Source Water Assessment for Borealis Alpha Water System Anchorage, Alaska

A Hydrogeologic Susceptibility and Vulnerability Analysis

DRINKING WATER PROTECTION PROGRAM REPORT 173
PWSID 211708.001

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Source Water Assessment for Borealis Alpha Water System's Source of Public Drinking Water, Anchorage, Alaska

A Hydrogeologic Susceptibility and Vulnerability Analysis

By Heather A. Hammond

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EXECUTIVE SUMMARY

The Public Water System for Borealis Alpha is a Class A (community) water system consisting of one well in the Anchorage area. Identified potential and current sources of contaminants for Borealis Alpha's public water system includes: approximately 36 acres of residential area, residential septic systems, paved roads, and recreation trails. These identified potential and existing sources of contamination are considered sources of bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other organic chemicals. Overall, the public water sources for Borealis Alpha received a vulnerability rating of **Low** for bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other organic chemicals.

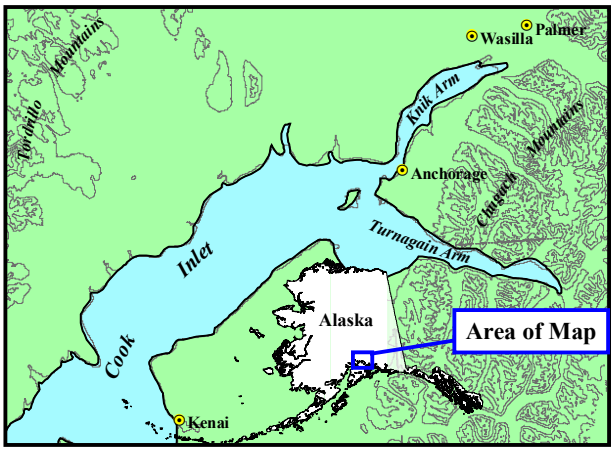

Figure 1. Index map showing the location of Anchorage, Alaska

INTRODUCTION

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

DESCRIPTION OF THE ANCHORAGE AREA, ALASKA

Location

Anchorage, located in southcentral Alaska, encompasses 1,698 square miles of land and 264 square miles of water. The area containing a majority of the urban development, commonly referred to as the Anchorage Bowl, encompasses approximately 180 square miles [*Partick, Brabets, and Glass, 1989*] and envelopes the low lands of the area. This area is bounded on the east by the Chugach Mountains and the north, west, and south by the Knik and Turnagain Arms of Cook Inlet (Figure 1). In recent times, urban development has extended eastward along the flanks of the Chugach Mountains. This area, known locally as the Anchorage Hillside, contains development at elevations exceeding 3,700 feet in elevation above sea level.

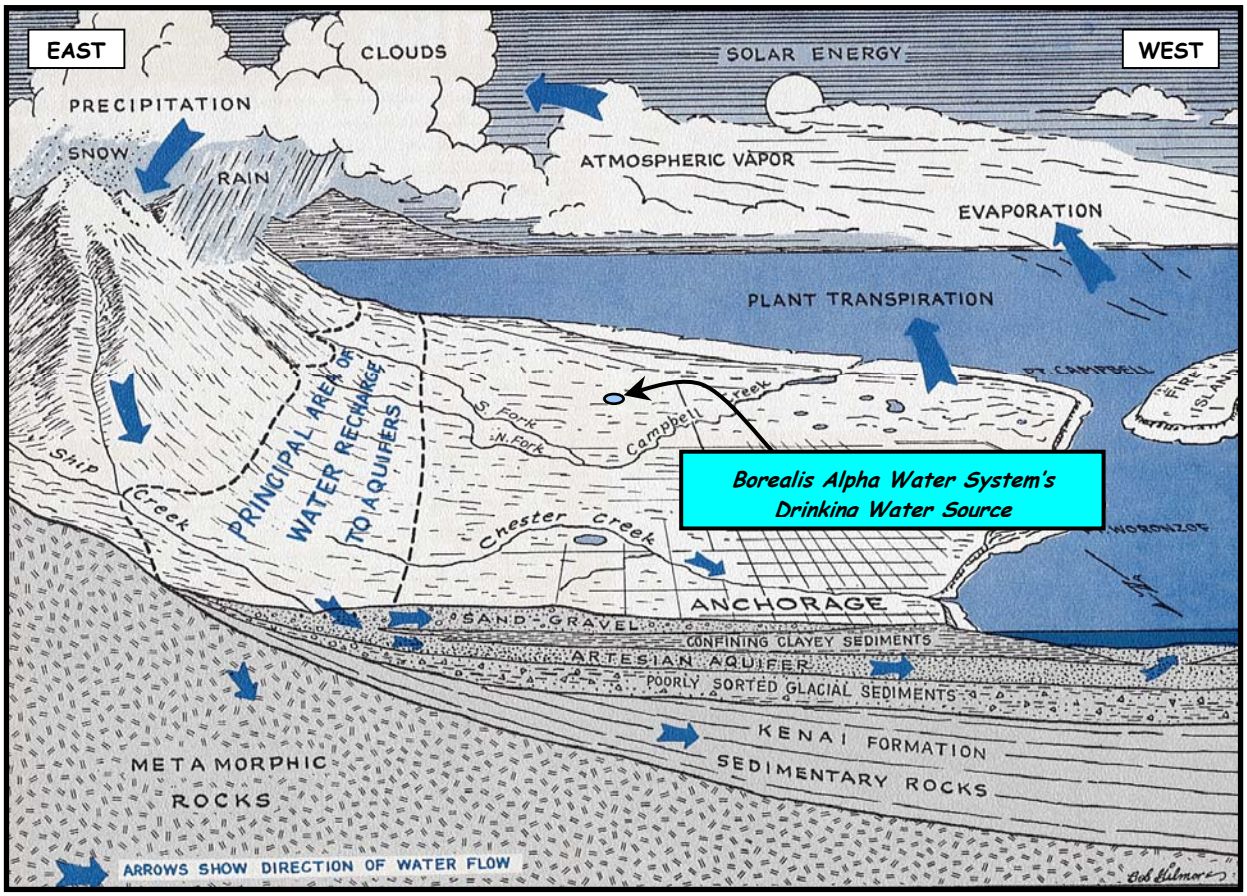

Figure 2. Generalized hydrologic cycle in the Anchorage area [*Barnwell, George, Dearborn,Weeks, and Zenone*, 1972].

Climate

The Anchorage area climate is somewhat transitional in that it does not experience large daily and annual temperature fluctuations like those experienced in the interior of Alaska nor does it experience high amounts of precipitation typified by gulf coast regions. Mean annual precipitation at the Anchorage International Airport is approximately 16 inches per year. On average, Anchorage receives a total snow accumulation of 69 inches per year. Precipitation generally increases inland toward the Chugach Mountains where annual precipitation may exceed 160 inches per year [*Barnwell, George, Dearborn, Weeks, and Zenone*, 1972]. Mean daily temperature ranges from 65^{o} F during July to 8^{o} F in January [*Western Regional Climate Center*, 2000].

Physiography and Groundwater Conditions

Surface elevations in the Anchorage area range from sea level at Knik and Turnagain Arms to well over 5,000 feet in the peaks that bound the area. Glacial moraine and outwash deposits primarily mantle the surface of the Anchorage Bowl.

The backbone of the Chugach Mountains is composed primarily of metamorphic marine and volcanic rocks (bedrock). These high peaks that bound Anchorage's east side are flanked with colluvium or slope deposits. These slope deposits eventually grade into the glacial and stream deposits at lower elevations in the Anchorage Bowl.

In the Anchorage area, two principal groundwater flow systems or aquifers exist (see Figure 2). The upper unconfined aquifer or water-table aquifer is separated from a lower confined aquifer system by layers of silty, clayey glacially derived sediments (confining layer) [*Ulery and Updike*, 1983]. The lower confined aquifer system consists of a series of hydrologically interconnected layers and lenses of gravel, sand and silt that, collectively, form the confined aquifer. The confining layer ranges from 0 to 270 feet thick throughout the Anchorage area and generally thins with increasing distance from Cook Inlet, thus pinching out at the mountain front [*Patrick, Brabets, and Glass*, 1989].

Water enters or recharges these two aquifer systems in several different ways. Along the front of the Chugach

Mountains, groundwater seeps from fractures in bedrock into the sediments. At these higher elevations, rain and snowmelt also enter the sediments. This area along the mountain front is considered the principal recharge area for wells in the Anchorage area. Precipitation in the low lands may also percolate directly into the ground. Lastly, aquifers may also be recharged by streams where surface water percolates into surrounding permeable sediments (losing reaches of streams). Groundwater flow in the confined aquifer is generally east to west from the mountain front toward Cook Inlet and Turnagain Arm, except in areas where the direction of flow is influenced by large municipal or industrial production wells. The direction of groundwater flow in the upper unconfined aquifer is more variable due to the influence from surfacial topography as well as its close connection with surface water bodies.

BOREALIS ALPHA'S PUBLIC DRINKING WATER SYSTEM

Borealis Alpha Public Drinking Water System is a Class A (community) water system, which is owned and operated by The Borealis Homeowners Association. The system consists of one well, which is located within the cul-de-sac off of Alpha Circle (T12N, R3W, Section 22), at an elevation of approximately 500 feet above sea level (see Figure 3).

According to the most recent Sanitary Survey (10/11/96) the area surrounding the well is properly drained and protected against flooding by a well house with the ground surface sloping away from the well site. Installation of the well occurred January, 1976 to a total depth of 154 feet below ground surface. The well was completed in a 6" well casing and has a static water level of 75 feet below ground surface. It is unknown whether the well was grouted at the time of drilling as no formal well log is available. Proper grouting provides added protection against contaminants travelling along the well casing and into source waters.

This system operates year round and serves 30 residents through 10 service connections.

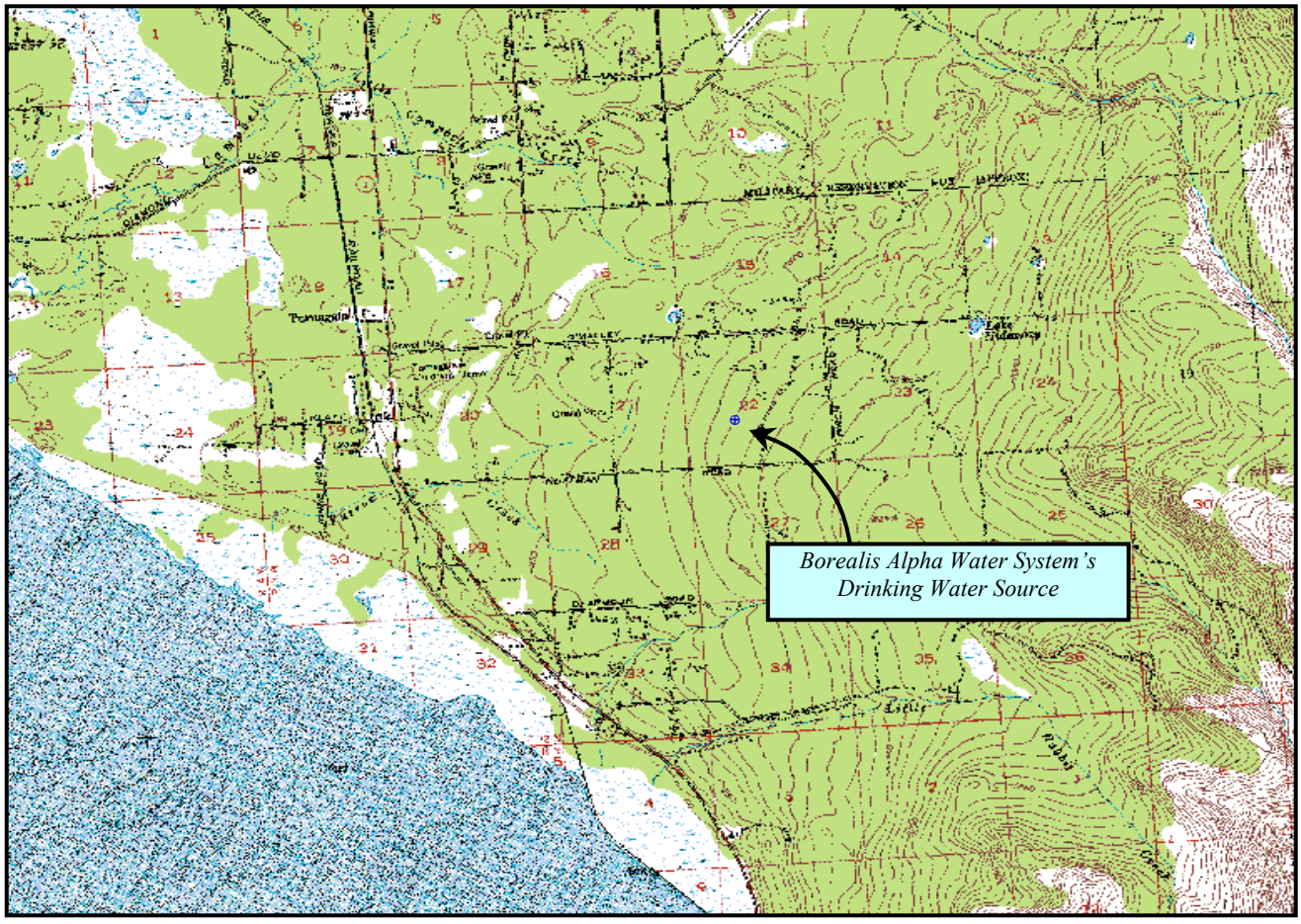

Figure 3. Map showing the location of the drinking water sources for Borealis Alpha Water System [Base: USGS Anchorage A8].

ASSESSMENT AND PROTECTION AREA FOR BOREALIS ALPHA WATER SYSTEM'S DRINKING WATER SOURCE

The Drinking Water Protection and Assessment Area that has been established for Borealis Alpha Water System's source of drinking water is the area that is most sensitive to contamination. This area has served as a basis for assessing the risk of the drinking water source to contamination. The zones around the drinking water source outline the most critical area for the preservation of the quality of the drinking water for this system. For simplicity, this area will be known as your Drinking Water Protection Area and will serve as the focus for voluntary protection efforts.

Conceptually, groundwater enters the aquifer systems along the front range of the Chugach Mountains (Figure 2) and flows toward Cook Inlet. An analytical calculation was used to determine the size and shape of the area that contributes water to the well. The input parameters describing the attributes of the aquifer in this calculation were adopted from the U.S. Geological Survey [*Patrick, Brabets, and Glass, 1989*]. This analytical calculation was used as a guide as the first step in establishing the protection area for each public drinking water source in Anchorage. Additional methods were further employed to take into account any uncertainties in groundwater flow and aquifer characteristics to arrive at meaningful and conservative protection areas with respect to public health (Please refer to the Guidance Manual for Class A Public Water Systems for additional information).

The Drinking Water Protection Areas established for wells by the Alaska Department of Environmental Conservation are separated into zones. These zones correspond to a time-of-travel. Time-of-travel is the time required for water to move in the saturated zone of the ground from a specific point to the well. The Drinking Water Protection Area for Borealis Alpha Water System contains four zones, Zone A through Zone D (See Map 1 in Appendix A). Zone A corresponds to the area between the wells and the distance equal to ¼ of the distance of the 2-year time-of-travel. Depending on where a contaminant source is located within Zone A, travel time for a contaminant to the wells may be on the order of several days to several hours. Zone A also extends downgradient from the wells to take into account the area of the aquifer that is influenced by pumping of the wells. Zone B corresponds to a time-of-travel of less than two years. Zones C and D correspond to those areas between 5 years and 10 years time-of-travel, respectively.

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 Drinking Water Protection Area for Borealis Alpha Water System. This survey was completed through a search of agency records and other publicly available information. Potential sources of contamination to drinking water supplies cover a wide range of categories and types. Potential drinking water contaminants are found within agricultural, residential, commercial, and industrial areas, but can also occur within areas that have little or no development.

For the basis of this assessment and all Class A public water 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

Maps 2 through 4 in Appendix C depict the Contaminant Source Inventory for Borealis Alpha Water System. Table 1 in Appendix B lists the inventoried potential sources of contamination within Zones A through D. Below is a summary of the contaminant sources inventoried within the Drinking Water Protection Area for Borealis Alpha Water System:

- Approximately 36 acres of residential area;
- residential septic systems;
- paved roads;
- recreation trails.

These potential and existing contaminant sources present risk for all six categories of drinking water contaminants for Borealis Alpha Water System's source of public drinking water.

RANKING OF CONTAMINANT RISKS

Potential and existing sources of contamination have been identified, sorted, and ranked according to what type and level of risk they represent. Ranking of contaminant risks for a "potential" or "existing" source of contamination is a function of toxicity and volumes of specific

contaminants associated with that source. Contaminant risks are further a function of the number and density of those types of contaminant sources as well as the proximity of those sources to the public drinking water wells.

VULNERABILITY OF BOREALIS ALPHA WATER SYSTEM'S DRINKING WATER SOURCE

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

- natural susceptibility; and
- contaminant risks.

Each of the six categories of drinking water contaminants have been analyzed and an overall vulnerability score of 0 to 100 ultimately assigned:

Natural Susceptibility (0 – 50 points)

+

Contaminant Risks (0 – 50 points)

=

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

A score for the Natural Susceptibility is achieved by analyzing the properties of the well and the aquifer.

