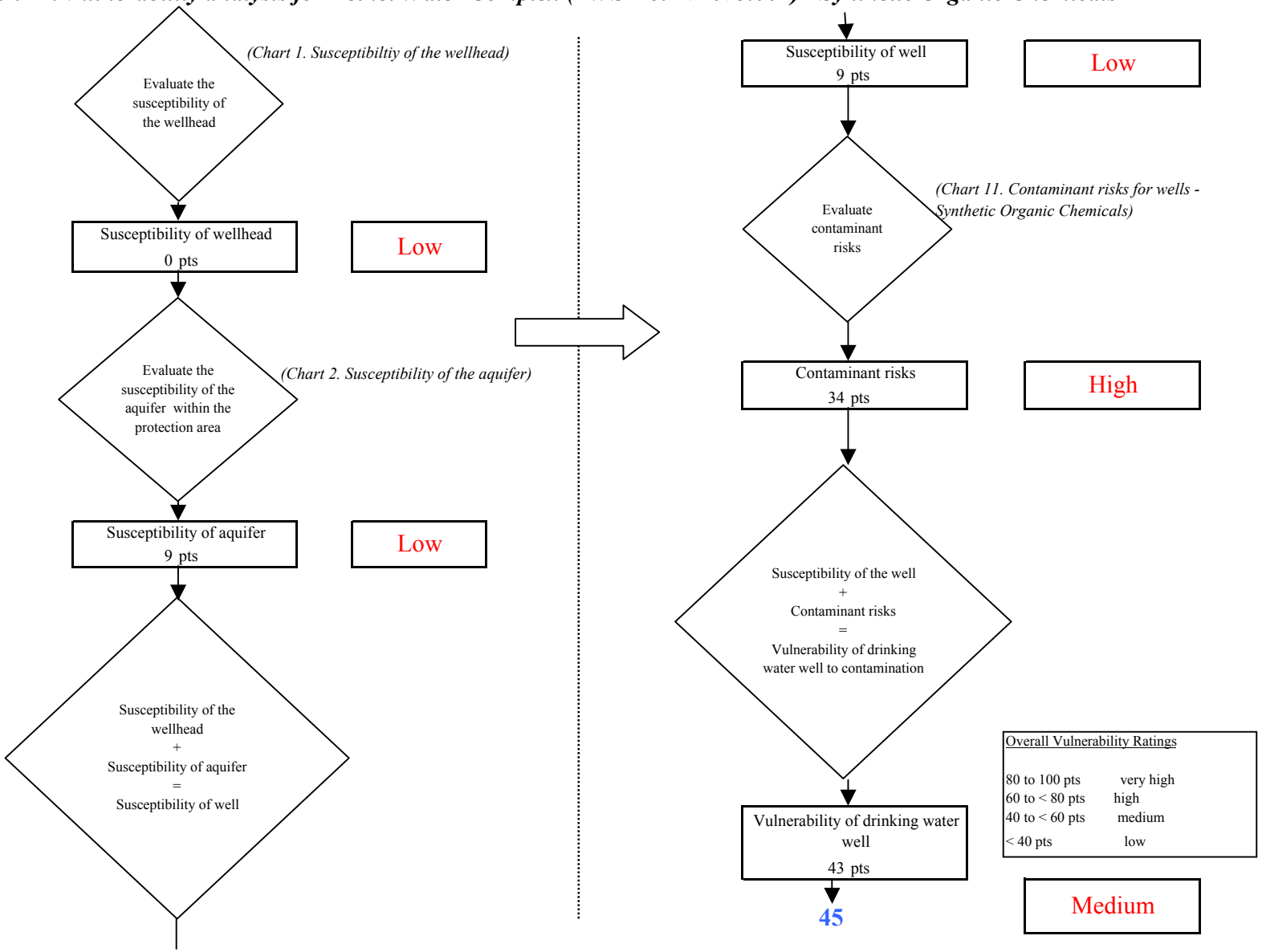


Chart 13. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Other Organic Chemicals

