Source Water Assessment

A Hydrogeologic Susceptibility and Vulnerability Assessment for Thorne Bay Prince of Wales Island, Alaska

PWSID # 120216

September 2003

Drinking Water Protection Program Report #840

Alaska Department of Environmental Conservation

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Thorne Bay
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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 the Thorne Bay Public Water System

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

The Thorne Bay water system is a Class A (community) water system that obtains water from Water Lake. The system's intake is located approximately 4000-feet northeast from the shoreline of Thorne Bay and is accessible via a restricted use gravel road. The overall protection area received a susceptibility rating of "**very high**". *A rating of high to very high is typical for all systems with surface water catchment areas*. Identified potential and current sources of contaminants for the drinking water source include gravel roads, inactive logging areas, and beaver habitat. The water system operator also indicated that the area is habitat for deer. Potential and existing sources of the following contaminants were evaluated for this assessment: bacteria and viruses, nitrates and/or nitrites, heavy metals, cyanide, and other inorganic chemicals, synthetic organic chemicals, volatile organic chemicals, and other organic chemicals. Combining the susceptibility of the surface water source with the contaminant risk, this water system has received a vulnerability rating of **"medium"** for synthetic organic chemicals, and other organic chemicals; **"high"** for bacteria and viruses, and nitrates and/or nitrites; and "**very high**" for volatile organic chemicals, heavy metals, cyanide and other inorganic chemicals.

DRINKING WATER SYSTEM AND AREA OVERVIEW

Thorne Bay is located in the Ketchikan Recording District on Prince of Wales Island in the Southeast Panhandle of Alaska (Please see the inset of Map 1 in Appendix A for location). The current population is approximately 600 (ADCED, 2003). The Thorne Bay water system is a Class A (community) water system that operates year round and serves approximately 612 users. The system's intake is located on the northwest end of Water Lake, approximately 4000-feet northeast from the shoreline of Thorne Bay (T71S, R84E, Section 27) (See Map 1 of Appendix A). Access to the intake is available via a restricted access gravel road.

Approximately 75% of households are to piped water and sewer systems and are fully plumbed. Residents on the south side of the community use rain catchment, streams or springs, and a central water source is being designed for this area. The City provides refuse collection services, a regional baler, a recycling facility and landfill, and participates in annual hazardous waste disposal events. Construction is underway to connect Thorne Bay and Kasaan to the Black Bear Lake Hydroelectric facility. 46% of residents heat using fuel oil, 48% heat using wood, and the remainder heat with electricity (ADCED, 2003).

Rounded mountains composed primarily of volcanic rock dominate this area. At the higher elevtions, soils are shallow over bedrock, often organic, and less productive. Well drained glacial till soils predominate at the lower elevations. Hemlock and hemlock-spruce forests are present on the well-drained areas, while mixed conifers and lodgepole pines dominate on the wetter areas. Shrubby bogs and fens occur on the wettest spots (USDA, 2001).

The area is dominated by a cool, maritime climate. Average temperatures in the summer range from 49 to 63; winter temperatures range from 32 to 42. Annual precipitation is approximately 120-inches, with 40-inches of snow (ADCED, 2003).

The most recent Sanitary Survey (2002) indicates that the intake is screened and that human access is restricted in the watershed. Water system operators did not provide information regarding lake depth and volume, but residence time is estimated to be less than one year. The average daily production of the water system is approximately 55,000 gallons.

THORNE BAY DRINKING WATER PROTECTION AREA

Identifying the pathways most likely for surface contamination to reach water intake areas is the first step in determining the water system's risk. These are initially determined by looking at the drainage area contributing overland water flow to a surface water source intake. The entire drainage area is also known as the "drinking water protection area". Please refer to pages 10-11of the "Guidance Manual for Class A Public Water Systems" for additional information.

The protection area established for surface water sources by the ADEC is usually separated into three zones, limited by the watershed boundary. These zones correspond to the overland-flow distance that water travels to get to the source. The ADEC Drinking Water

Protection Program's Technical Advisory Committee developed guidelines for derivation of these zones in 1998. The following is a summary of the three protection area zones:

Table 1. Definition of Zones

Zone	Definition
A	Areas within 1000-ft of lakes or streams
B	Areas within 1-mile of lakes or streams
C	The watershed boundary

The protection area for Thorne Bay includes each of these Zones (See Map 1 of Appendix A). It should be noted here that, because of the small watershed size, Zones C and B are identical.

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 Thorne Bay protection area. This inventory was completed through a search of agency records and other publicly available information. There is a wide array of potential contamination sources to surface water. These contaminants are found within agricultural, residential, commercial, and industrial areas, but *can also occur within areas that have little or no development*.

For 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; and
- Other Organic Chemicals.

Sources identified in the Thorne Bay protection area are displayed on Map 2 of Appendix C and summarized in Table 1 of Appendix B.

RANKING OF CONTAMINANT RISKS

Once potential and existing sources of contamination have been identified, they are assigned a ranking according to what category and level of risk they represent. Ranking of contaminant risks for "potential" or "existing" sources of contamination is a function of the toxicity and the volume of specific contaminants associated with that source. Rankings include:

- Low;
- Medium;
- High; and
- Very High.

The time-of-travel for contaminants within the water is dependent on the physical and chemical characteristics of each contaminant. Bacteria and Viruses are only inventoried in Zones A because of their short life span. Only "Very High" and "High" rankings are inventoried within Zones B and C due to the probability of contaminant dilution by the time the contaminants reach the water intake.

Tables 2 through 6 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, and other organic chemicals.

VULNERABILITY OF THE THORNE BAY DRINKING WATER SYSTEM

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

- Surface Water Susceptibility; and
- Contaminant risks.

Appendix D contains 13 charts, which together form the 'Vulnerability Analysis' for the public drinking water Source Water Assessment. Chart 1 analyzes the 'Susceptibility of the Surface Water Source' to contamination by looking at the climate, terrain, and intake location. Chart 2 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 intake area. Chart 3 contains the 'Vulnerability Analysis for Bacteria and Viruses', which is a composite score of the Vulnerability Analysis and the overall Susceptibility. Charts 4 through 13 repeat 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 Surface Water Susceptibility of the source is reached by considering the properties of the water intake and the surrounding area. The derivation of this information is presented below and the data for this source is shown in Chart 1 of Appendix D.

Susceptibility of the Surface Water Source – always considered to be "high" (30 points)

+

Adequate Construction of the Intake (0 – 5 Points)

+

Runoff Potential Within Zone B (0 – 5 Points)

+

Dilution Capacity of the Surface Water (0 – 10 Points)

=

Natural Susceptibility
(0 – 50 Points)

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

Surface Water Source Susceptibility Ratings	
40 to 50 pts	Very High
30 to < 40 pts	High

Table 2. Susceptibility of the Thorne Bay Water Source

	Score	Rating
Minimum Allowable Susceptibility	30	
Intake Construction Adequate	0	
Runoff Potential	5	
Dilution Capacity	10	
Overall Susceptibility	45	Very High

For contaminants, risks to a drinking water source depend on the type, number or density, and distribution of the contaminant sources. The Contaminant Risk score has been derived from an examination of existing, and historical contamination sources that have been detected in the protection area 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 the 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. Thorne Bay Contaminant Risks

Category	Score	Rating
Bacteria and Viruses	30	High
Nitrates and/or Nitrites	30	High
Volatile Organic Chemicals	50	Very High
Heavy Metals, Cyanide, and Other Inorganic Chemicals	37	High
Synthetic Organic Chemicals	0	Low
Other Organic Chemicals	12	Low

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

Susceptibility of the Surface Water Source

(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 and ratings for each of the six categories of drinking water contaminants. Note: scores are rounded off to the nearest five.

Table 4. Thorne Bay Overall Vulnerability

Category	Score	Rating
Bacteria and Viruses	75	High
Nitrates and Nitrites	75	High
Volatile Organic Chemicals	95	Very High
Heavy Metals, Cyanide, and Other Inorganic Chemicals	80	Very High
Synthetic Organic Chemicals	45	Medium
Other Organic Chemicals	55	Medium

Bacteria and Viruses

The contaminant risk for bacteria and viruses is "high". Typically, there is positive coliform detection in water samples, which is normal in samples of raw water collected from surface water sources. (See Chart 2 – Contaminant Risks for Bacteria and Viruses in Appendix D).

Coliforms (a bacteria) are found naturally in the environment and although they aren't necessarily a health threat, they are an indicator of other potentially harmful bacteria in the water, more specifically, fecal coliforms and E. coli which only come from human and animal fecal waste. Harmful bacteria can cause diarrhea, cramps, nausea, headaches, or other symptoms (EPA, 2003). Positive samples increase the overall vulnerability of the drinking water source, indicating that the source is susceptible to bacteria and virus contamination.