Susceptibility of the Wellhead (0 – 25 Points)
+
Susceptibility of the Aquifer (0 – 25 Points)

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

No well log was available for the source of drinking water serving Borealis Alpha Water System. Therefore, the geologic information reported was gathered from a Waiver of Separation Distance produced by Alaska Water and Wastewater. Well logs were analyzed within a ¼ mile distance of the well serving Borealis Alpha. Assuming that the geological profile is similar it is suspected that the well was completed in a confined aquifer. There is a strata of silt and/or clay from 37 to 71 feet. Groundwater isn't encountered in the area until approximately 100 feet below land surface. Static water level in Borealis Alpha's well was recorded at 75 feet below land surface. This is an indication that the aquifer is confined. This confining layer may provide a protective barrier against the movement of contaminants in the subsurface. However, near the base of the Chugach Mountains, these clay layers tend to be discontinuous and thin toward the mountains. Therefore, contaminants that enter the subsurface near the base of the mountains may enter the confined aquifer uninhibited by the absence of any protective layer.

Combining the susceptibility of the wellhead and the aquifer to contamination leads to a score (0 – 50 points) and rating of overall Susceptibility of the well to contamination (See Appendix D). Table 1 depicts the overall Susceptibility score and rating for the sources of public drinking water serving Borealis Alpha Water System.

Table 1. Natural Susceptibility - Susceptibility of the Wellheads and Aquifer to Contamination

	Score	Rating
Susceptibility of the Wellhead	5	Low
Susceptibility of the Aquifer	16	High
Natural Susceptibility	21	Medium

Contaminant risks to a drinking water source depend on the type, number or density, and distribution of contaminant sources. A score (0 – 50 points) and rating of Contaminant Risks (See Appendix D) is assigned based on the findings of the Contaminant Source Inventory (See Appendix B - Table 1 – Table 7). This portion of the analysis examines any existing or historical contamination that has been detected at the drinking water source through routine sampling. It also reviews contamination that has or may have occurred but has not arrived or been detected at the either well. Table 2 summarizes the Contaminant Risks for each category of drinking water contaminants.

Table 2. Contaminant Risks to Borealis Alpha Water System's Public Drinking Water Source

Contaminant Risks	Score	Rating
Bacteria and Viruses	12	Low
Nitrates and/or Nitrites	16	Low
Volatile Organic Chemicals	12	Low
Heavy Metals, Cyanide, And Other Inorganic Chemicals	12	Low
Synthetic Organic Chemicals	12	Low
Other Organic Chemicals	12	Low

Appendix D contains fourteen charts, which together form the 'Vulnerability Analysis' for a Class A public drinking water system. 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. Lastly, Chart 4 contains the 'Vulnerability Analysis for Bacteria and Viruses'. Charts 5 through 14 contain the Contaminant Risks and Vulnerability Analysis for nitrates and nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other organic chemicals, respectively.

Vulnerability of drinking water sources to contamination is the combination of susceptibility of the aquifer and the well with contaminant risks. Table 3 contains the overall vulnerability scores (0 – 100) and ratings for each of the six categories of drinking water contaminants (See Appendix D). Note: scores are rounded off to the nearest five.

Table 3. Overall Vulnerability of Borealis Alpha Water System's Public Drinking Water Source to Contamination by Category

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

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, heavy metals, synthetic organic chemicals, and other organic chemicals, respectively.

Nitrates and/or nitrites are found in natural background concentration at this site, as elsewhere throughout Alaska. Nitrate concentrations in uncontaminanted groundwater are typically less than 2 milligrams per liter (mg/L) and are derived primarily from the decomposition of organic matter in soils [Wang, Strelakos, Jokela, 2000].

Sampling history for Borealis Alpha Water System's well indicates that low concentrations of nitrates have been detected (See Chart 5 – Contaminant Risks for Nitrates and/or Nitrites in Appendix D). Existing nitrate concentration is approximately 8% of the Maximum Contaminant Level or MCL. The MCL is the maximum level of contaminant that is allowed to exist in drinking water and still be consumed by humans without harmful health effects. Due to the high solubility and weak retention by soil, nitrates are very mobile, moving at approximately the same rate as water. Though existing nitrate contamination was detected at the site, concentrations remain at very safe levels with respect to human health.

It is unknown how much of the existing nitrate concentration can be attributed to natural or human-made sources. The most resent Sanitary Survey (10/11/96) notes that a number of septic systems in the Borealis Alpha Subdivision are less than 200 feet from the well. Residential septic systems, because of their effluent discharge, pose the greatest potential contaminant risk to the Borealis Alpha Water System for bacteria and viruses and nitrates and or nitrites. Review of the historical

sampling data indicates that the surrounding septic systems have not impacted the groundwater source.

Paved roads within the protection area are the most significant source of potential volatile organic chemical contamination to Borealis Alpha's drinking water source.

Residential areas within the protection area are the most significant source of potential contamination, from heavy metals, synthetic organic chemicals and other organic chemicals, to the well.

SUMMARY

A *Source Water Assessment* has been completed for the sources of public drinking water serving Borealis Alpha Water System. The overall vulnerability of this source to contamination is **Low** for bacteria and viruses, nitrates and/or nitrites, volatile organic chemicals, heavy metals, synthetic organic chemicals, and other organic chemicals. This assessment of contaminant risks can be used as a foundation for local voluntary protection efforts as well as a basis for the continuous efforts on the part of Borealis Alpha Water System 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 Borealis Alpha Water System 's public drinking water source.

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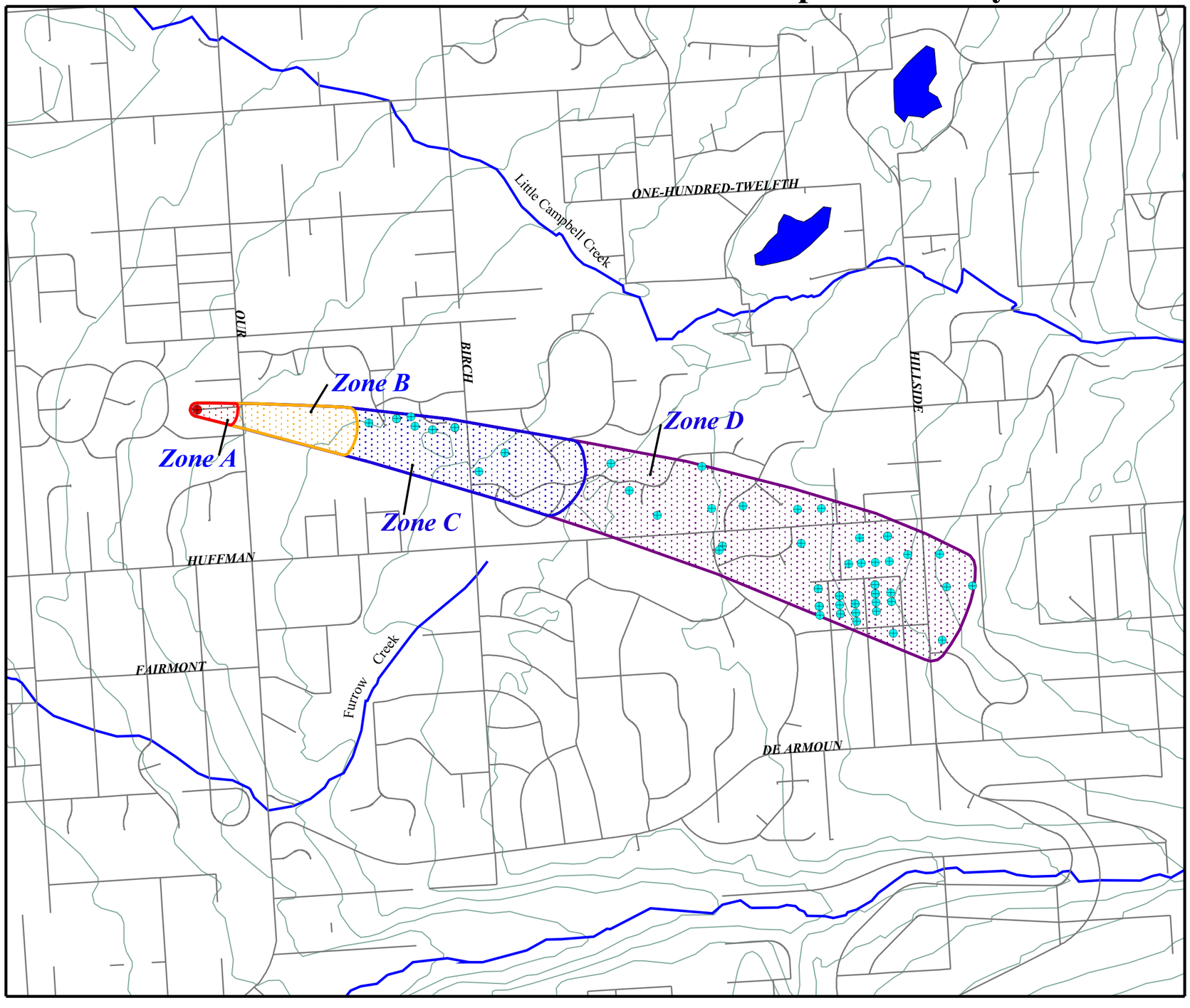
APPENDIX A

Borealis Alpha Water System's Drinking Water Protection Area

Drinking Water Protection Area for Borealis Alpha Water System



- Borealis Alpha DW Well
- Private/Public DW Wells

Zone A Protection Area
- Several Months Travel Time

Zone B Protection Area
- Less Than 2 Years Travel Time

Zone C Protection Area
- Less Than 5 Years Travel Time

Zone D Protection Area
- Less Than 10 Years Travel Time

- Roads
- MOA Lakes
- Anchorage Streams
- Elevation Contours

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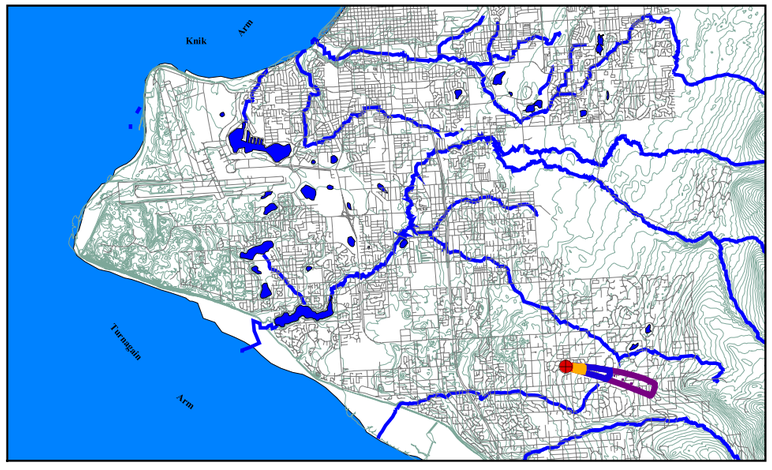

2000 0 2000 4000 Feet

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Map 1

APPENDIX B

Contaminant Source Inventory and Risk Ranking for Borealis Alpha Water System

Table 1

Contaminant Source Inventory for ***Borealis Alpha Water System***

PWSID 211708.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Location*	*Map Number*	*Comments*
Residential Areas	R01	R1-1	A	Residential areas located within Zone A	2	Approximately 2 acres of residential area.
Septic systems (serves one or more single-family homes)	R02	R2-1	A	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-2	A	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-3	A	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-4	A	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-5	A	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-6	A	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-7	A	Along Alpha Circle	3	
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Alpha Circle	2	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Our Road	2	
Residential Areas	R01	R1-2	C	Residentail areas located within Zone C	2	Approximately 34 acres of residential area.
Highways and roads, paved (cement or asphalt)	X20	X20-3 - 9	C	All roads located within Zone C	2	
Dog walking areas/foot trails	X46	X46-1	C	Trail along west side of Birch Road	2	
Dog walking areas/foot trails	X46	X46-2	C	Trail along east side of Birch Road	2	

Table 2

Contaminant Source Inventory and Risk Ranking for Borealis Alpha Water System Sources of Bacteria and Viruses

PWSID 211708.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Overall Rank after Analysis*	*Location*	*Map Number*	*Comments*
Residential Areas	R01	R1-1	A	Low	1	Residential areas located within Zone A	2	Approximately 2 acres of residential area.
Septic systems (serves one or more single-family homes)	R02	R2-1	A	Low	2	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-2	A	Low	3	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-3	A	Low	4	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-4	A	Low	5	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-5	A	Low	6	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-6	A	Low	7	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-7	A	Low	8	Along Alpha Circle	3	
Residential Areas	R01	R1-2	C	Low	9	Residentail areas located within Zone C	2	Approximately 34 acres of residential area.
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Low	10	Alpha Circle	2	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Low		Our Road	2	
Highways and roads, paved (cement or asphalt)	X20	X20-3 - 9	C	Low		All roads located within Zone C	2	
Dog walking areas/foot trails	X46	X46-1	C	Low		Trail along west side of Birch Road	2	
Dog walking areas/foot trails	X46	X46-2	C	Low		Trail along east side of Birch Road	2	

Table 3

Contaminant Source Inventory and Risk Ranking for Borealis Alpha Water System Sources of Nitrates/Nitrites

PWSID 211708.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Overall Rank after Analysis*	*Location*	*Map Number*	*Comments*
Residential Areas	R01	R1-1	A	Low	1	Residential areas located within Zone A	2	Approximately 2 acres of residential area.
Septic systems (serves one or more single-family homes)	R02	R2-1	A	Low	2	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-2	A	Low	3	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-3	A	Low	4	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-4	A	Low	5	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-5	A	Low	6	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-6	A	Low	7	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-7	A	Low	8	Along Alpha Circle	3	
Residential Areas	R01	R1-2	C	Low	9	Residentail areas located within Zone C	2	Approximately 34 acres of residential area.
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Low	10	Alpha Circle	2	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Low		Our Road	2	
Highways and roads, paved (cement or asphalt)	X20	X20-3 - 9	C	Low		All roads located within Zone C	2	
Dog walking areas/foot trails	X46	X46-1	C	Low		Trail along west side of Birch Road	2	
Dog walking areas/foot trails	X46	X46-2	C	Low		Trail along east side of Birch Road	2	

Table 4

Contaminant Source Inventory and Risk Ranking for Borealis Alpha Water System Sources of Volatile Organic Chemicals

PWSID 211708.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Overall Rank after Analysis*	*Location*	*Map Number*	*Comments*
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Low	1	Alpha Circle	2	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Low	2	Our Road	2	
Residential Areas	R01	R1-1	A	Low	3	Residential areas located within Zone A	2	Approximately 2 acres of residential area.
Septic systems (serves one or more single-family homes)	R02	R2-1	A	Low	4	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-2	A	Low	5	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-3	A	Low	6	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-4	A	Low	7	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-5	A	Low	8	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-6	A	Low	9	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-7	A	Low	10	Along Alpha Circle	3	
Residential Areas	R01	R1-2	C	Low		Residentail areas located within Zone C	2	Approximately 34 acres of residential area.
Highways and roads, paved (cement or asphalt)	X20	X20-3 - 9	C	Low		All roads located within Zone C	2	

Table 5

Contaminant Source Inventory and Risk Ranking for Borealis Alpha Water System

Sources of Heavy Metals, Cyanide and Other Inorganic Chemicals

PWSID 211708.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Overall Rank after Analysis*	*Location*	*Map Number*	*Comments*
Residential Areas	R01	R1-1	A	Low	1	Residential areas located within Zone A	2	Approximately 2 acres of residential area.
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Low	2	Alpha Circle	2	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Low	3	Our Road	2	
Septic systems (serves one or more single-family homes)	R02	R2-1	A	Low	4	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-2	A	Low	5	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-3	A	Low	6	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-4	A	Low	7	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-5	A	Low	8	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-6	A	Low	9	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-7	A	Low	10	Along Alpha Circle	3	
Residential Areas	R01	R1-2	C	Low		Residentail areas located within Zone C	2	Approximately 34 acres of residential area.
Highways and roads, paved (cement or asphalt)	X20	X20-3 - 9	C	Low		All roads located within Zone C	2	

Table 6

Contaminant Source Inventory and Risk Ranking for Borealis Alpha Water System Sources of Synthetic Organic Chemicals

PWSID 211708.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Overall Rank after Analysis*	*Location*	*Map Number*	*Comments*
Residential Areas	R01	R1-1	A	Low	1	Residential areas located within Zone A	2	Approximately 2 acres of residential area.
Residential Areas	R01	R1-2	C	Low	2	Residentail areas located within Zone C	2	Approximately 34 acres of residential area.
Septic systems (serves one or more single-family homes)	R02	R2-1	A	Low	3	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-2	A	Low	4	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-3	A	Low	5	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-4	A	Low	6	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-5	A	Low	7	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-6	A	Low	8	Along Alpha Circle	3	
Septic systems (serves one or more single-family homes)	R02	R2-7	A	Low	9	Along Alpha Circle	3	

Table 7

Contaminant Source Inventory and Risk Ranking for Borealis Alpha Water System Sources of Other Organic Chemicals