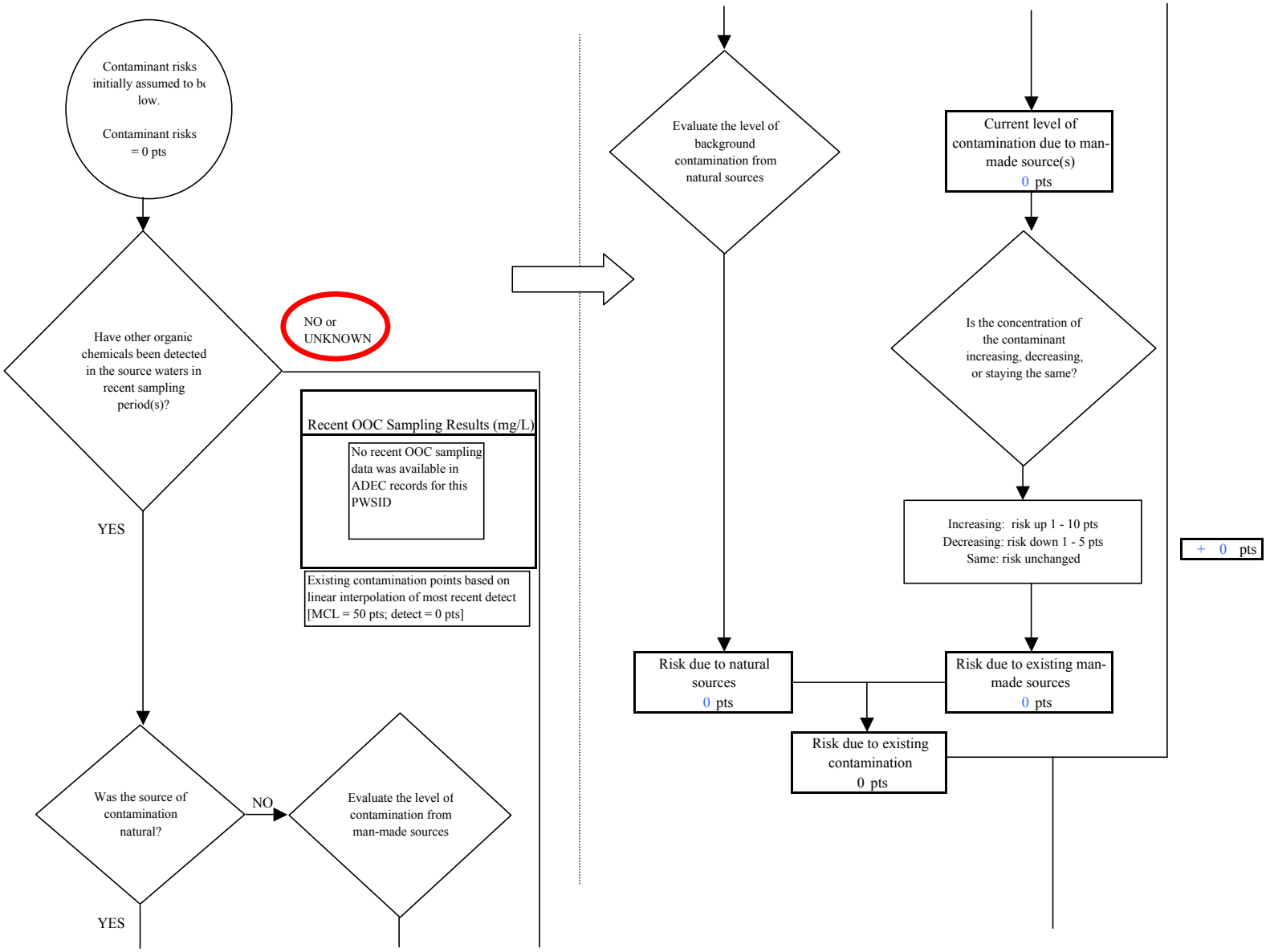


Chart 13. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Other Organic Chemicals

+ 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)	3	4	7
Low(s)	0	0	0

	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.