Beaver presence poses a high risk of bacterial contamination. No positive bacteria counts have been detected in the sampling period of 2000 – 2003.

After combining the contaminant risk for bacteria and viruses with the natural susceptibility of the source, the overall vulnerability of the source to bacteria and virus contamination remains "high".

Nitrates and Nitrites

The contaminant risk for nitrates and nitrites is "high" with the proximity of the source water to beaver habitat, gravel roads, and logging areas (both active and inactive) posing the most significant contaminant risks to this source of public drinking water (See Chart 4 - Contaminant Risks for Nitrates and/or Nitrites in Appendix D). Nitrates are very mobile, moving at approximately the same rate as water.

Sampling history for the Thorne Bay water source indicates that nitrates have not been detected in samples taken since 1997. The Maximum Contaminant Level (MCL) for nitrates is 10 milligrams per liter (mg/L). 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 (EPA, 2003).

After combining the contaminant risk for nitrates and nitrites with the natural susceptibility of the source, the overall vulnerability of the well to contamination is "high".

Volatile Organic Chemicals

The contaminant risk for volatile organic chemicals is "very high" (See Chart 6 – Contaminant Risks for Volatile Organic Chemicals in Appendix D).

Chloroform and trihalomethanes have been detected during recent sampling. The MCL for chloroform is 0.2 milligrams per liter (mg/L) and the MCL for total trihalomethanes is 0.1 mg/L. Both of these chemicals originate from human-made sources. Chloroform, trihalomethanes, and tolulene are often present in trace amounts following the water treatment process. Other possible sources of volatile organic chemicals in the protection area are logging areas (both active and inactive), and gravel roads. After combining the contaminant risk for volatile organic chemicals with the natural susceptibility of the source, the overall vulnerability of the well to contamination is "very high".

Heavy Metals, Cyanide, and Other Inorganic Chemicals

The contaminant risk for heavy metals is "high". This is primarily due to the detection of lead and copper during 2002-2001 (See Chart 8 – Contaminant Risks for Heavy Metals, Cyanide, and Other Inorganic Chemicals in Appendix D).

Possible sources of these chemicals in the protection area are the logging areas (both active and inactive), and gravel roads.

After combining the contaminant risk for heavy metals with the natural susceptibility of the source, the overall vulnerability of the well to contamination is "very high".

Synthetic Organic Chemicals

The contaminant risk for synthetic organic chemicals is "low". After combining the contaminant risk with the natural susceptibility of the source, the overall vulnerability to synthetic organic chemicals of the well is "medium" (See Chart 11 – Contaminant Risks for Synthetic Organic Chemicals in Appendix D).

Review of the historical sampling data indicates that sampling for dibromochloropropane occurred in 2002, but was not detected.

Other Organic Chemicals

The contaminant risk for other organic chemicals is "low". Gravel roads are a possible source of these chemicals. After combining the contaminant risk with the natural susceptibility of the source, the overall vulnerability to other organic chemicals of the source is "medium" (See Chart 13 – Contaminant Risks for Other Organic Chemicals in Appendix D).

Review of the historical sampling data indicates that no other organic chemicals have been sampled recently.

REFERENCES

Alaska Department of Community and Economic Development (ADCED), 2003 [WWW document]. URL http://www.dced.state.ak.us/cbd/commdb/CF_COMDB.htm

United States Forest Service – Alaska Region (USDA), 2001. Technical Publication No. R10-TP-75. Ecological Subsections of Southeast Alaska and Neighboring Areas of Canada.

United States Environmental Protection Agency (EPA), 2003 [WWW document]. URL http://www.epa.gov/safewater/mcl.html.

APPENDIX A

Thorne Bay
Drinking Water Protection Area Location Map
(Map 1)

Thorne Bay -
Drinking Water Protection Area

Map 1: Thorne Bay Drinking Water Protection Area

PWSID: 120216.001

Alaska Department of Environmental Conservation

Alaska Drinking Water Protection Program

0 2,000 4,000 8,000 12,000 Feet

1:48,000

Data Sources:

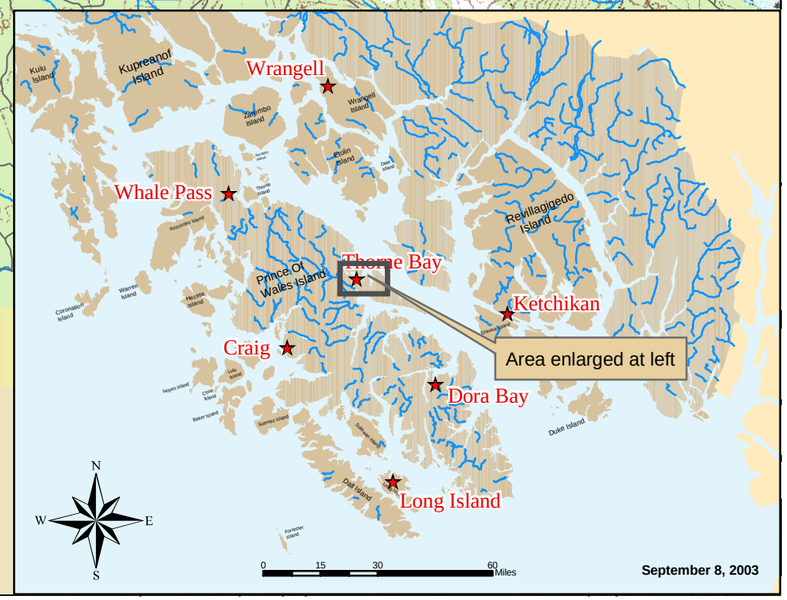
Background image - USGS 1:63,000 mapping
Lakes & streams - U.S. Forest Service, Tongass
Roads, Contours - Shannon & Wilson, Inc.

Protection zones were delineated based upon streams noted on USGS 1:63,000 mapping.

For this PWS, Zone C (the entire watershed) covers the same area as Zone B (areas within 1-mile of the stream).

Legend

- Thorne Bay PWS
- Zone A Protection Area
- Zone B Protection Area
- Zone C Protection Area
- Stream
- Lake



September 8, 2003

APPENDIX B

Contaminant Source Inventory and Risk Rankings (Tables 1-6)

Table 1

Contaminant Source Inventory for ***Thorne Bay***

PWSID 120216.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Map Number*	*Comments*
Beaver/muskrat/otter habitat	B01	B01 - 1	A	2	From operator information , March 2003, Ralph Groshong
Logging areas	E02	E02 1-3	A	2	2 Areas on Tongass GIS data. 1 area visible on aerial photo, operator reports that logging is inactive in the area, March 2003
Highways and roads, dirt/gravel	X24	X24 1-3	A	2	From Tongass GIS data

Table 2

Contaminant Source Inventory and Risk Ranking for Thorne Bay
Sources of Bacteria and Viruses

PWSID 120216.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Beaver/muskrat/otter habitat	B01	B01 - 1	A	High	2	From operator information , March 2003, Ralph Groshong
Highways and roads, dirt/gravel	X24	X24 1-3	A	Low	2	From Tongass GIS data

Table 3

Contaminant Source Inventory and Risk Ranking for Thorne Bay
Sources of Nitrates/Nitrites

PWSID 120216.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Beaver/muskrat/otter habitat	B01	B01 - 1	A	High	2	From operator information , March 2003, Ralph Groshong
Logging areas	E02	E02 1-3	A	Low	2	2 Areas on Tongass GIS data. 1 area visible on aerial photo, operator reports that logging is inactive in the area, March 2003
Highways and roads, dirt/gravel	X24	X24 1-3	A	Low	2	From Tongass GIS data

Table 4

Contaminant Source Inventory and Risk Ranking for Thorne Bay
Sources of Volatile Organic Chemicals

PWSID 120216.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Logging areas	E02	E02 1-3	A	Medium	2	2 Areas on Tongass GIS data. 1 area visible on aerial photo, operator reports that logging is inactive in the area, March 2003
Highways and roads, dirt/gravel	X24	X24 1-3	A	Low	2	From Tongass GIS data

Table 5

Contaminant Source Inventory and Risk Ranking for Thorne Bay

Sources of Heavy Metals, Cyanide and Other Inorganic Chemicals

PWSID 120216.001

Contaminant Source Type	*Contaminant Source ID*	*CS ID tag*	*Zone*	*Risk Ranking for Analysis*	*Map Number*	*Comments*
Logging areas	E02	E02 1-3	A	Low	2	2 Areas on Tongass GIS data. 1 area visible on aerial photo, operator reports that logging is inactive in the area, March 2003
Highways and roads, dirt/gravel	X24	X24 1-3	A	Low	2	From Tongass GIS data