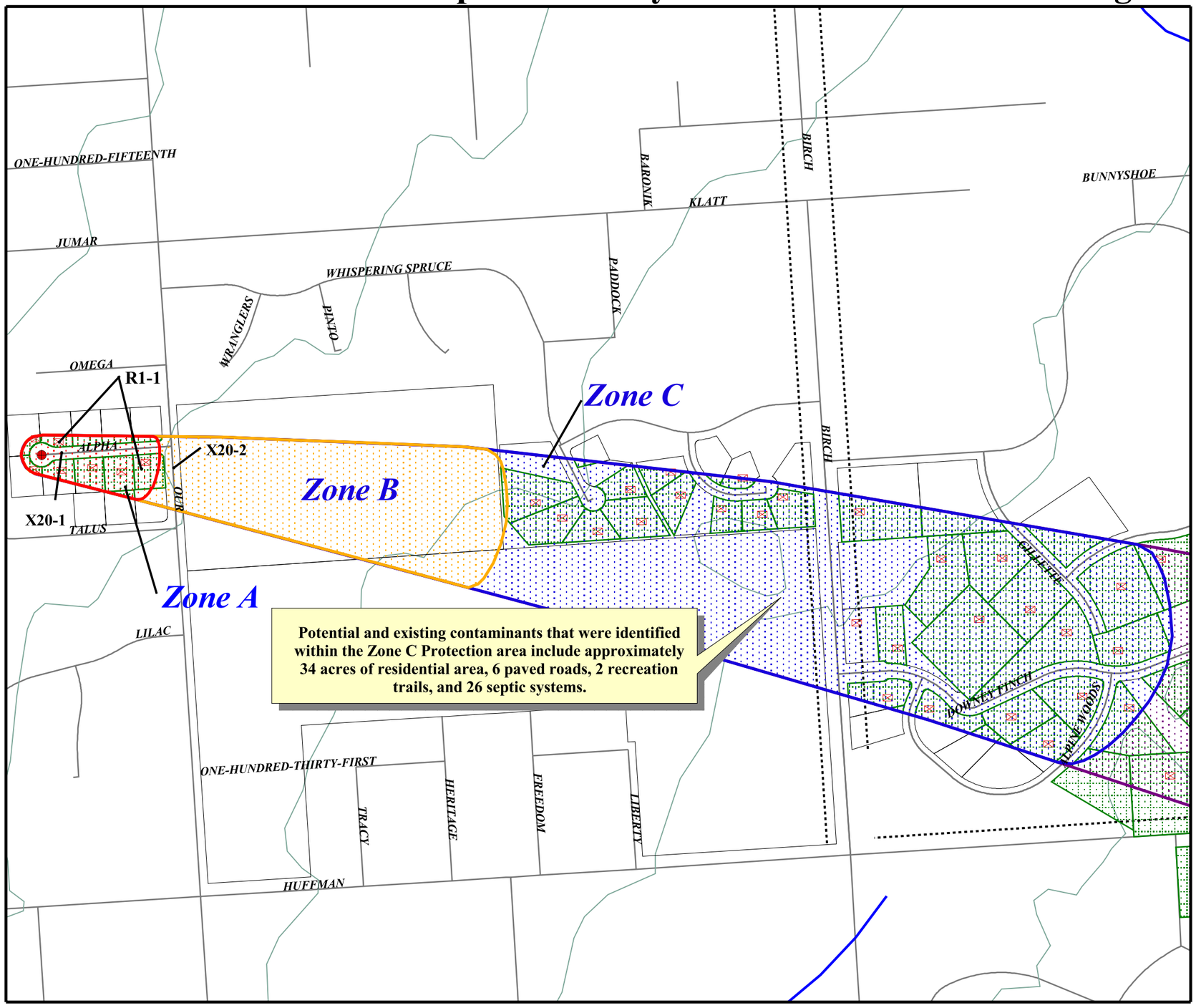
PWSID 211708.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Overall Rank after Analysis*	*Location*	*Map Number*	*Comments*
Residential Areas	R01	R1-1	A	Low	1	Residential areas located within Zone A	2	Approximately 2 acres of residential area.
Residential Areas	R01	R1-2	C	Low	2	Residentail areas located within Zone C	2	Approximately 34 acres of residential area.
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Low	3	Alpha Circle	2	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Low	4	Our Road	2	
Highways and roads, paved (cement or asphalt)	X20	X20-3 - 9	C	Low	5	All roads located within Zone C	2	

APPENDIX C

Borealis Alpha Water System's Drinking Water Protection Area and Potential & Existing Contaminant Sources

Drinking Water Protection Area for
Borealis Alpha Water System and Potential & Existing Contaminant Sources



- Borealis Alpha DW Well

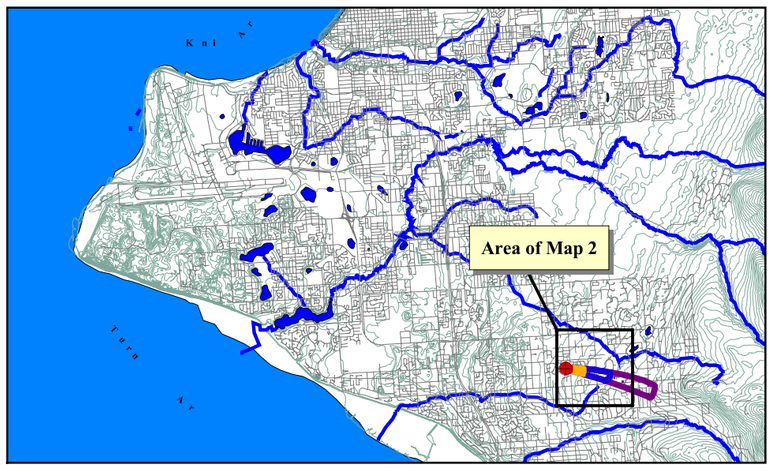
Zone A Protection Area
- Several Months Travel Time

Zone B Protection Area
- Less Than 2 Years Travel Time

Zone C Protection Area
- Less Than 5 Years Travel Time

Zone D Protection Area
- Less Than 10 Years Travel Time
- Lawns and Gardens (R1)
- MOA Land Parcels
- Roads (X20)
- Septic Systems (R2)
- Trails (X46)
- MOA Lakes
- Anchorage Streams
- Elevation Contours

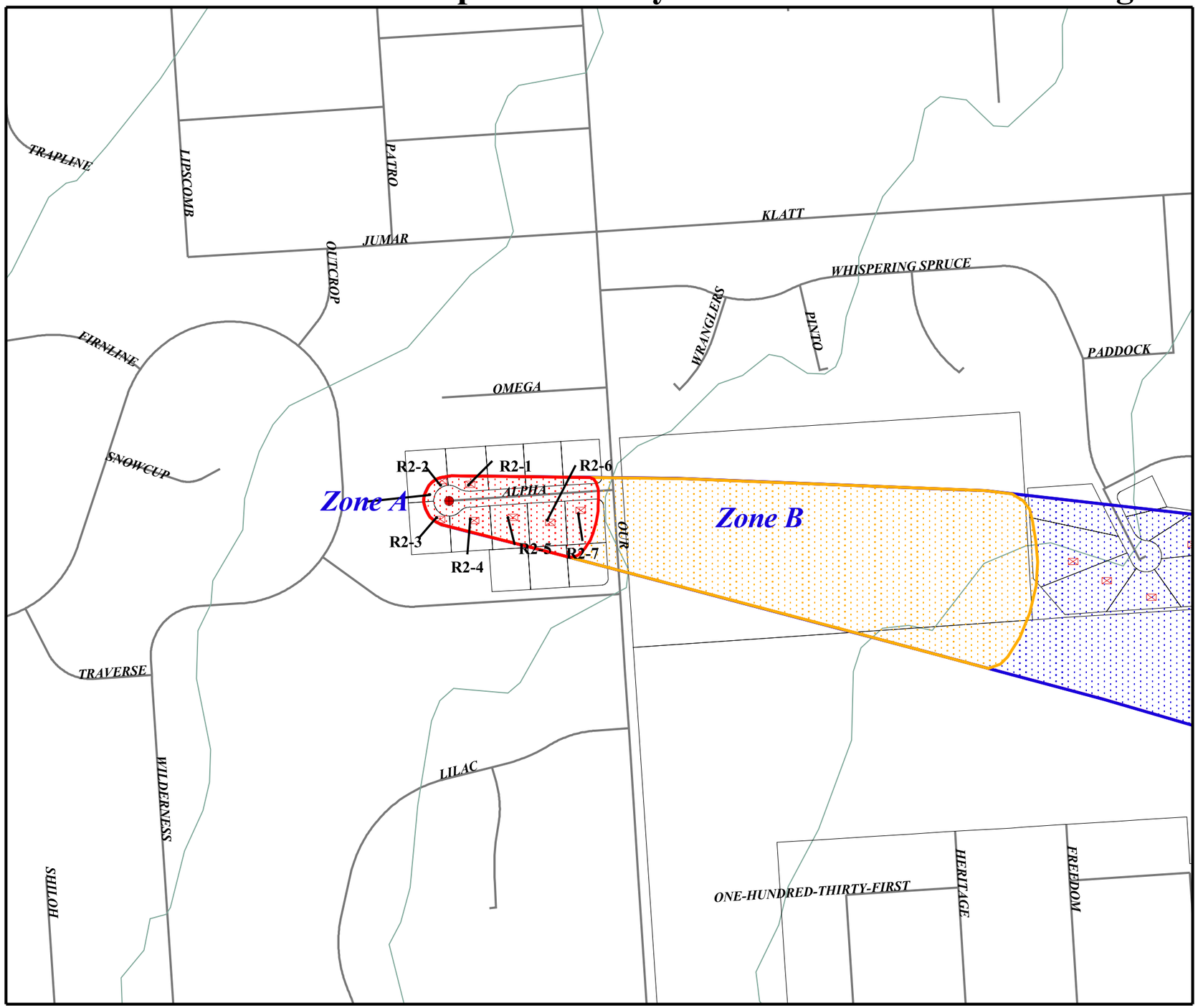
N
W E
S



PWSID 211708.001

Map 2

Drinking Water Protection Area for
Borealis Alpha Water System and Potential & Existing Contaminant Sources



- Borealis Alpha DW Well

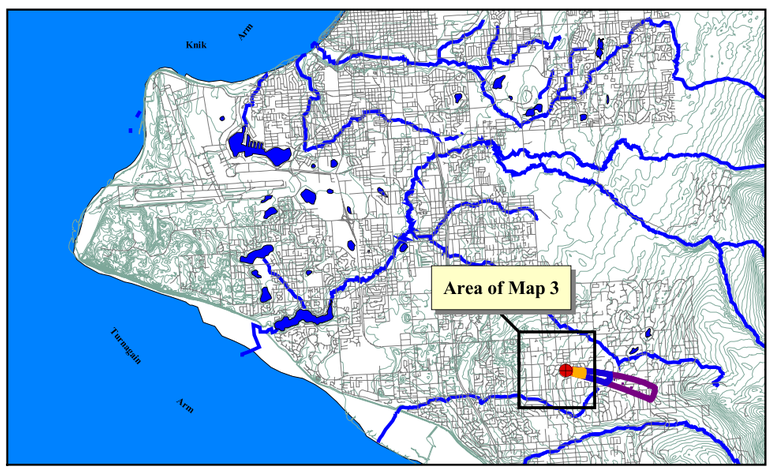
Zone A Protection Area
- Several Months Travel Time

Zone B Protection Area
- Less Than 2 Years Travel Time

Zone C Protection Area
- Less Than 5 Years Travel Time

Zone D Protection Area
- Less Than 10 Years Travel Time
- MOA Land Parcels
- Septic Systems (R2)
- Roads (X20)
- MOA Lakes
- Anchorage Streams
- Elevation Contours

N
W E
S

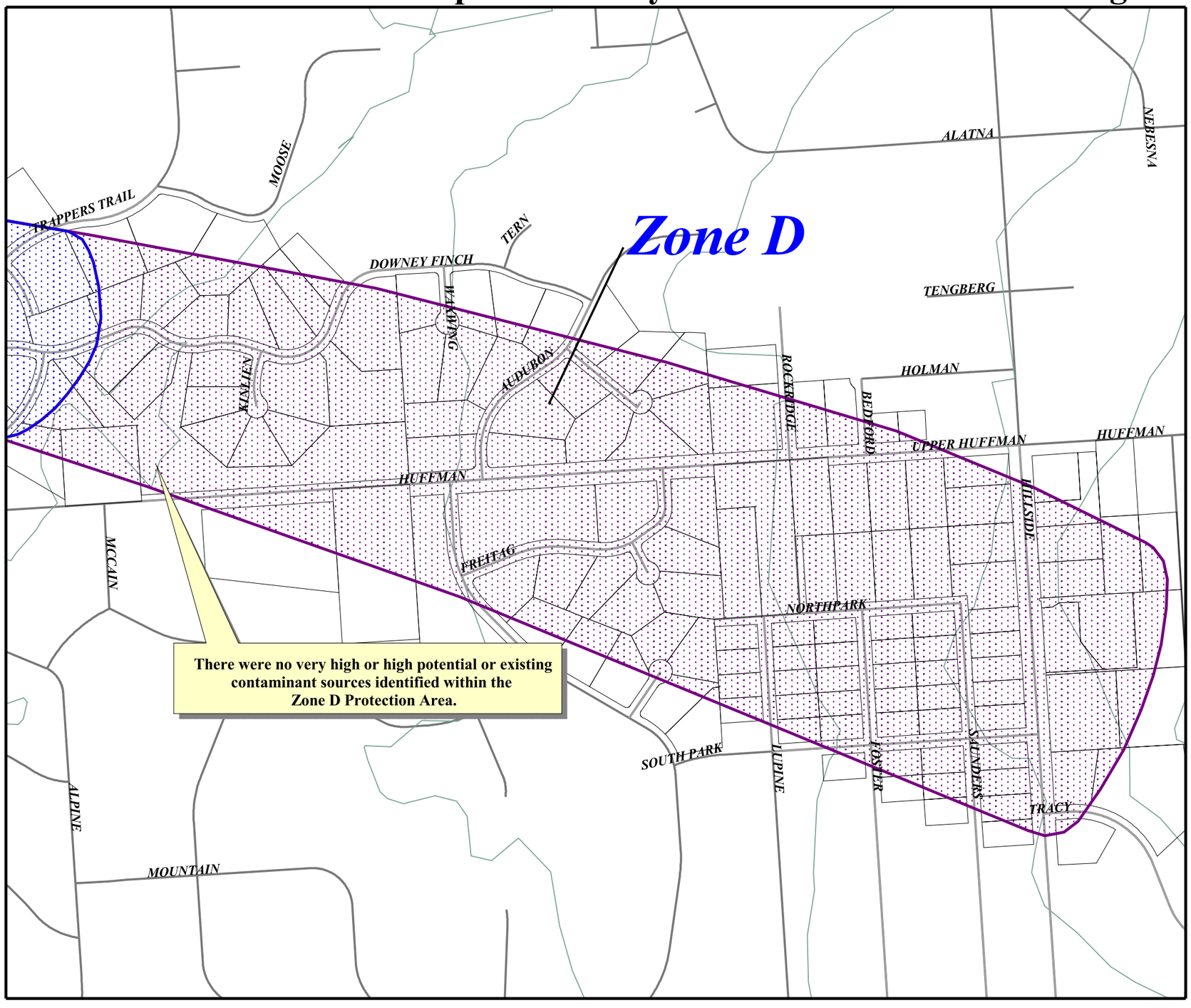


600 0 600 1200 Feet

PWSID 211708.001

Map 3

Drinking Water Protection Area for
Borealis Alpha Water System and Potential & Existing Contaminant Sources



- Borealis Alpha DW Well

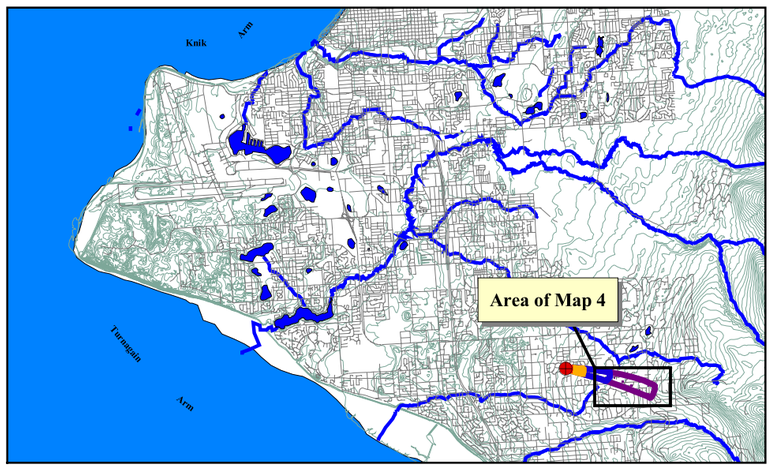
Zone A Protection Area
- Several Months Travel Time

Zone B Protection Area
- Less Than 2 Years Travel Time

Zone C Protection Area
- Less Than 5 Years Travel Time

Zone D Protection Area
- Less Than 10 Years Travel Time
- MOA Land Parcels
- Roads (X20)
- MOA Lakes
- Anchorage Streams
- Elevation Contours

N W E S



PWSID 211708.001

Map 4

APPENDIX D

Vulnerability Analysis for Borealis Alpha Water System's Public Drinking Water Source