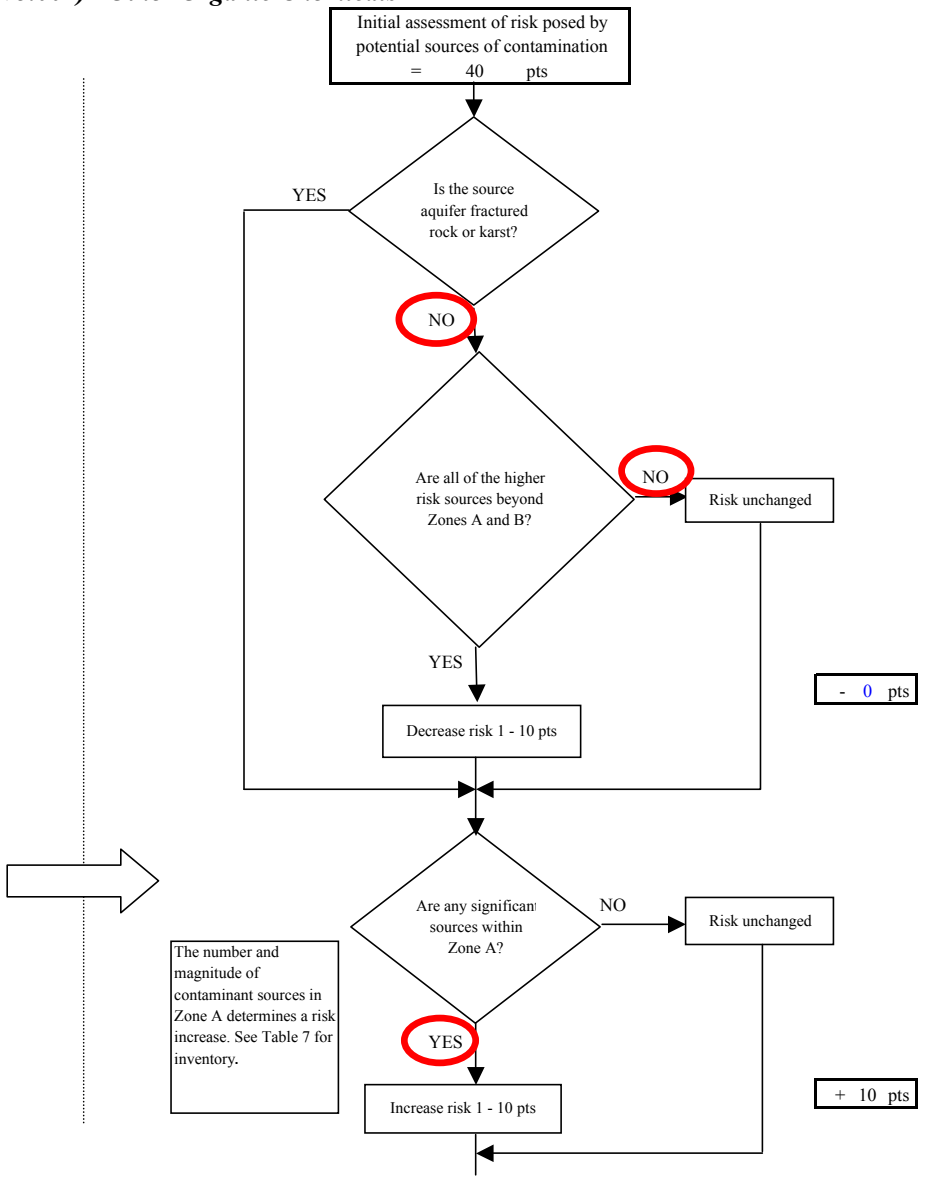


Chart 13. Contaminant risks for Bethel Water Complex (PWS No. 271075.001) - Other Organic Chemicals