Table 6

Contaminant Source Inventory and Risk Ranking for Thorne Bay
Sources of Other Organic Chemicals

PWSID 120216.001

Contaminant Source Type	***Contaminant Source ID***	***CS ID tag***	***Zone***	***Risk Ranking for Analysis***	***Map Number***	***Comments***
Highways and roads, dirt/gravel	X24	X24 1-3	A	Low	2	From Tongass GIS data

APPENDIX C

Thorne Bay
Drinking Water Protection Area
and Potential and Existing Contaminant Sources
(Map 2)

E02 - 1
(Logging Areas - inactive)

B01 - 1
(Beaver Habitat)

PWS Intake

Water Lake

X24 - 1 through 3
(Gravel Roads)

E02 - 2
(Logging Areas - inactive)

E02 - 3
(Logging Areas - inactive)

Deer Creek

Thorne Bay

Area enlarged at left

Map 2: Potential and Existing Contaminant Sources

PWSID: 120216.001

Alaska Department of Environmental Conservation

Alaska Drinking Water Protection Program

0 500 1,000 2,000 3,000 Feet

1:12,000

Data Sources:

Background image - Shannon & Wilson, Inc.
Lakes, streams, & roads - U.S. Forest Service
Roads, contours - Shannon & Wilson, Inc.

Protection zones were delineated based upon streams noted on USGS 1:63,000 mapping.

For this PWS, Zone C (the entire watershed) covers the same area as Zone B (areas within 1-mile of the stream).

Legend

- Thorne Bay PWS
- Zone A Protection Area
- Zone B Protection Area
- Zone C Protection Area
- Lake
- Streams
- Roads
- 100-ft Contours

N W E S

0 0.75 1.5 3 Miles

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APPENDIX D

Vulnerability Analysis and Contaminant Risks
(Charts 1-13)

Chart 1. Susceptibility of the Surface Water Source - Thorne Bay

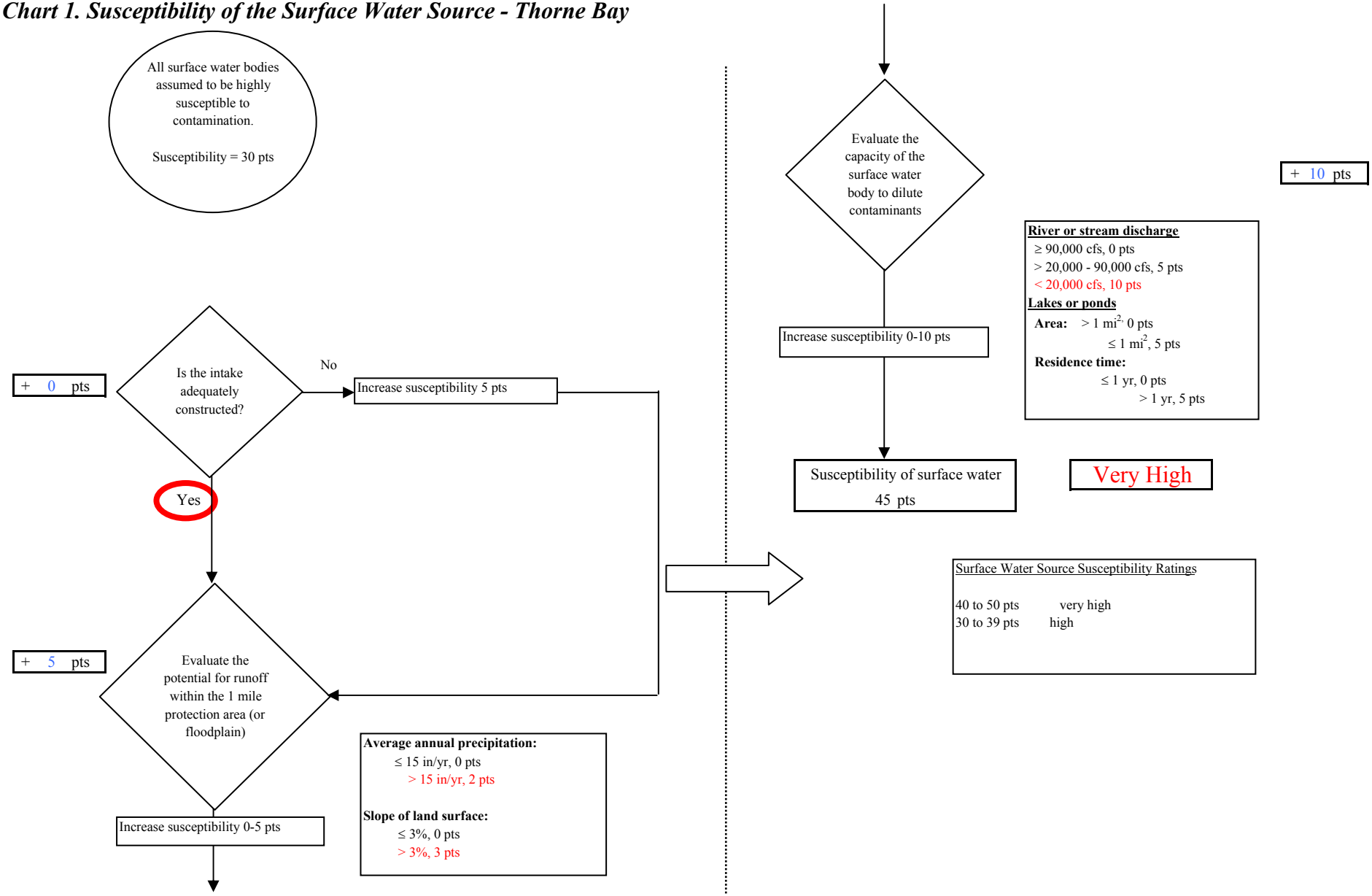
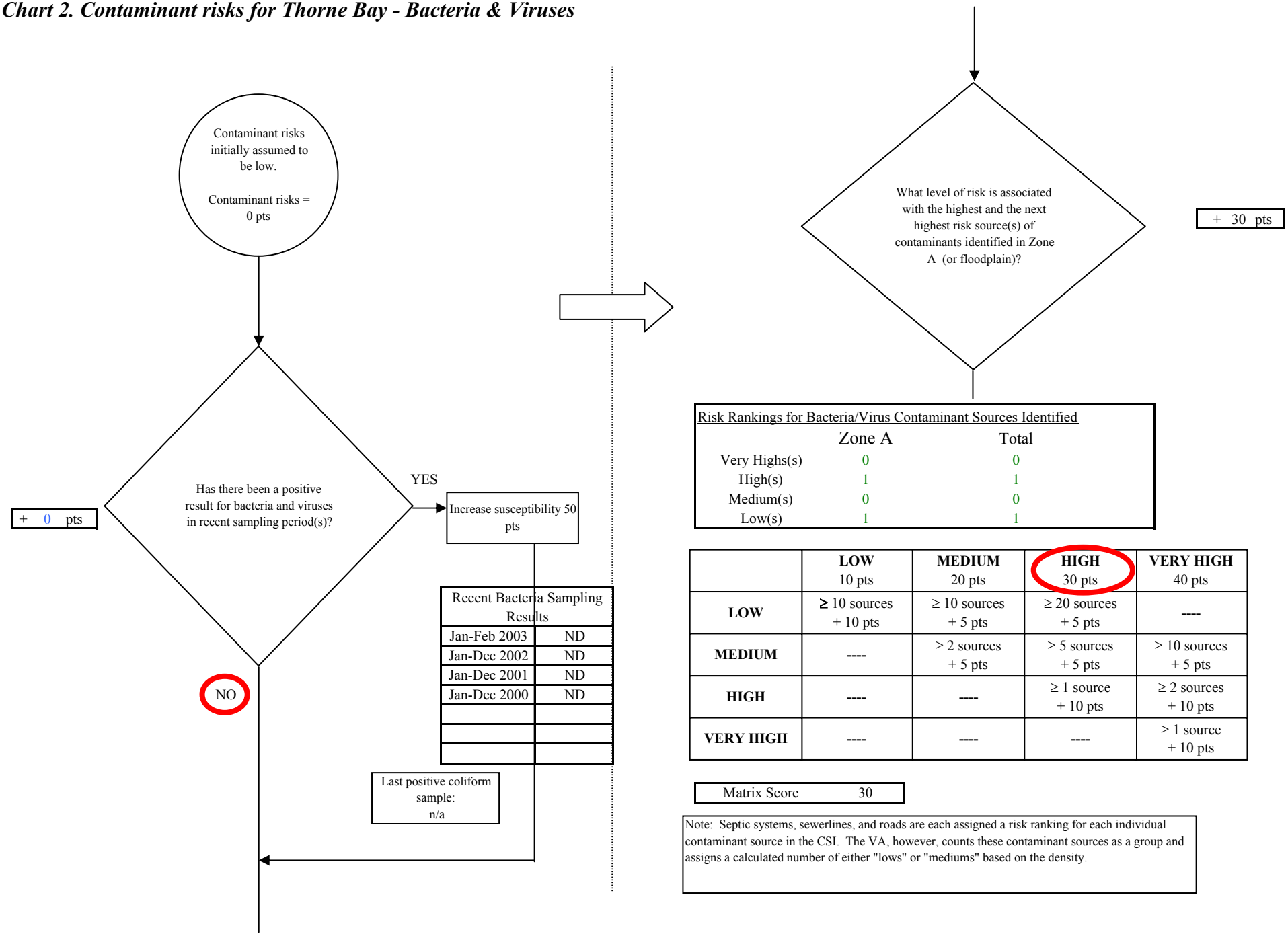