Chart 1. Susceptibility of the wellhead - Borialis Alpha Water System

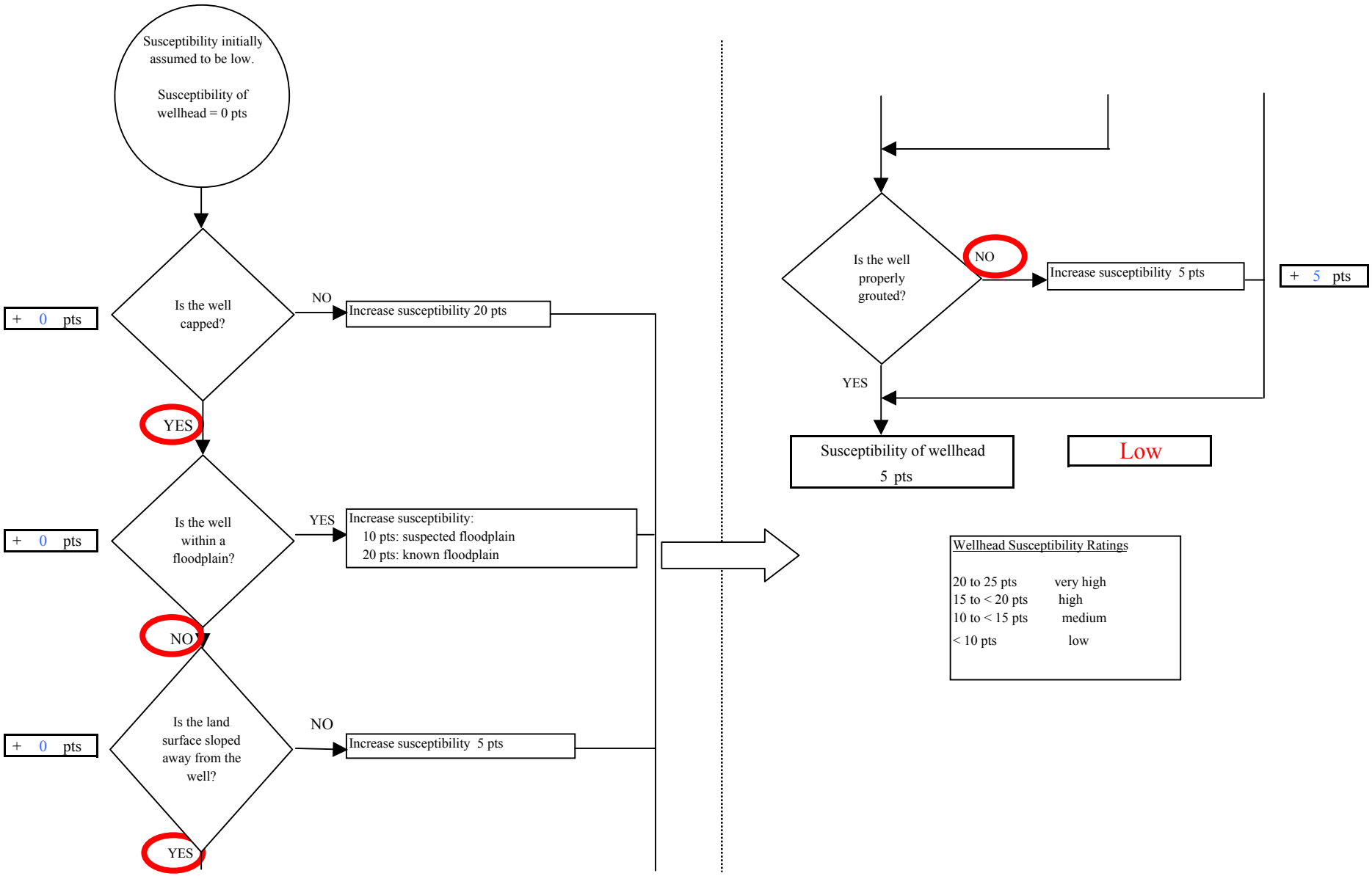


Chart 2. Susceptibility of the aquifer - Borealis Alpha Water System

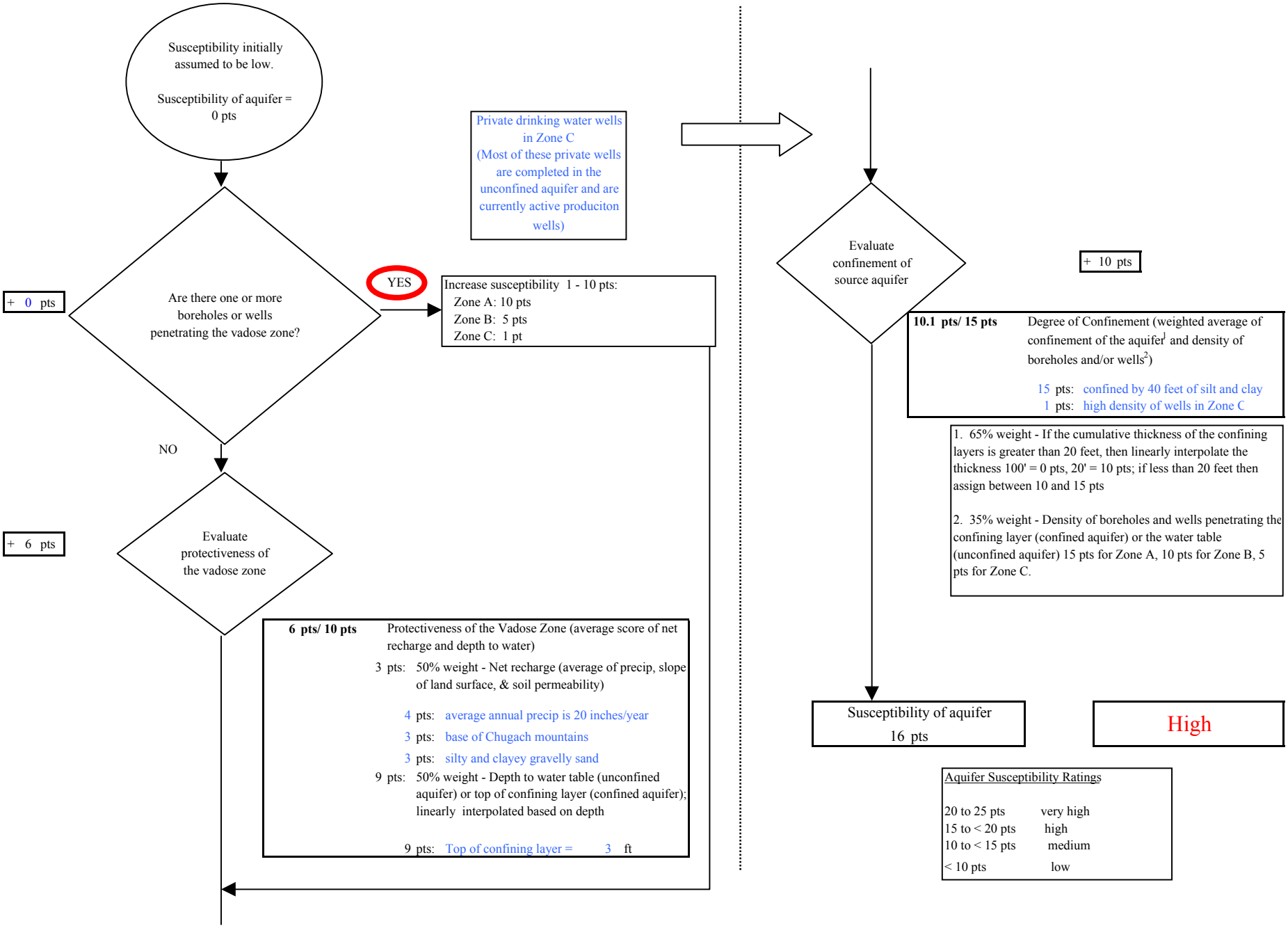
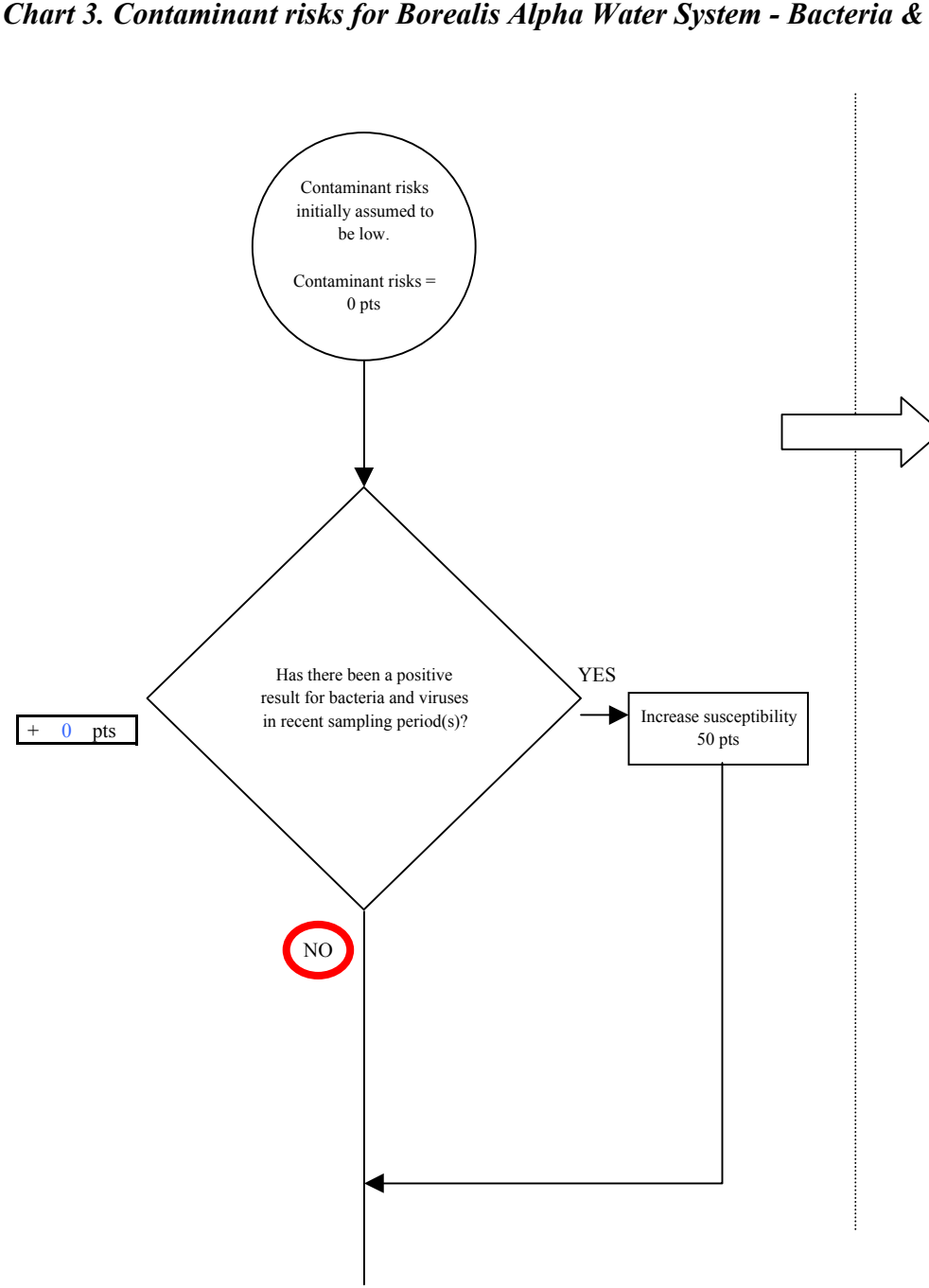
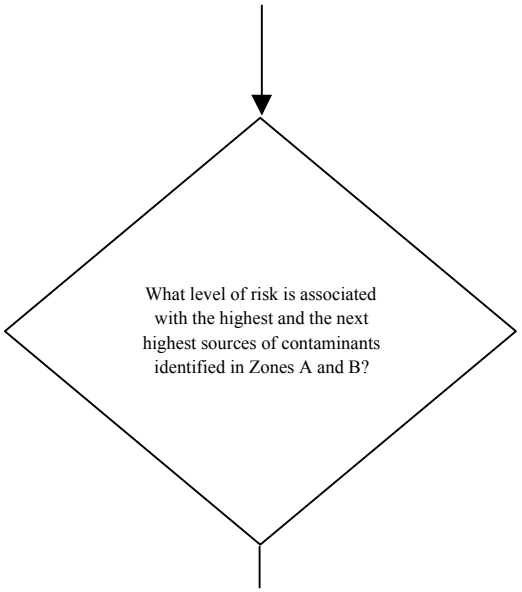


Chart 3. Contaminant risks for Borealis Alpha Water System - Bacteria & Viruses





+ 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)	9	1	10

	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 Borealis Alpha Water System - Bacteria & Viruses

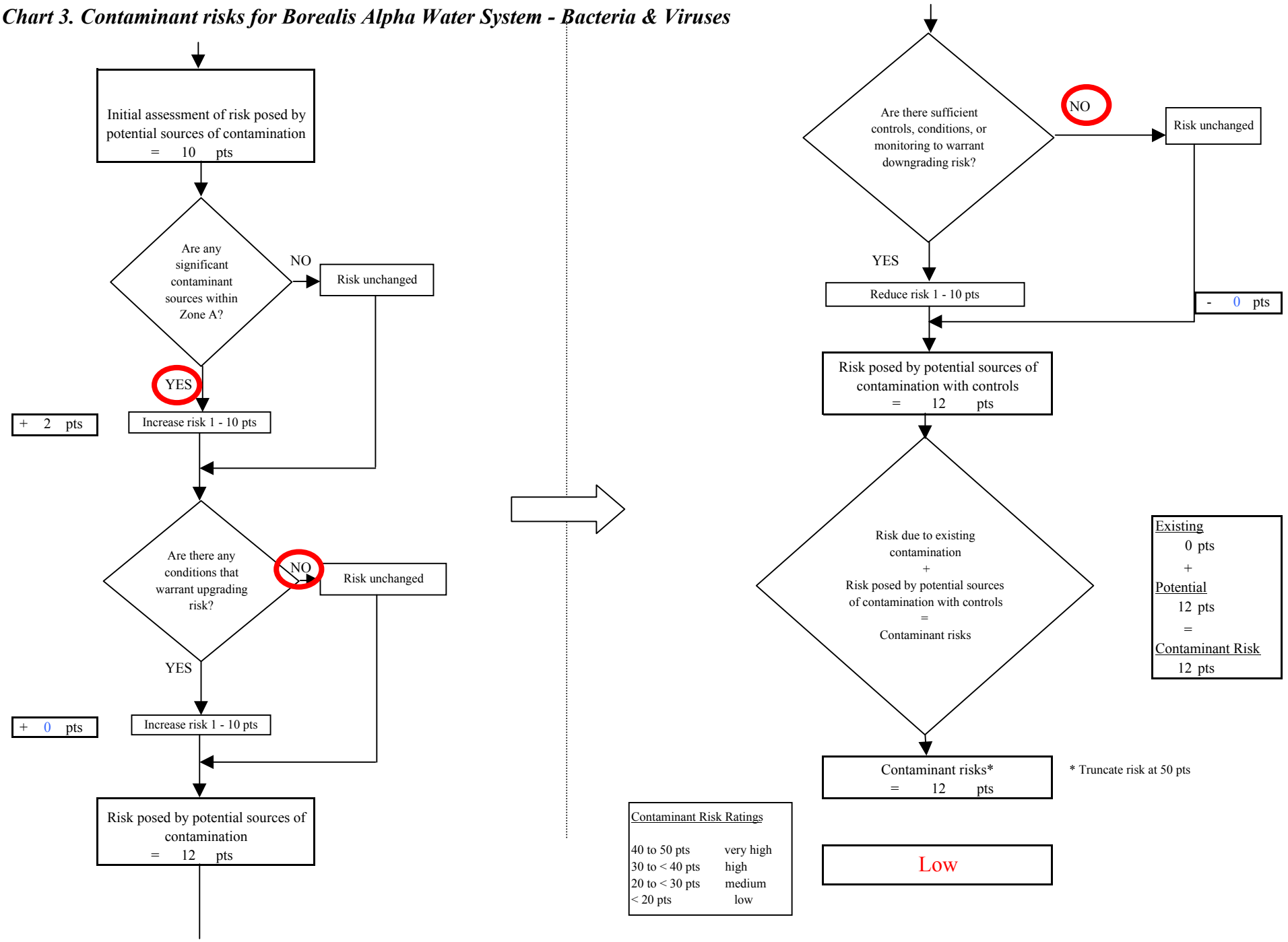


Chart 4. Vulnerability analysis for Borealis Alpha Water System - Bacteria & Viruses