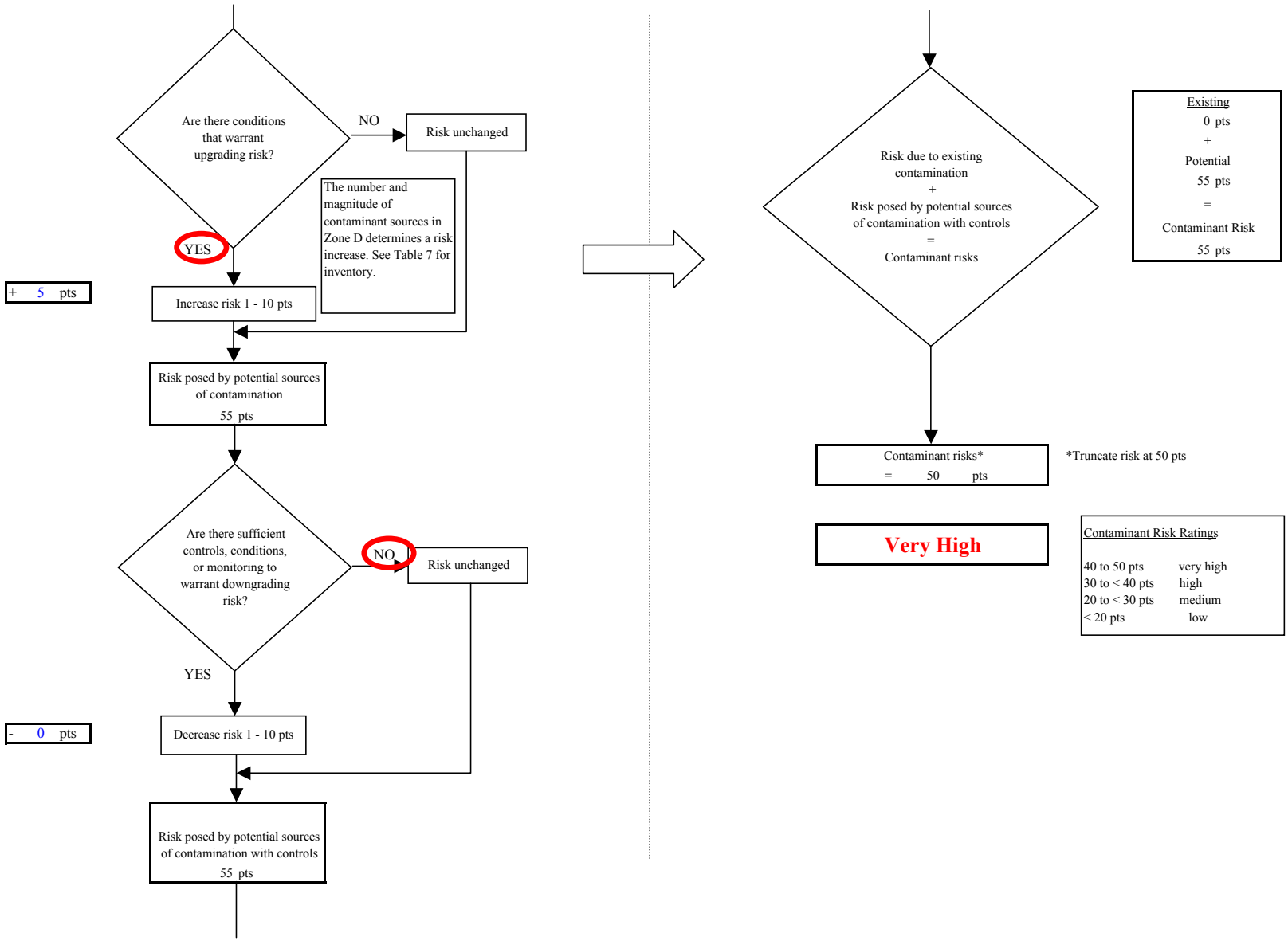


Chart 14. Vulnerability analysis for Bethel Water Complex (PWS No. 271075.001) - Other Organic Chemicals