Chart 2. Contaminant risks for Thorne Bay - Bacteria & Viruses



Risk Rankings for Bacteria/Virus Contaminant Sources Identified

	Zone A	Total
Very Highs(s)	0	0
High(s)	1	1
Medium(s)	0	0
Low(s)	1	1

	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 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 2. Contaminant risks for Thorne Bay - Bacteria & Viruses

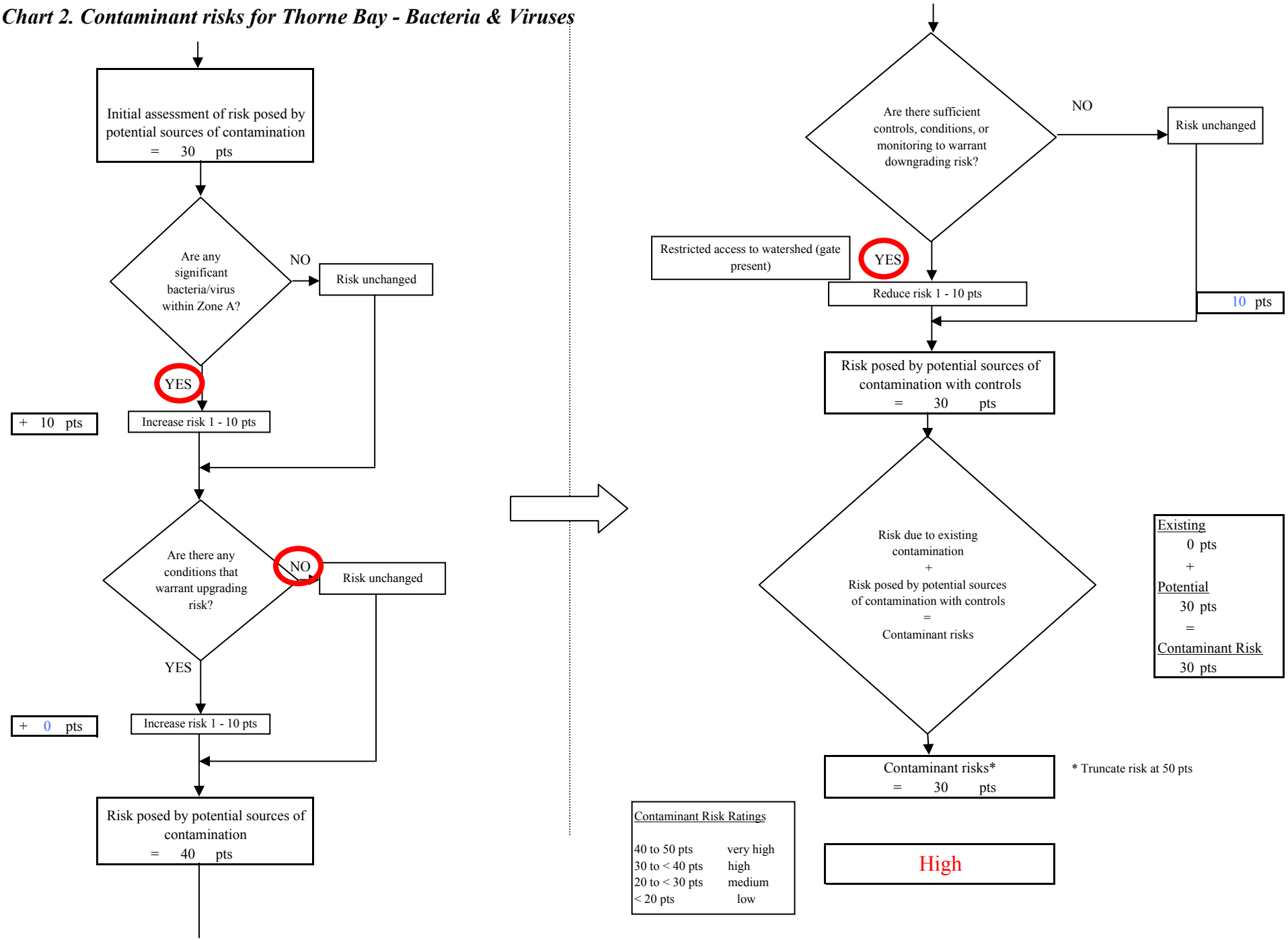


Chart 3. Vulnerability analysis for Thorne Bay - Bacteria & Viruses

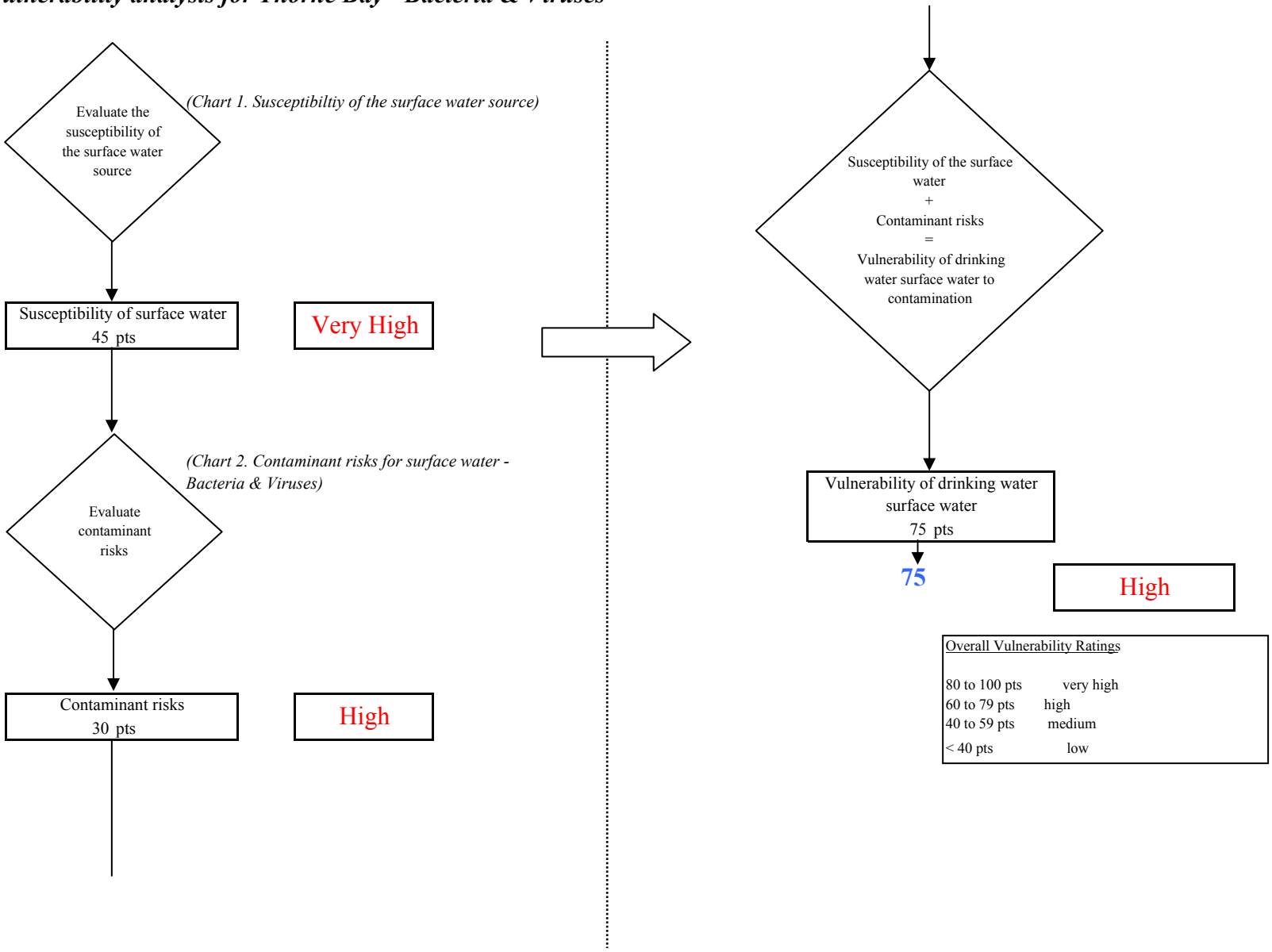


Chart 4. Contaminant risks for Thorne Bay - Nitrates and Nitrites

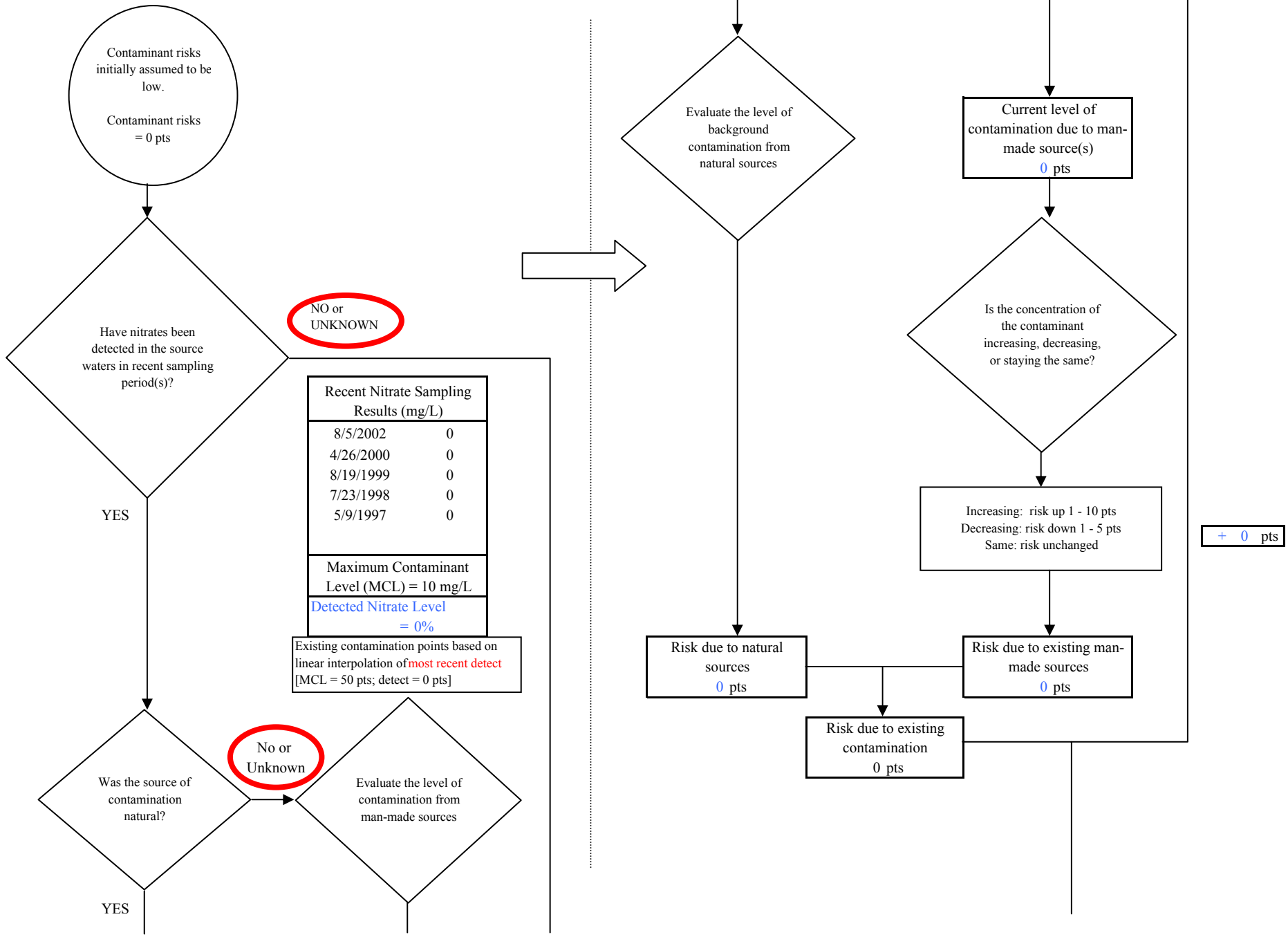


Chart 4. Contaminant risks for Thorne Bay - Nitrates and Nitrites

+ 30 pts

What level of risk is associated with the highest and the next highest risk sources(s) of contaminants identified in Zones A and B? (see Risk Matrix below)

Initial assessment of risk posed by potential sources of contamination = 30 pts

Are any significant nitrate/nitrite sources in Zone A?

NO → Risk unchanged

YES → Increase risk 1 - 10 pts

+ 10 pts

Risk Levels for Nitrate/Nitrite Sources identified in Zones A and B

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

	LOW 10 pts	**MEDIUM** 20 pts	**HIGH** 30 pts	**VERY HIGH** 40 pts
LOW	≥ 10 sources + 10 pts	≥ 10 sources + 5 pts	≥ 20 sources + 5 pts	----
MEDIUM	----	≥ 2 sources + 5 pts	≥ 5 sources + 5 pts	≥ 10 sources + 5 pts
HIGH	----	----	≥ 1 source + 10 pts	≥ 2 sources + 10 pts
VERY HIGH	----	----	----	≥ 1 source + 10 pts

Matrix Score 30

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 4. Contaminant risks for Thorne Bay - Nitrates and Nitrites