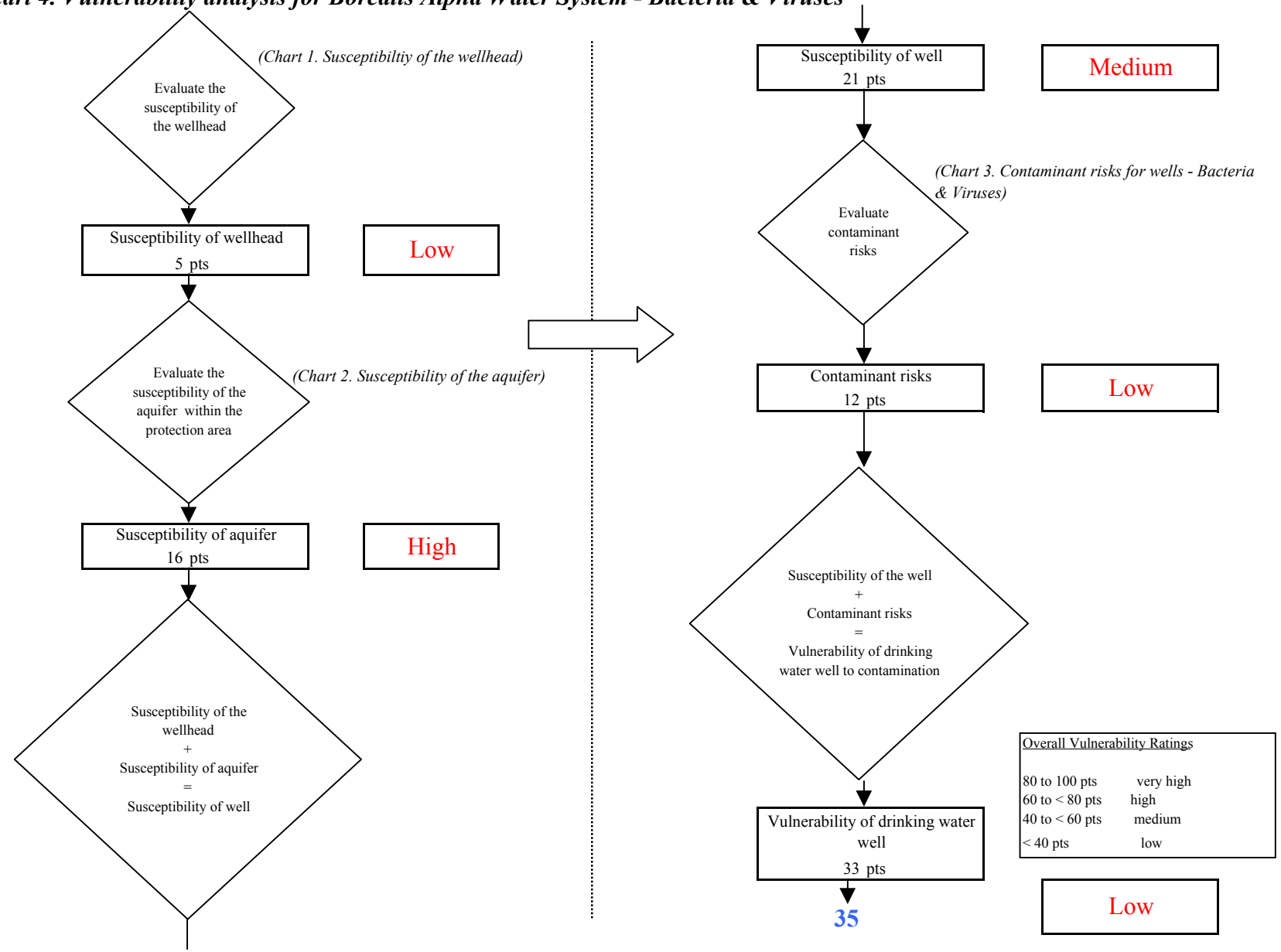


Chart 5. Contaminant risks for Borealis Alpha Water System - Nitrates and Nitrites

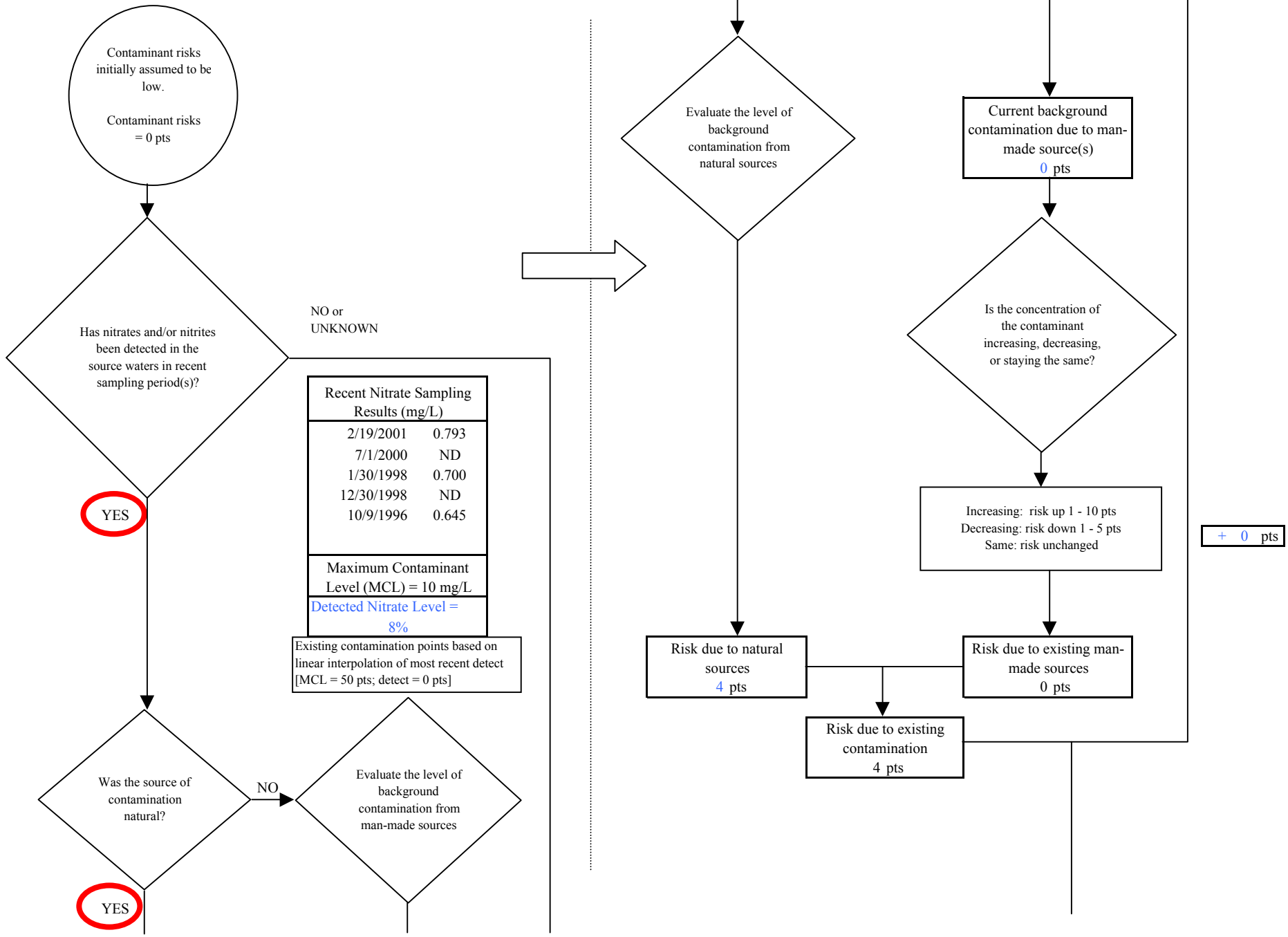


Chart 5. Contaminant risks for Borealis Alpha Water System - Nitrates and Nitrites

+ 10 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)	0	0	0
Low(s)	2	7	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 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.

Initial assessment of risk posed by potential sources of contamination = 10 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

Chart 5. Contaminant risks for Borealis Alpha Water System - Nitrates and Nitrites

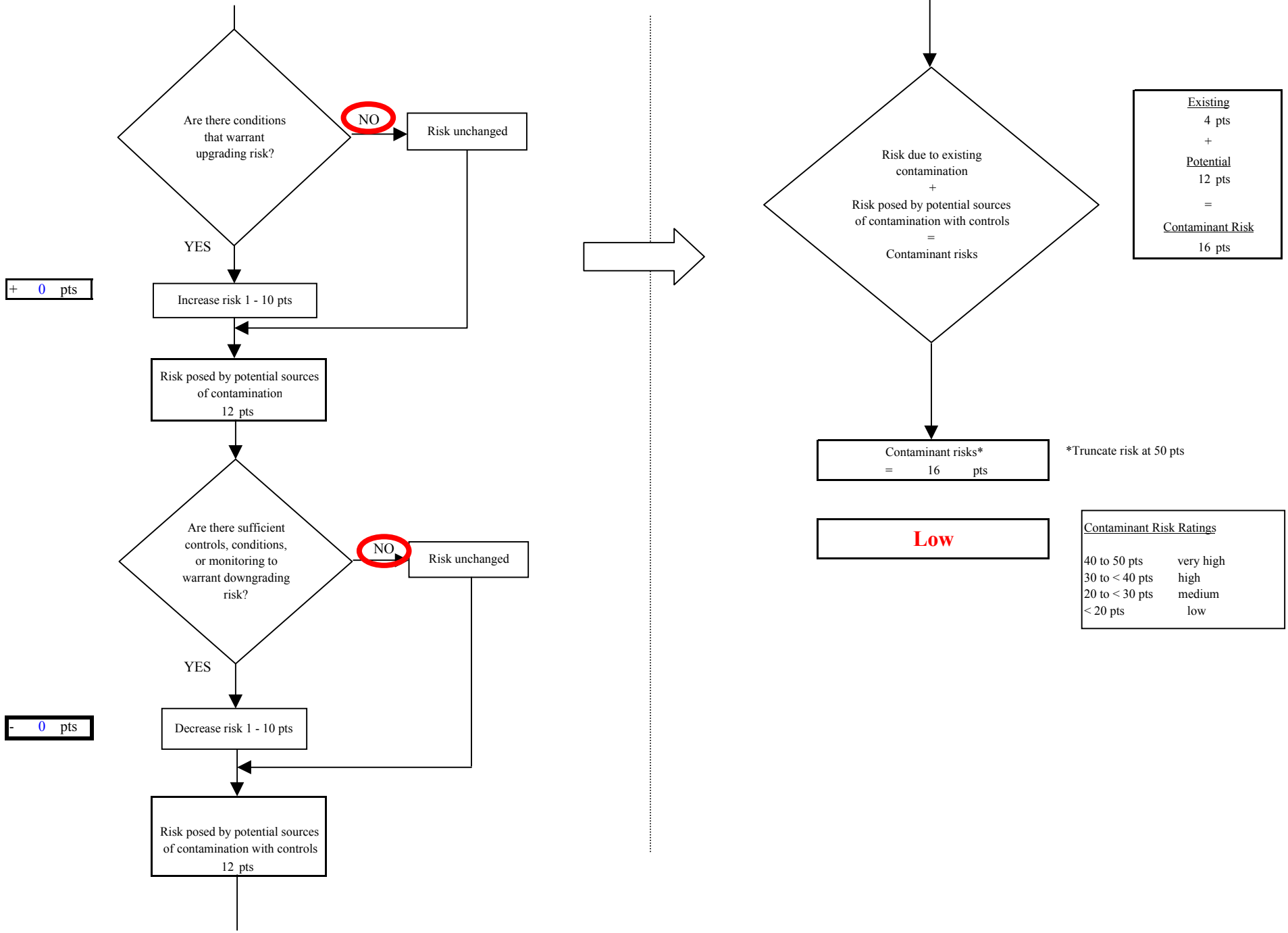


Chart 6. Vulnerability analysis for Borealis Alpha Water System - Nitrates and Nitrites

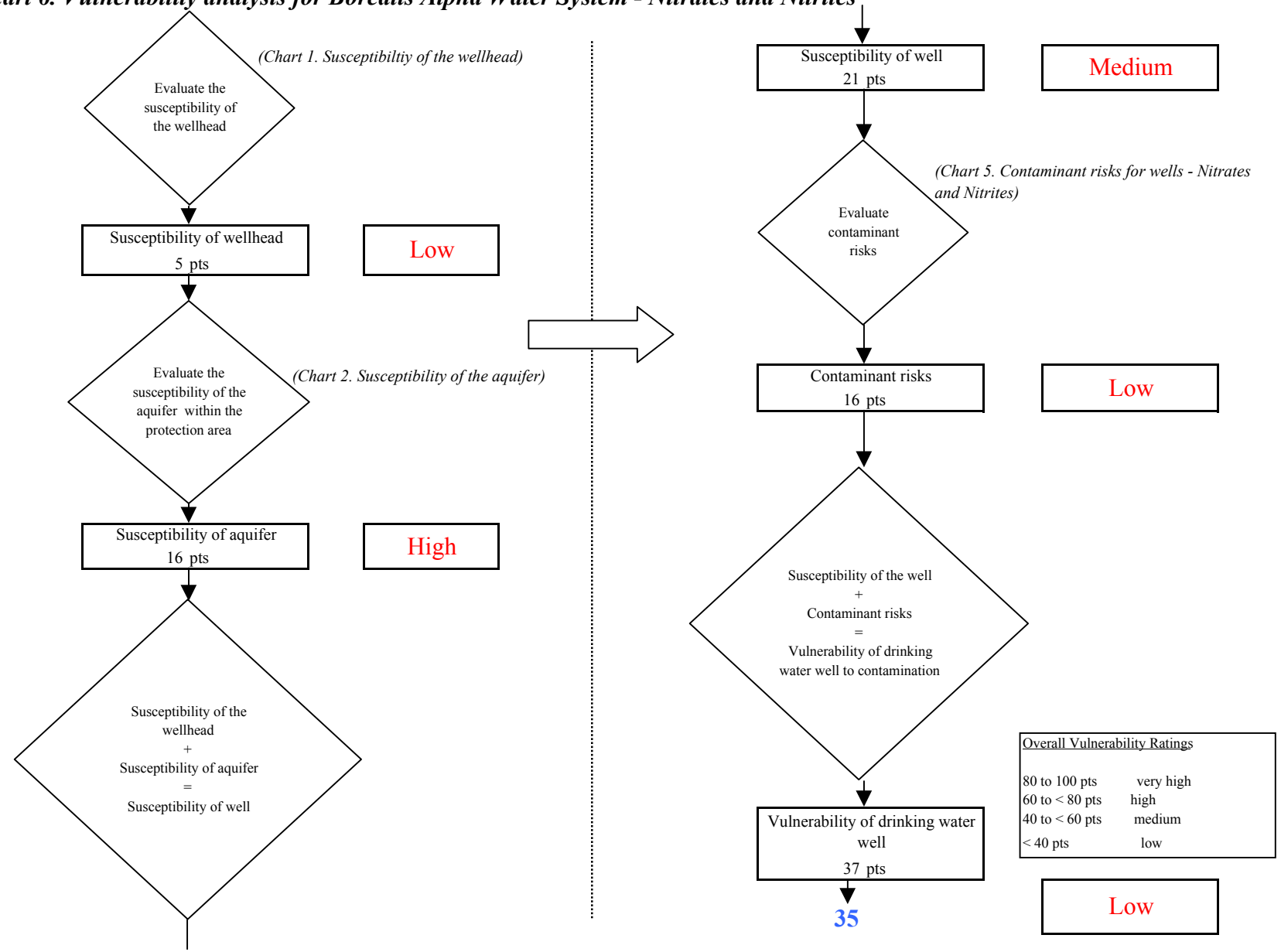


Chart 7. Contaminant risks for Borealis Alpha Water System - Volatile Organic Chemicals

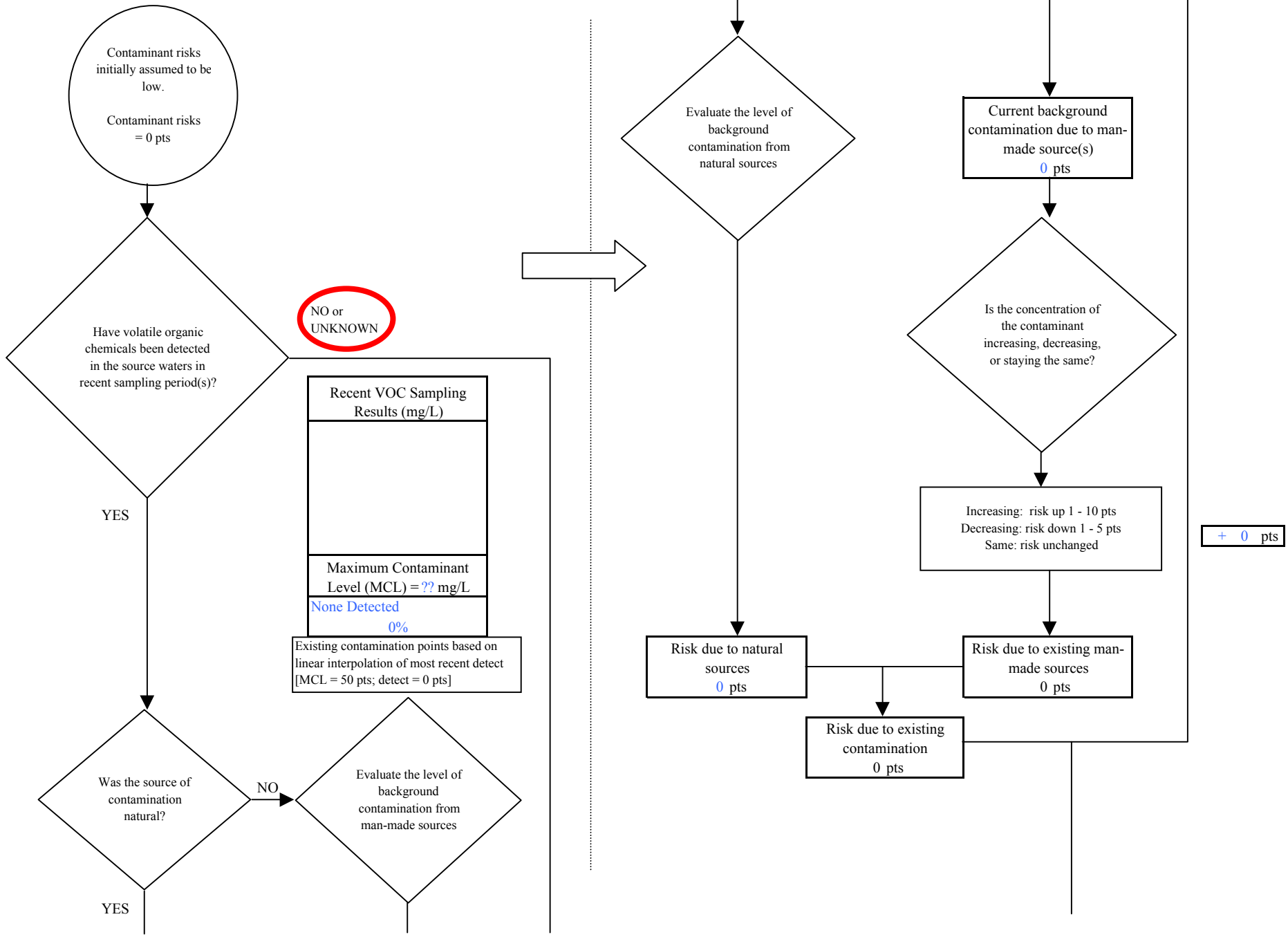


Chart 7. Contaminant risks for Borealis Alpha Water System - Volatile Organic Chemicals

+ 10 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)	0	0	0
Low(s)	3	3	6

	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.

Initial assessment of risk posed by potential sources of contamination = 10 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

Chart 7. Contaminant risks for Borealis Alpha Water System - Volatile Organic Chemicals

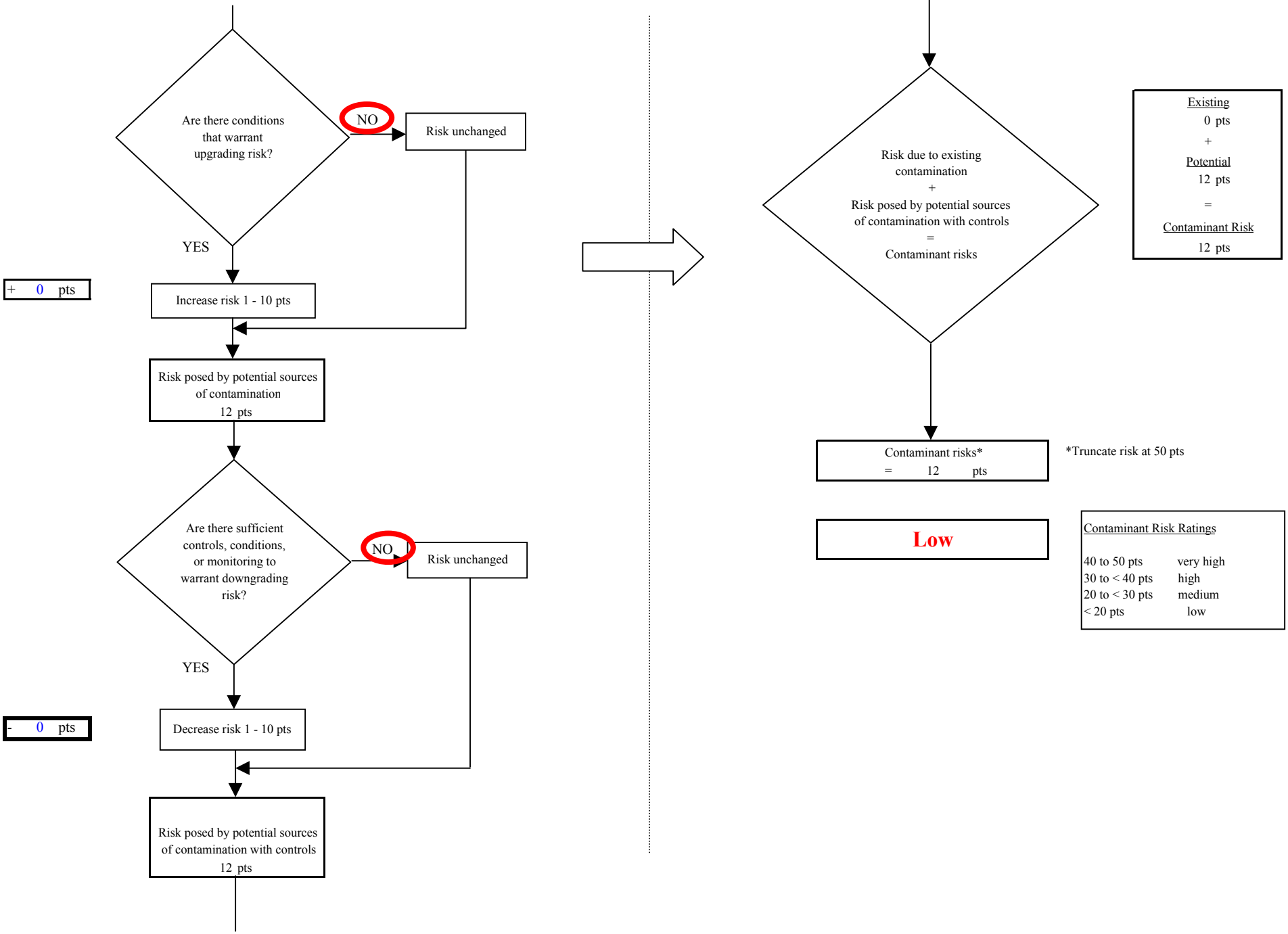


Chart 8. Vulnerability analysis for Borealis Alpha Water System - Volatile Organic Chemicals

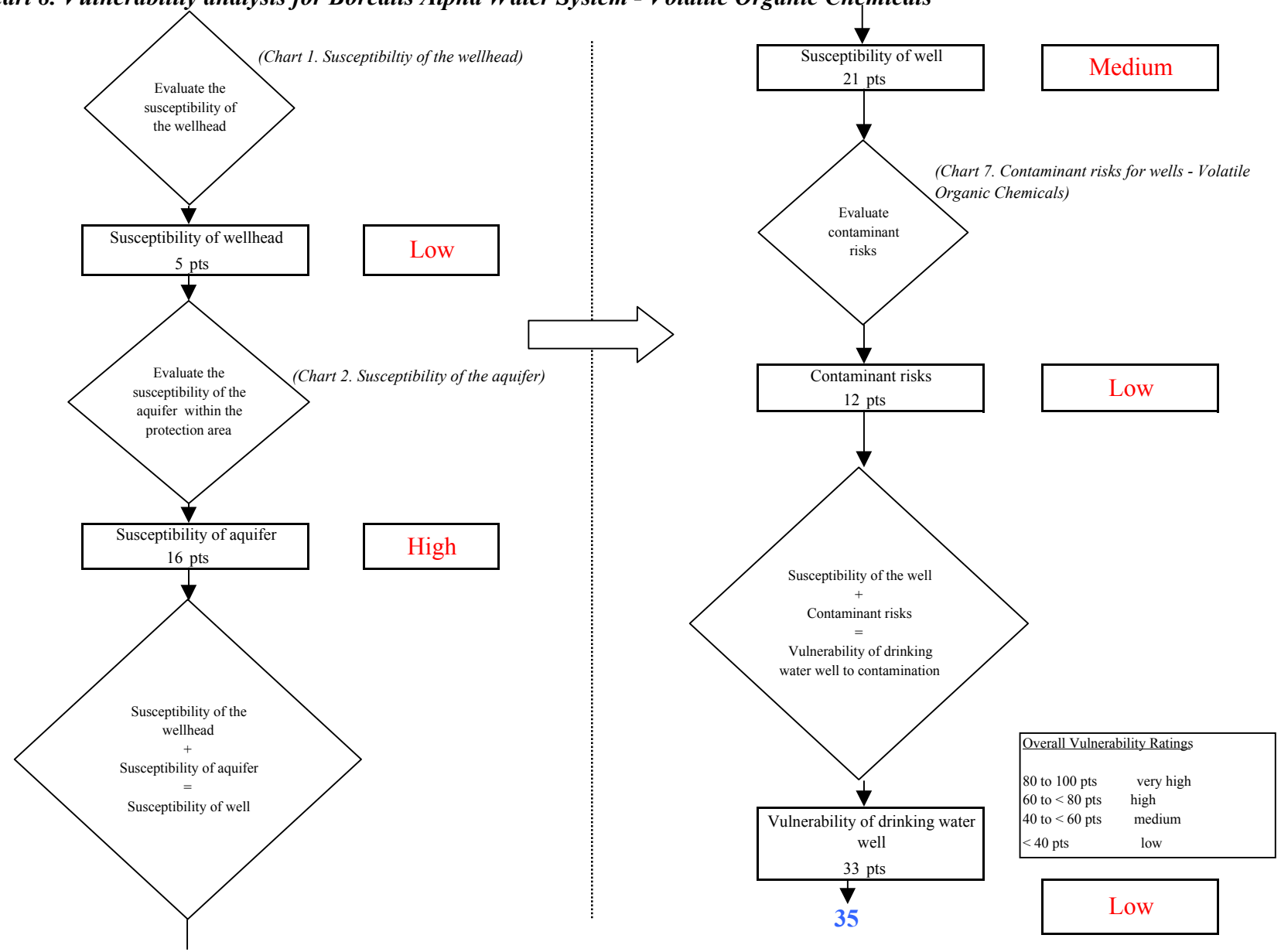


Chart 9. Contaminant risks for Borealis Alpha Water System - Heavy Metals, Cyanide and Other Inorganic Chemicals

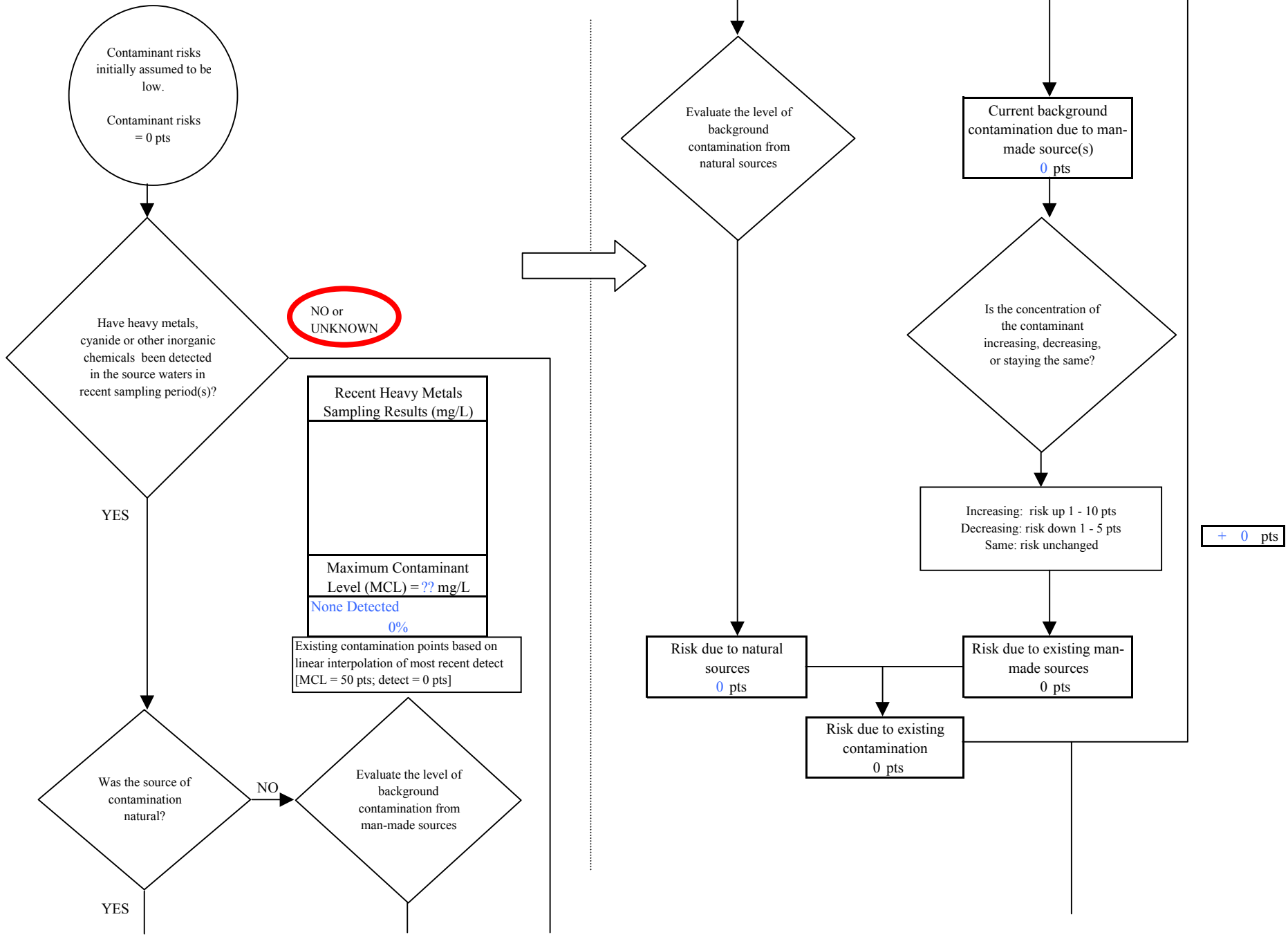


Chart 9. Contaminant risks for Borealis Alpha Water System - Heavy Metals, Cyanide and Other Inorganic Chemicals

+ 10 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)	0	0	0
Low(s)	3	3	6

	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.

Initial assessment of risk posed by potential sources of contamination = 10 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

Chart 9. Contaminant risks for Borealis Alpha Water System - Heavy Metals, Cyanide and Other Inorganic Chemicals

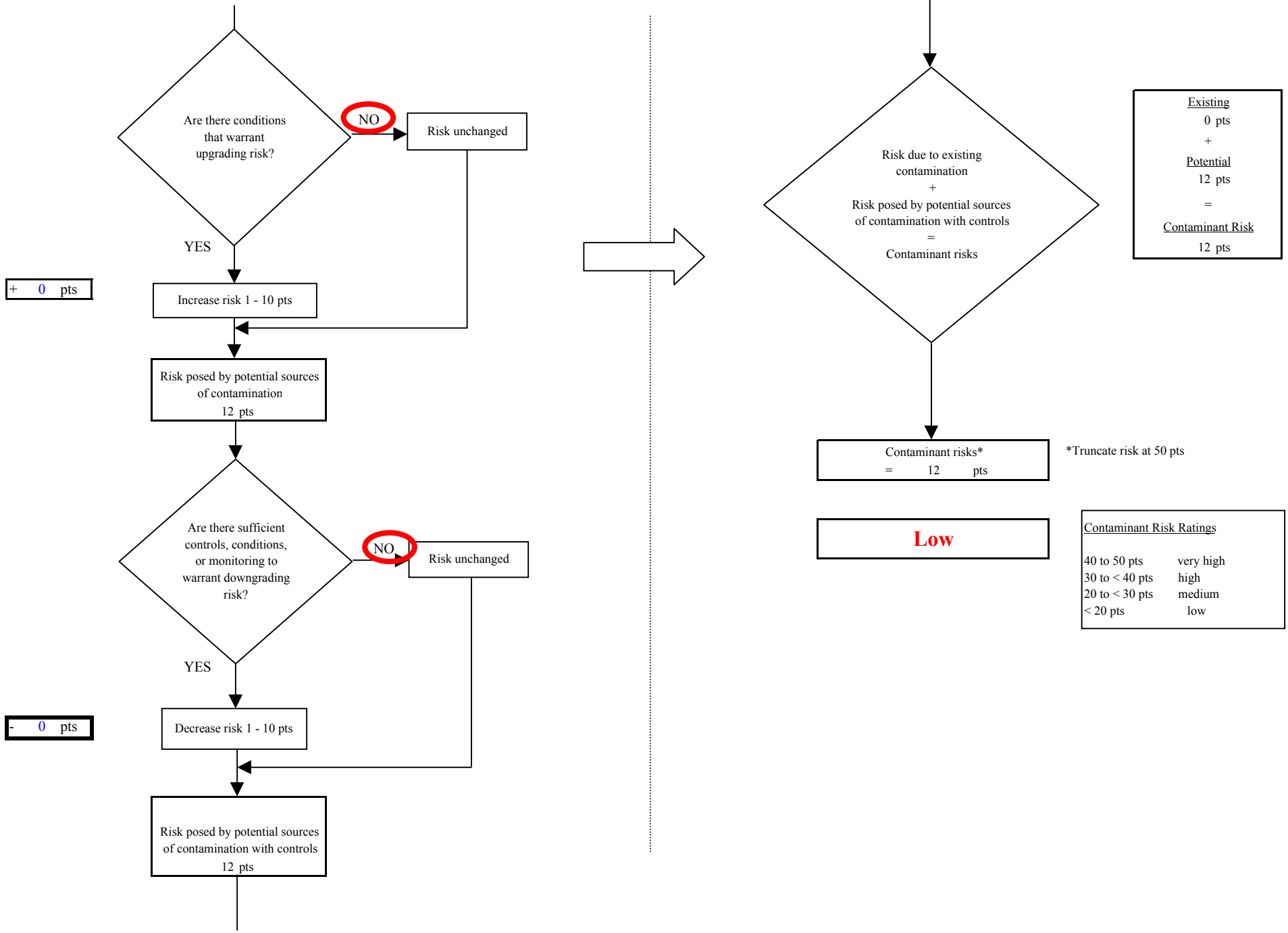


Chart 10. Vulnerability analysis for Borealis Alpha Water System - Heavy Metals, Cyanide and Other Inorganic Chemicals