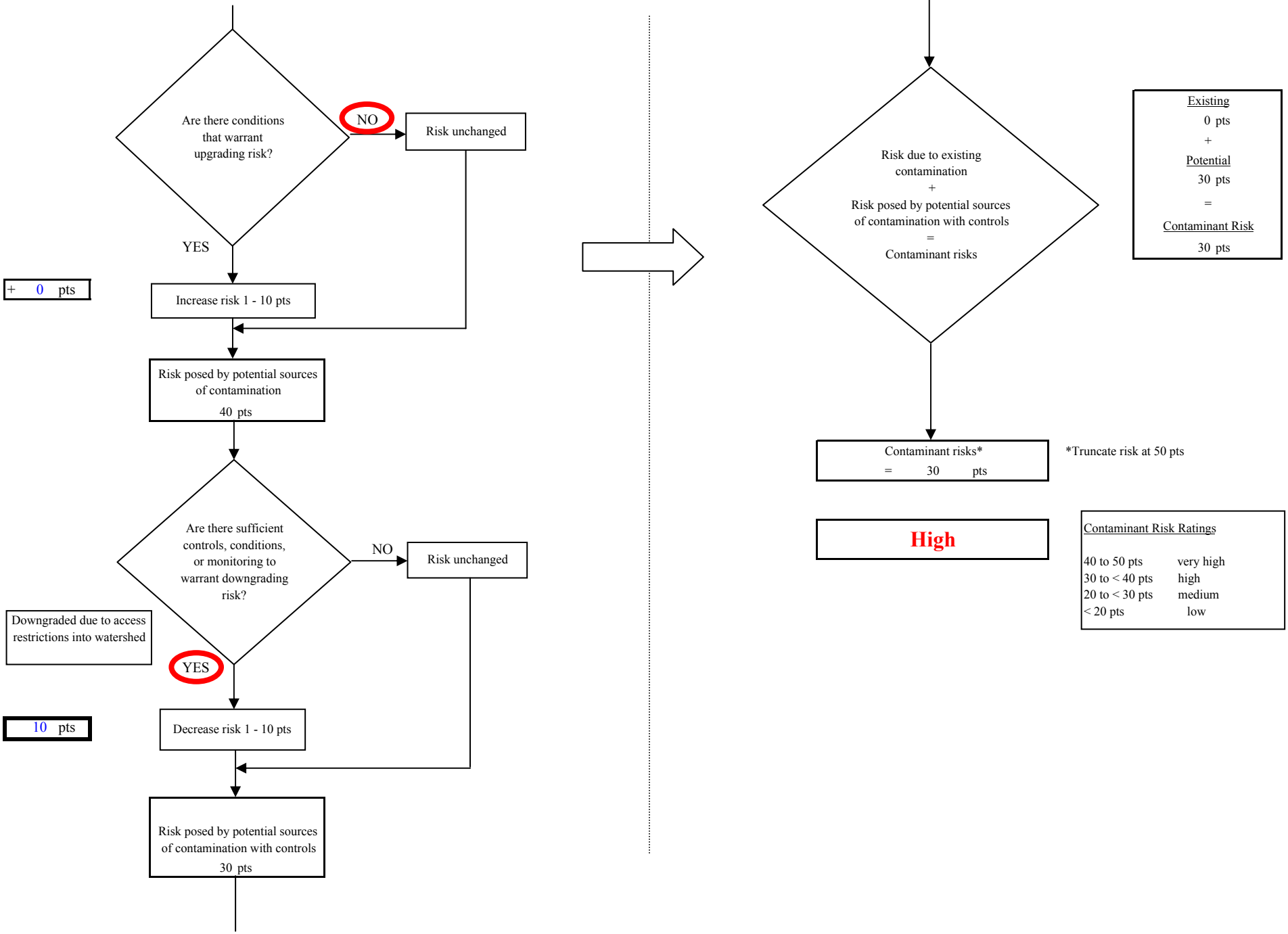


Chart 5. Vulnerability analysis for Thorne Bay - Nitrates and Nitrites

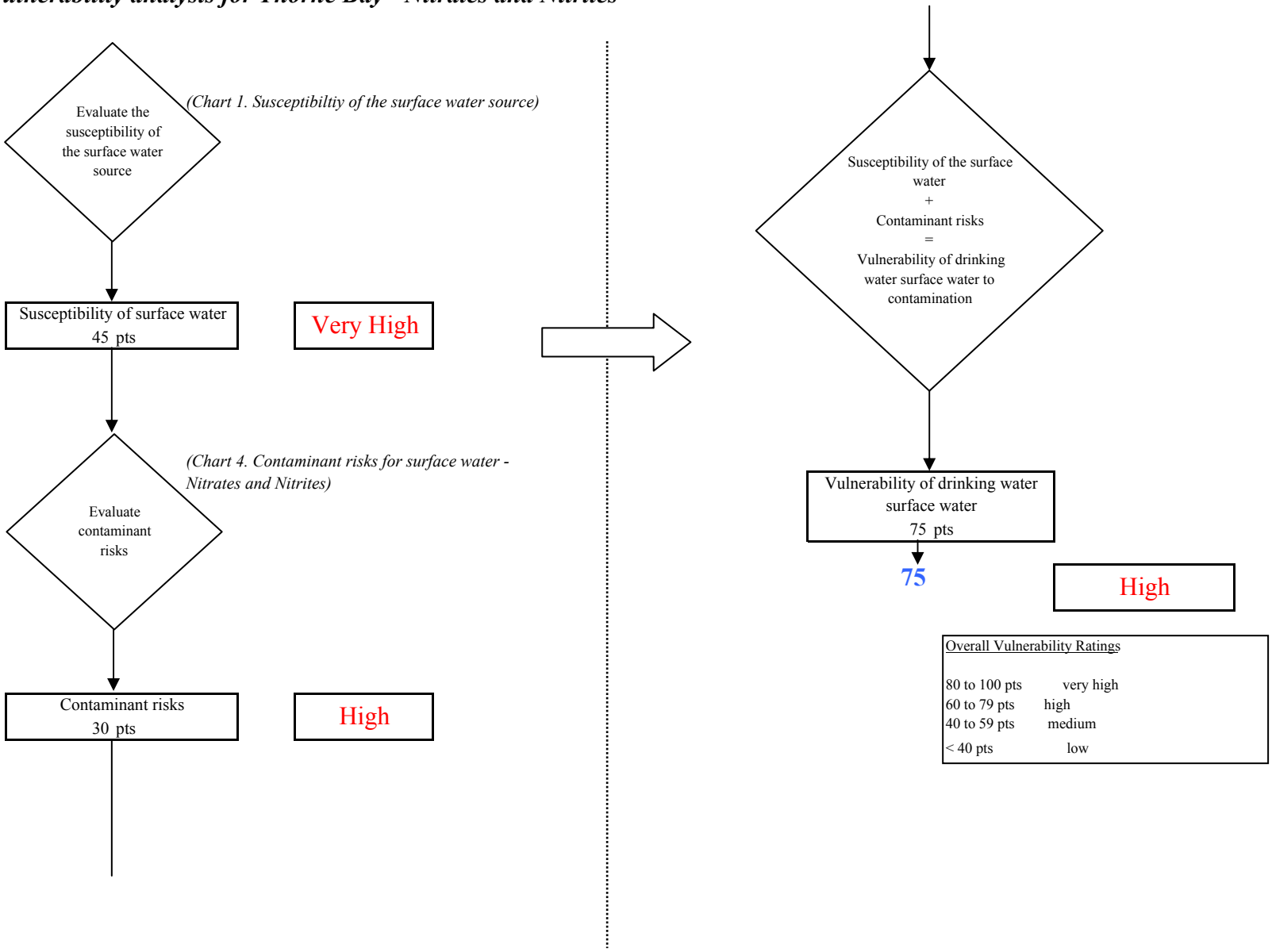


Chart 6. Contaminant risks for Thorne Bay - Volatile Organic Chemicals

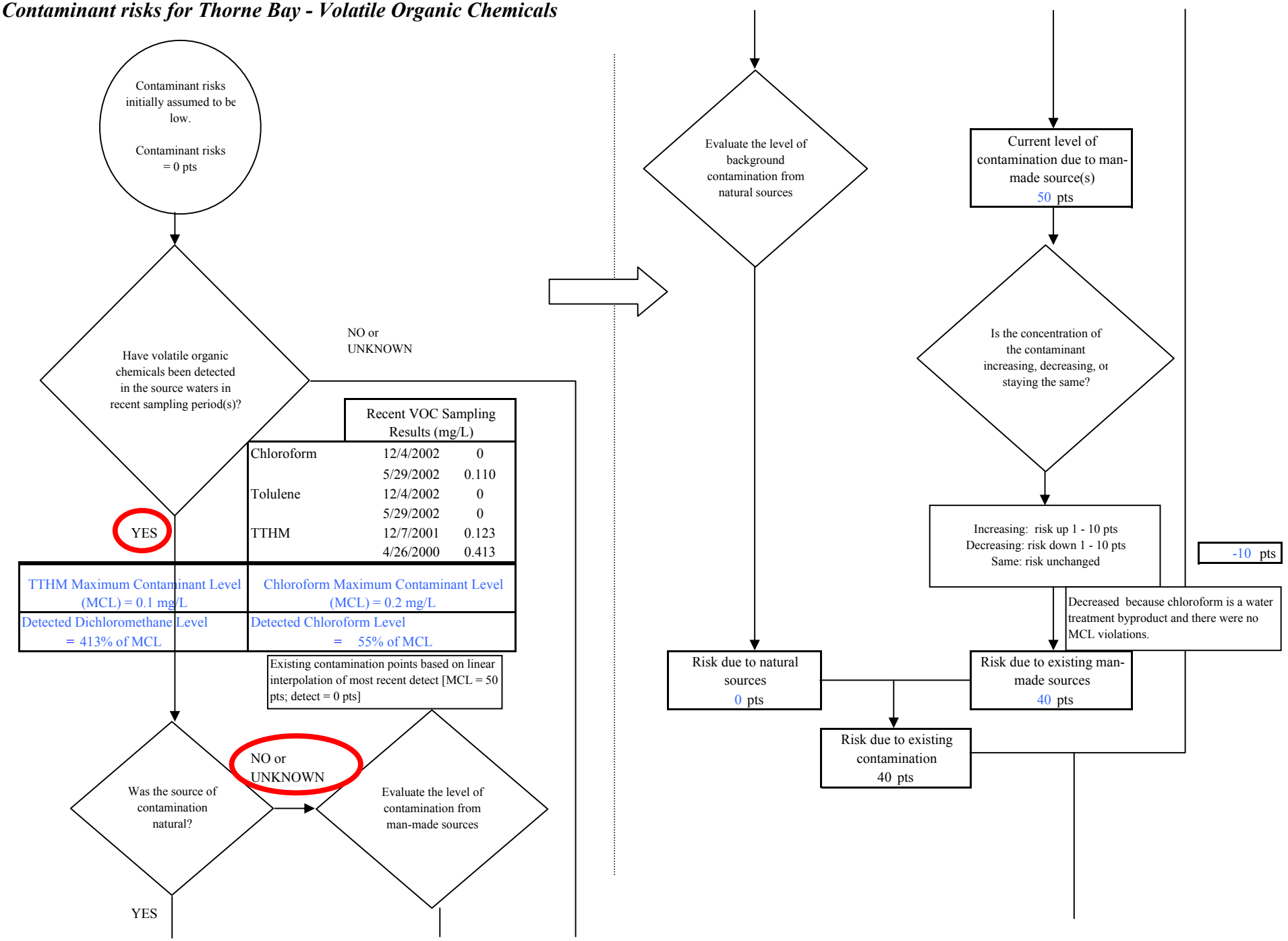
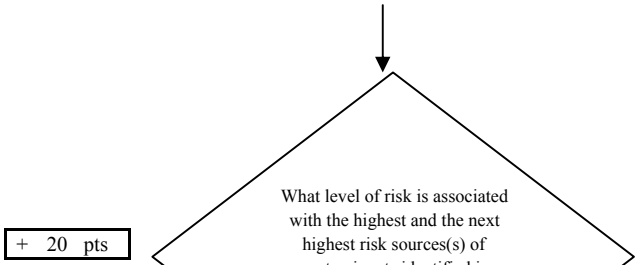