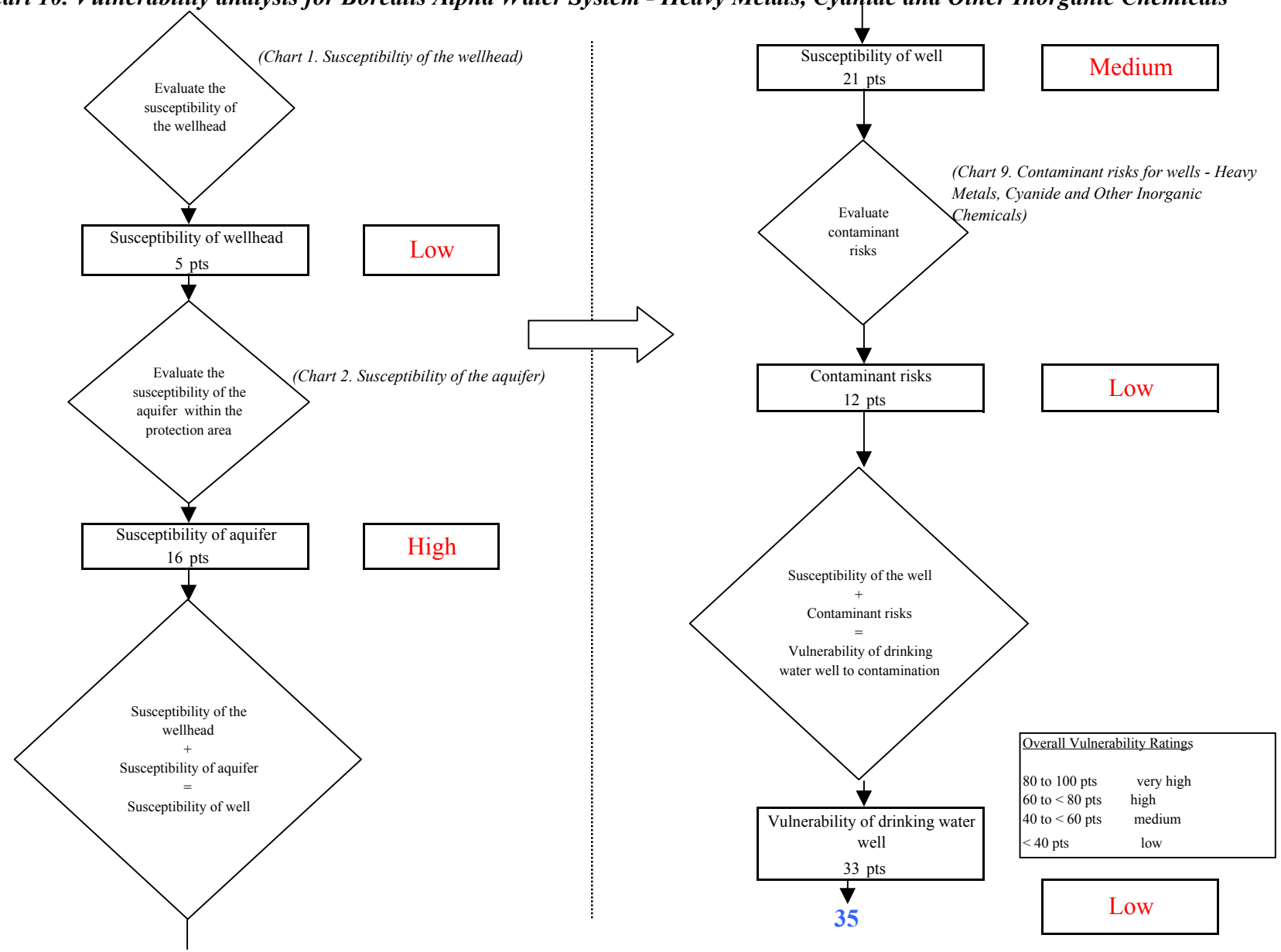


Chart 11. Contaminant risks for Borealis Alpha Water System - Synthetic Organic Chemicals

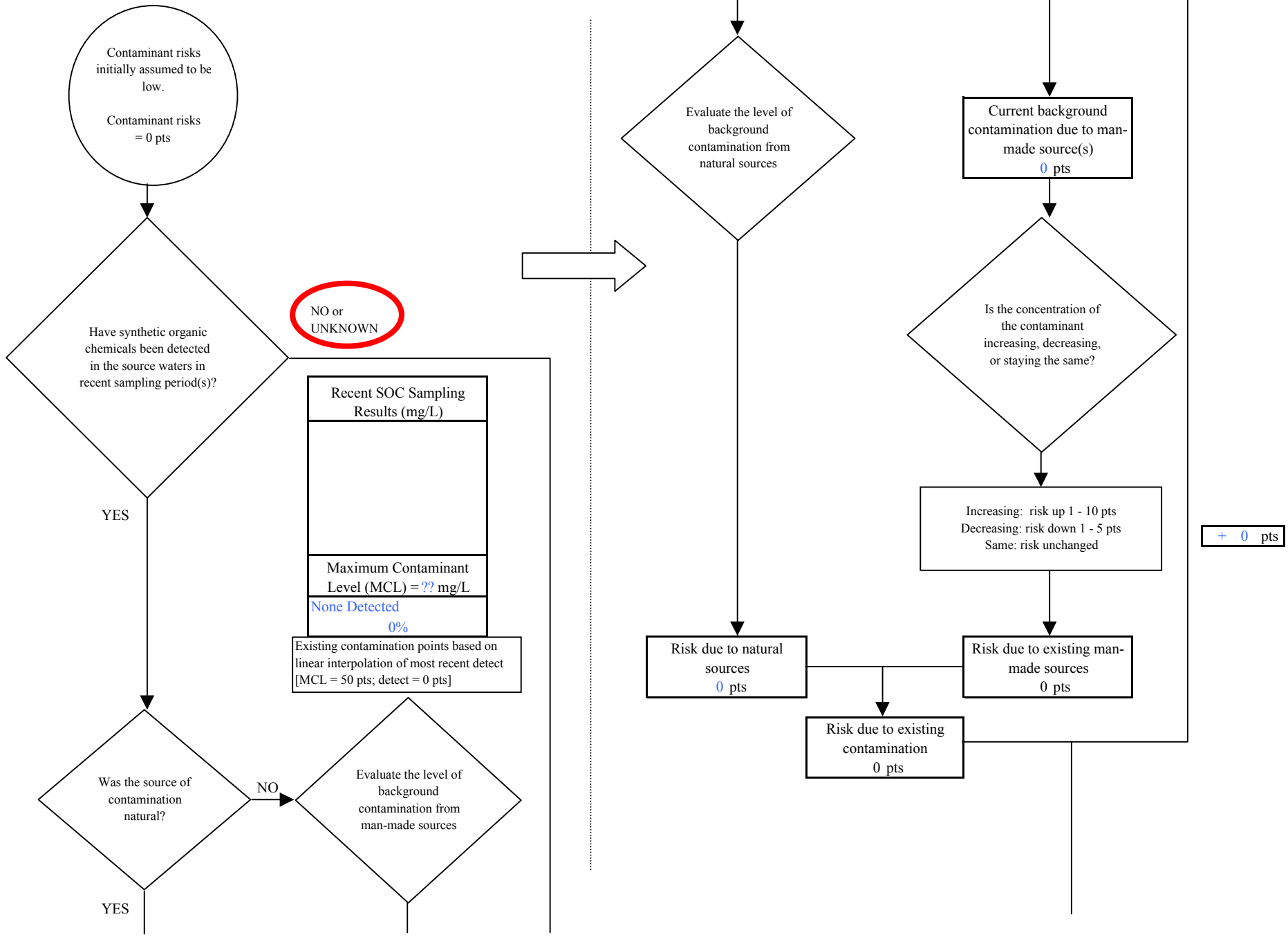
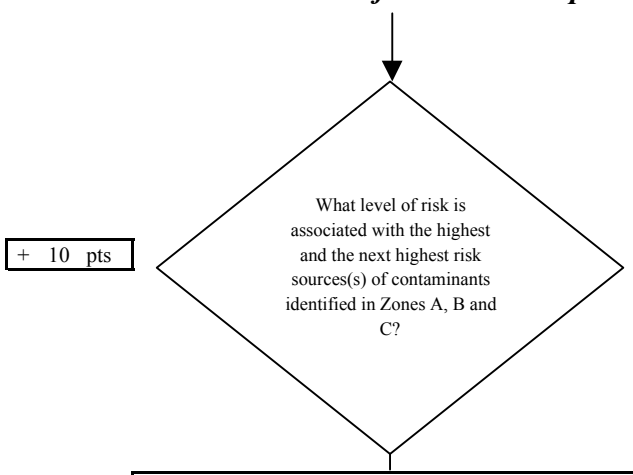


Chart 11. Contaminant risks for Borealis Alpha Water System - Synthetic Organic Chemicals



+ 10 pts

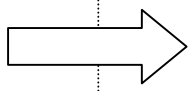
Risk Levels for Contaminant Sources identified in Zones A, B and C

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



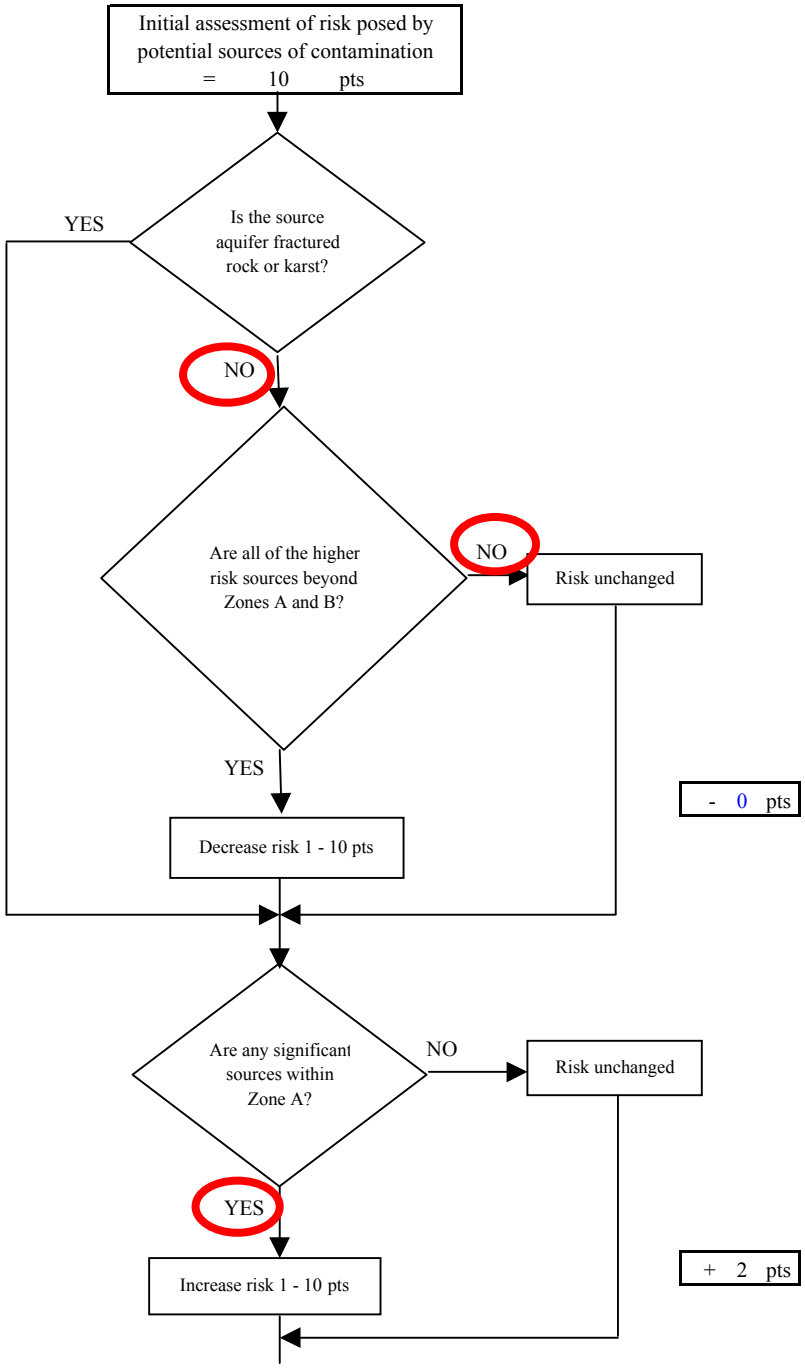
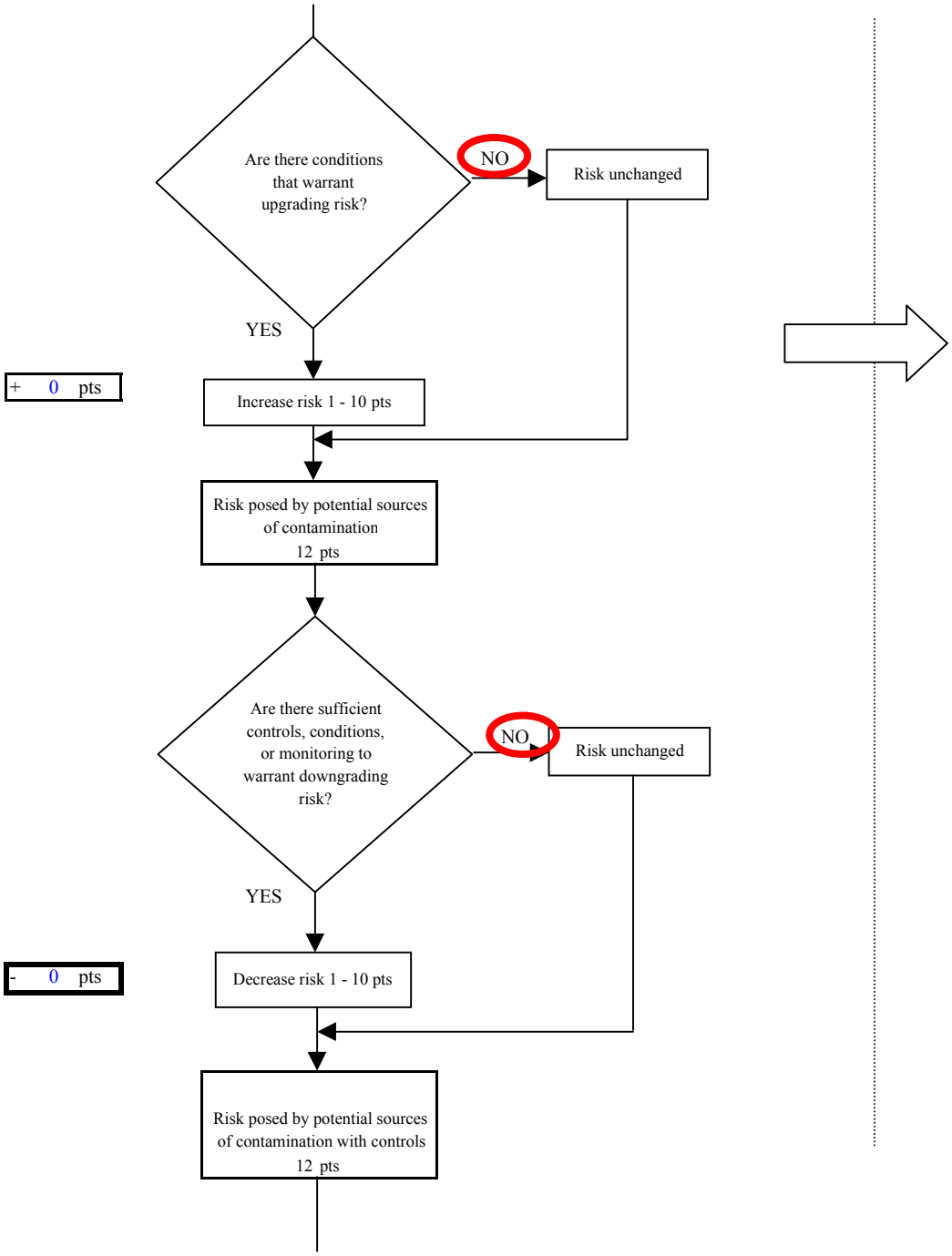
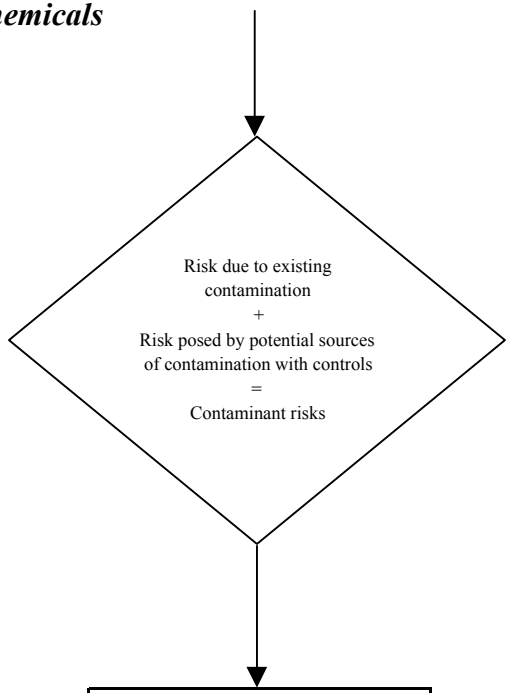


Chart 11. Contaminant risks for Borealis Alpha Water System - Synthetic Organic Chemicals





Existing
0 pts
+
Potential
12 pts
=
Contaminant Risk
12 pts

Contaminant risks*
= 12 pts

*Truncate risk at 50 pts

Low

Contaminant Risk Ratings

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

Chart 12. Vulnerability analysis for Borealis Alpha Water System - Synthetic Organic Chemicals

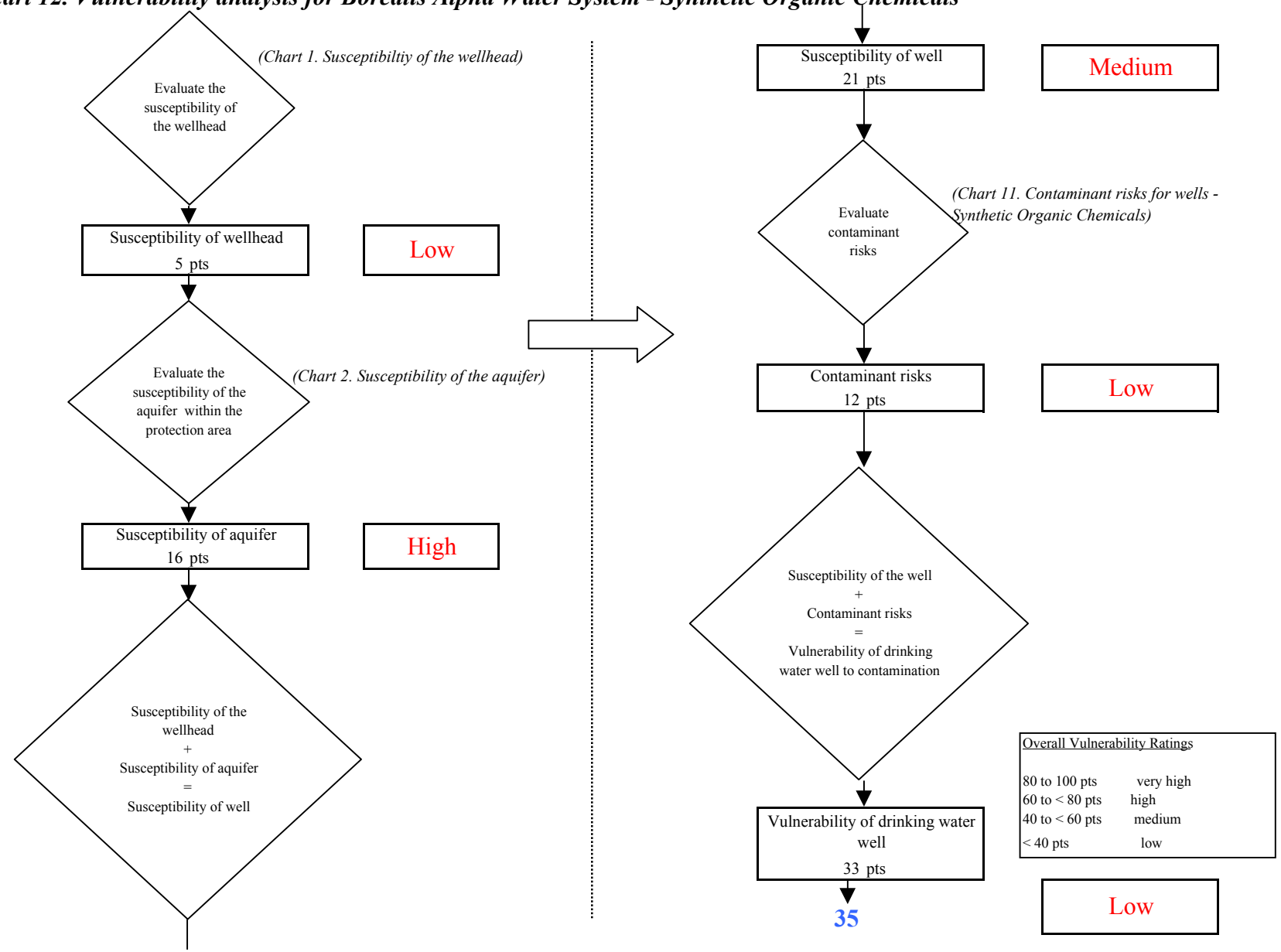


Chart 13. Contaminant risks for Borealis Alpha Water System - Other Organic Chemicals

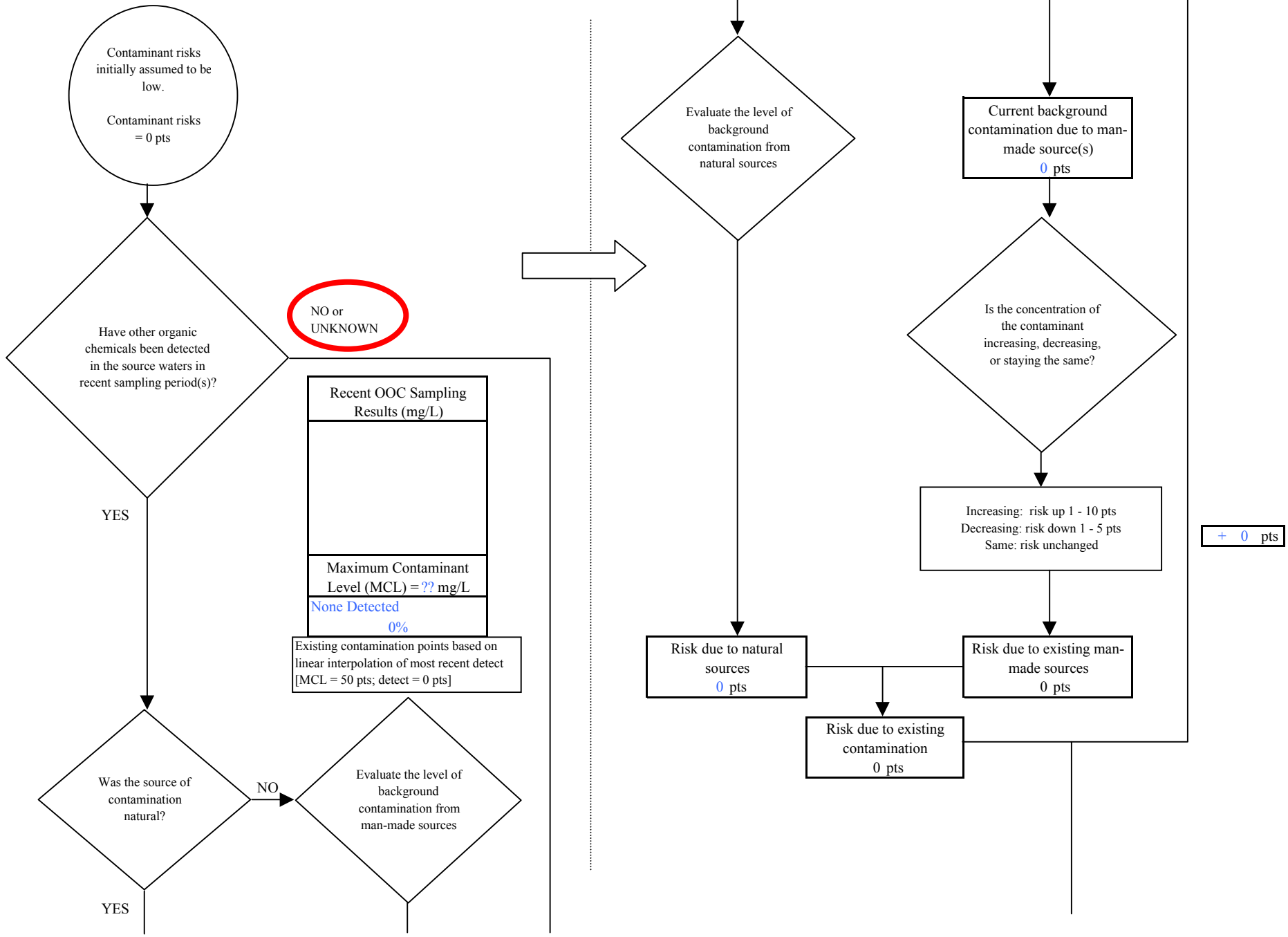
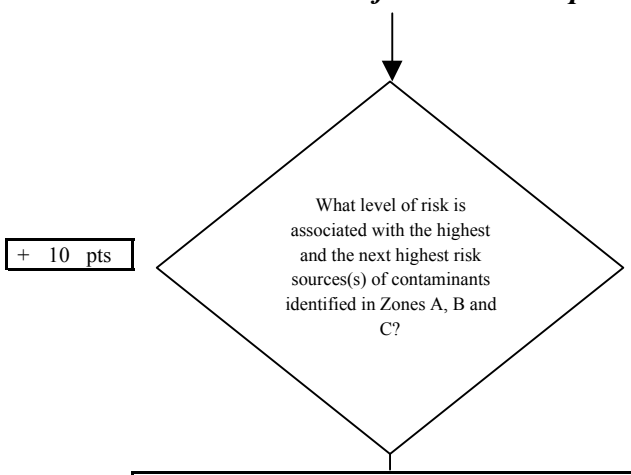


Chart 13. Contaminant risks for Borealis Alpha Water System - Other Organic Chemicals



+ 10 pts

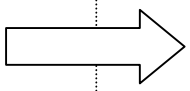
Risk Levels for Contaminant Sources identified in Zones A, B and C

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



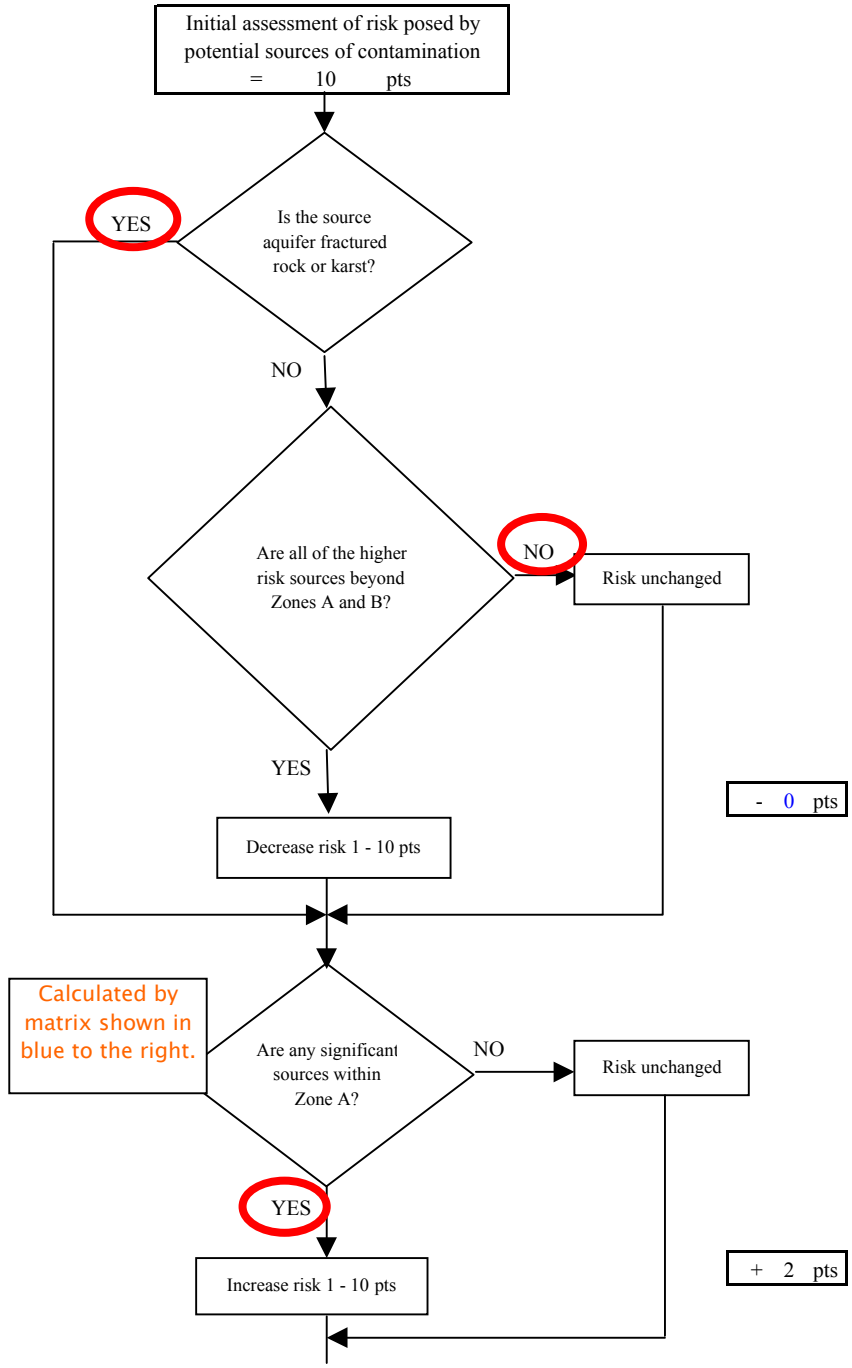


Chart 13. Contaminant risks for Borealis Alpha Water System - Other Organic Chemicals

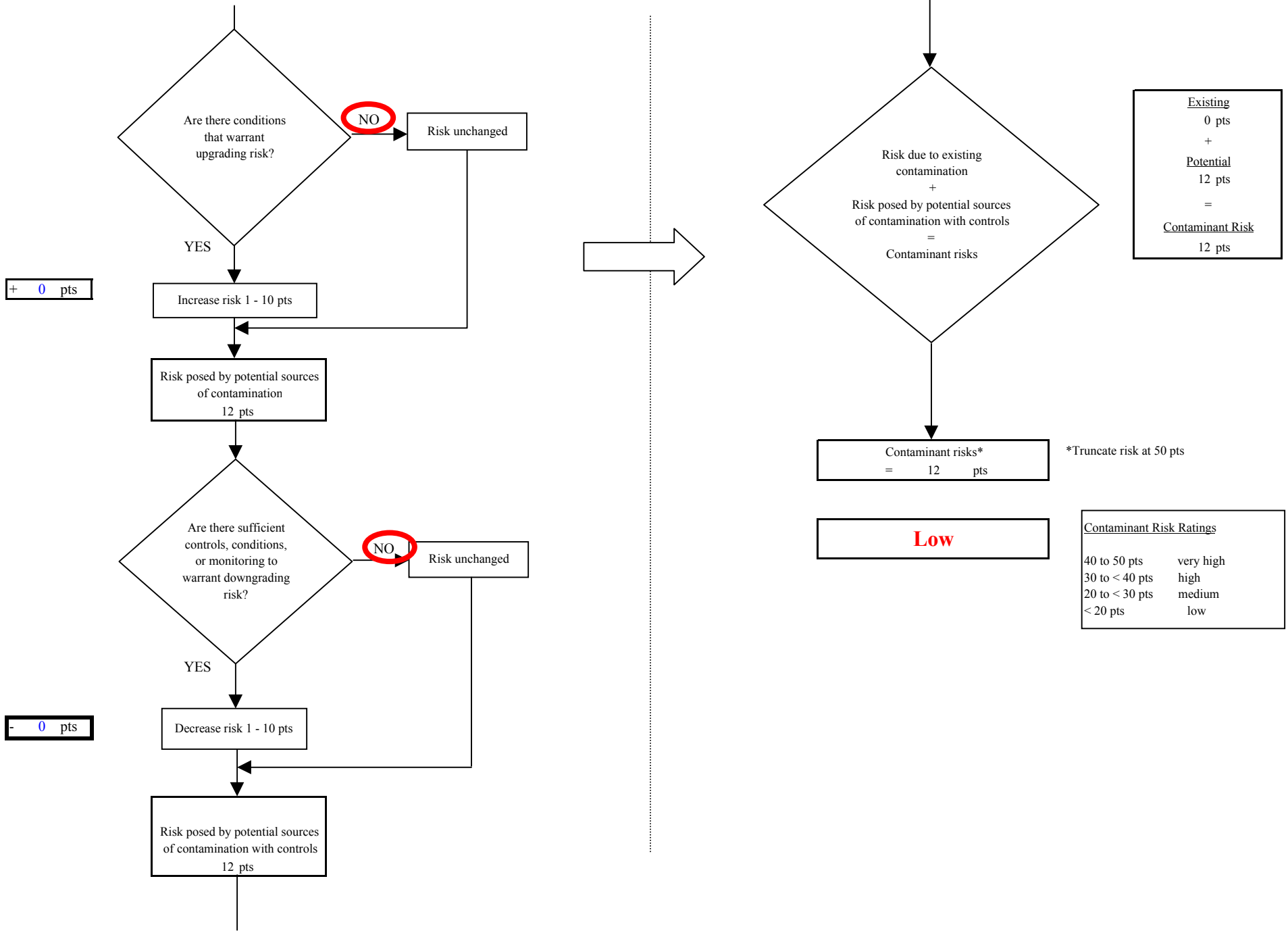


Chart 14. Vulnerability analysis for Borealis Alpha Water System - Other Organic Chemicals