Chart 6. Contaminant risks for Thorne Bay - Volatile Organic Chemicals



+ 20 pts

Risk Levels for VOC 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)	1		1
Low(s)	1		1

	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.

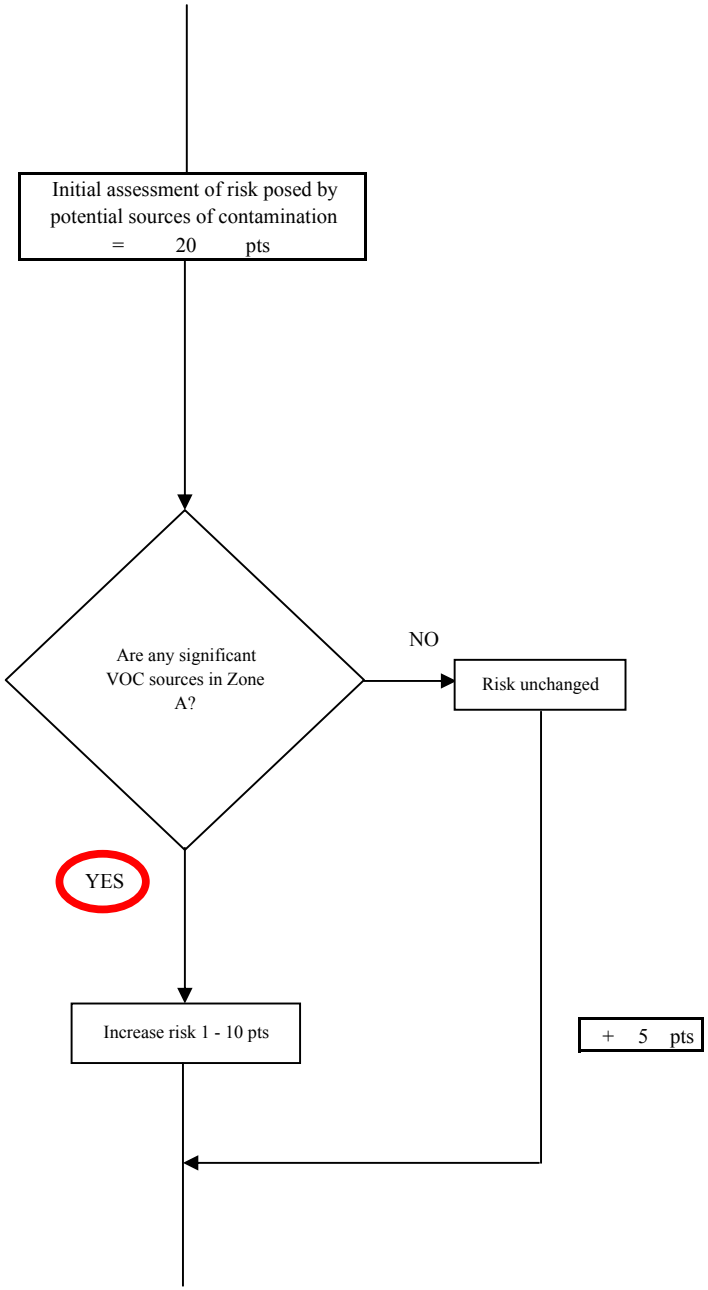


Chart 6. Contaminant risks for Thorne Bay - Volatile Organic Chemicals

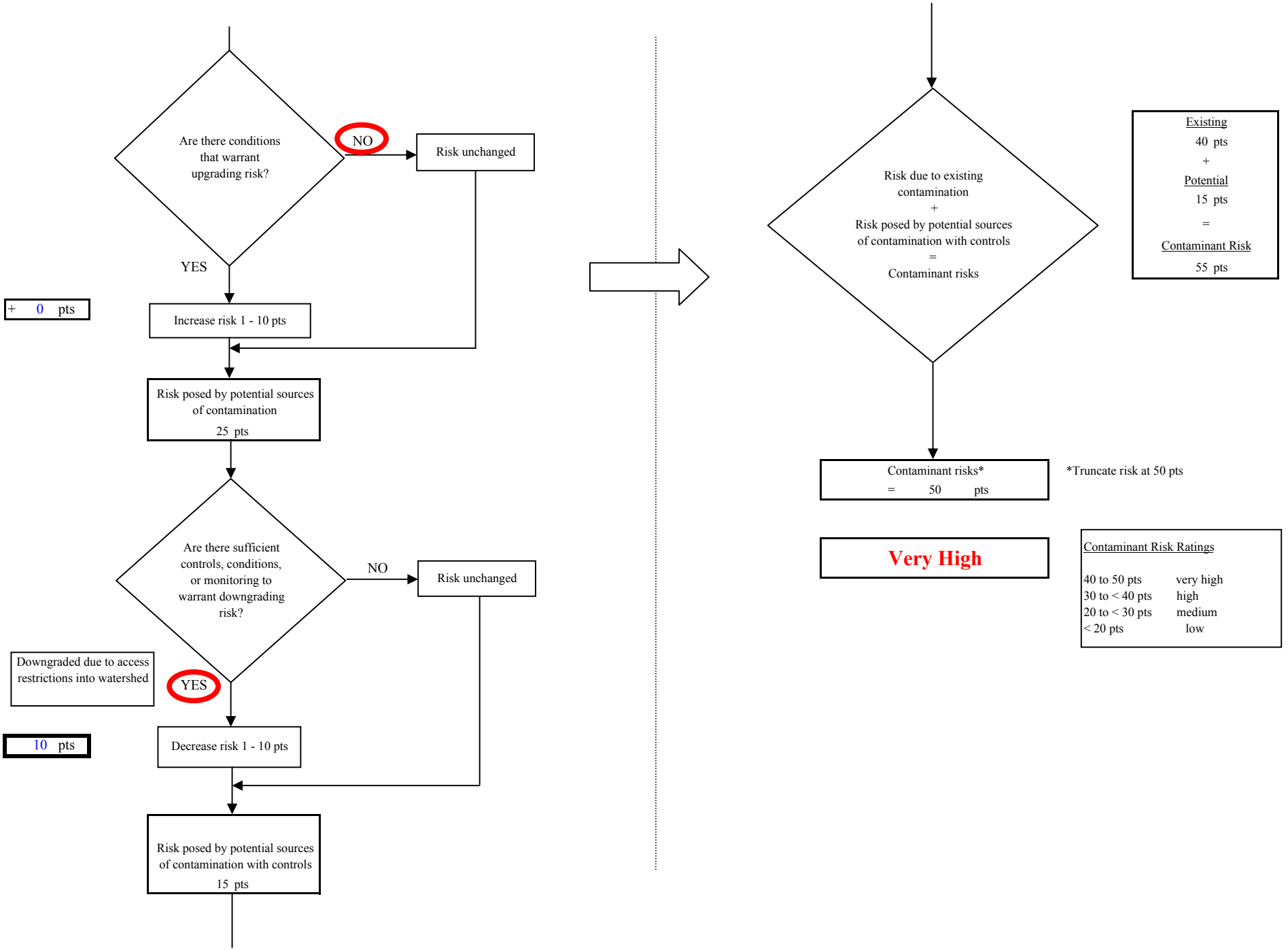

Are there conditions that warrant upgrading risk?
NO
Risk unchanged
YES
+ 0 pts
Increase risk 1 - 10 pts
Risk posed by potential sources of contamination
25 pts
Are there sufficient controls, conditions, or monitoring to warrant downgrading risk?
NO
Risk unchanged
Downgraded due to access restrictions into watershed
YES
10 pts
Decrease risk 1 - 10 pts
Risk posed by potential sources of contamination with controls
15 pts
Risk due to existing contamination
+
Risk posed by potential sources of contamination with controls
=
Contaminant risks
Existing
40 pts
+
Potential
15 pts
=
Contaminant Risk
55 pts
Contaminant risks*
= 50 pts
*Truncate risk at 50 pts
Very High
Contaminant Risk Ratings
40 to 50 pts very high
30 to < 40 pts high
20 to < 30 pts medium
< 20 pts low

Chart 7. Vulnerability analysis for Thorne Bay - Volatile Organic Chemicals

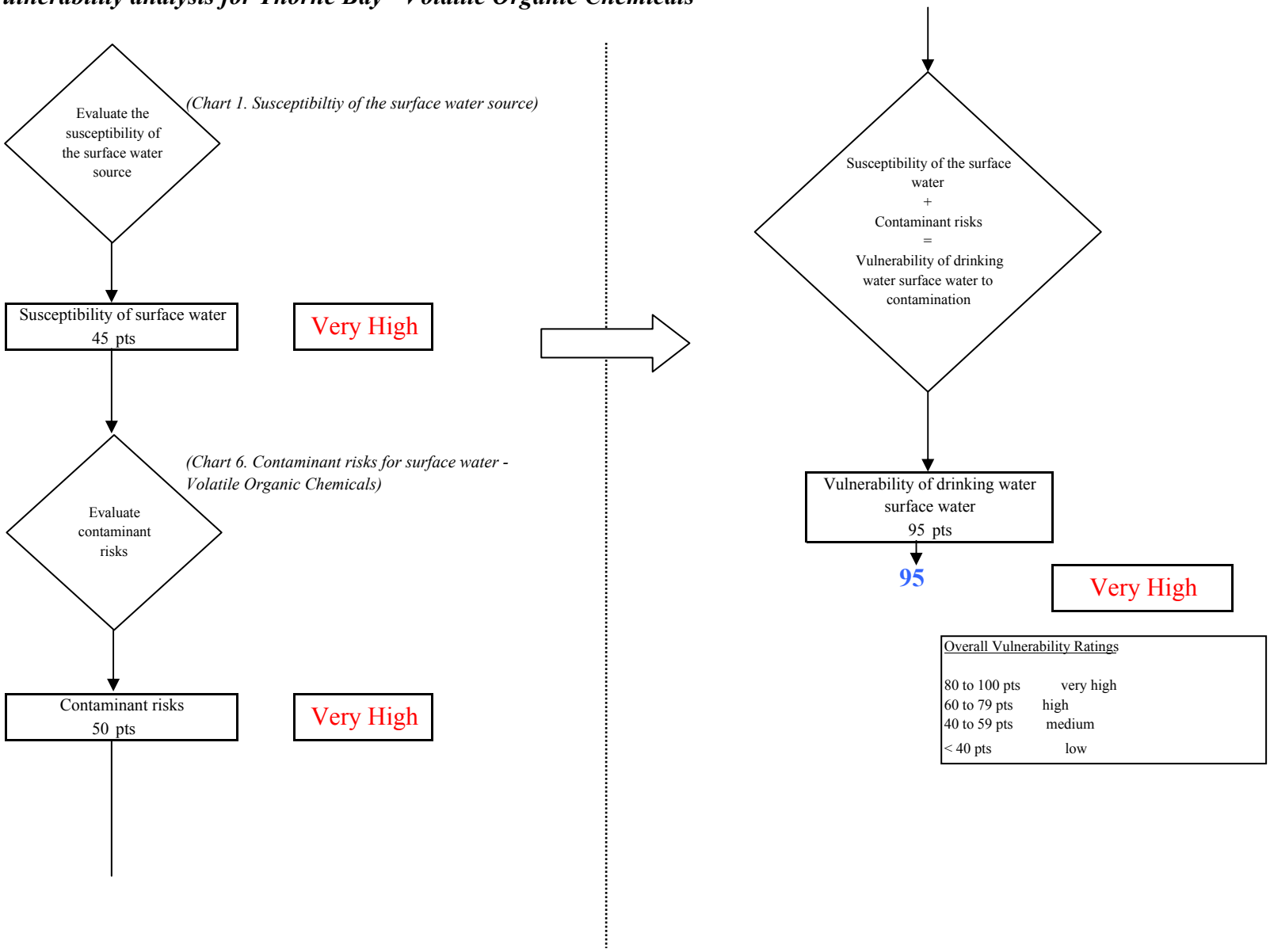


Chart 8. Contaminant risks for Thorne Bay - Heavy Metals, Cyanide and Other Inorganic Chemicals

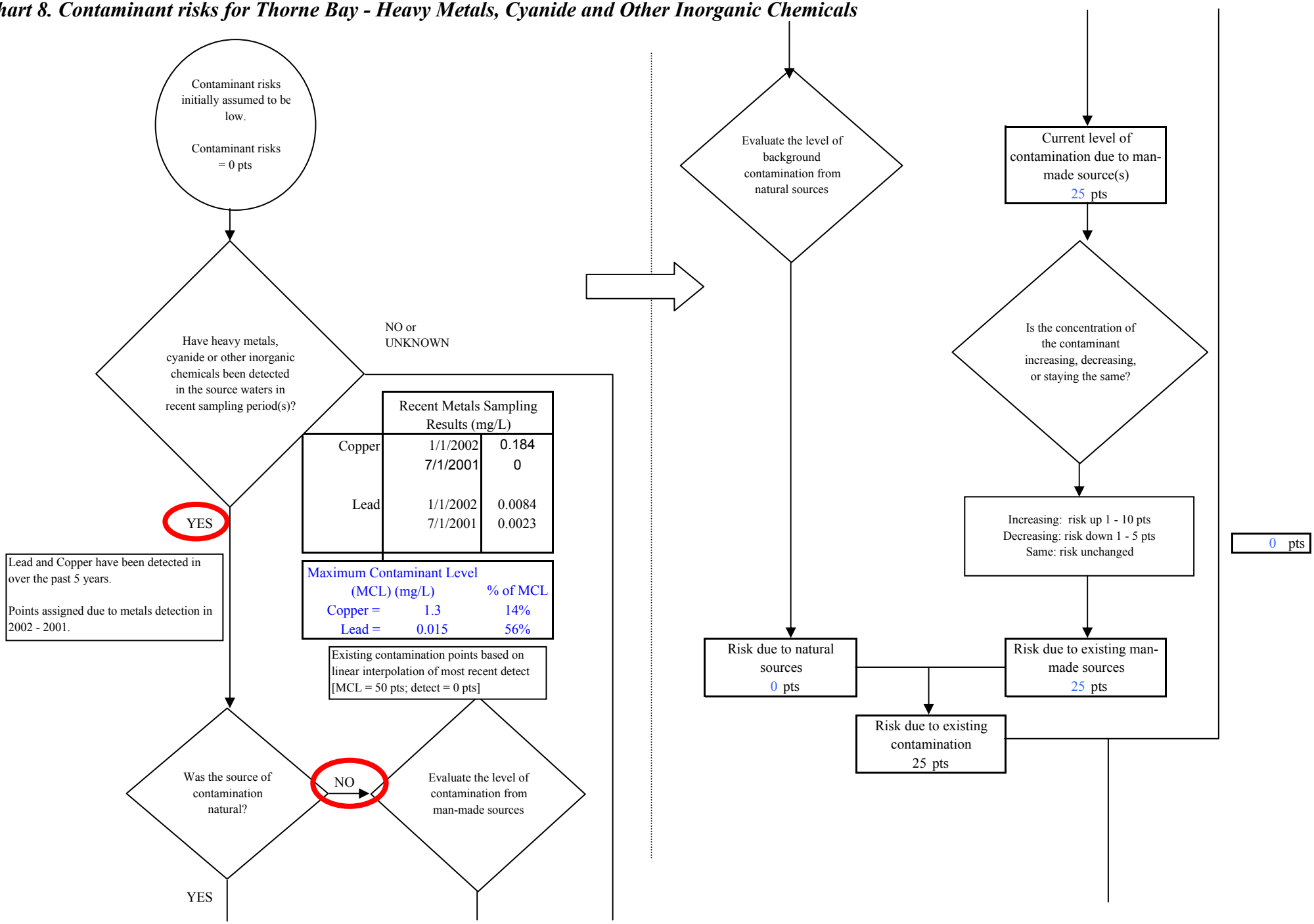


Chart 8. Contaminant risks for Thorne Bay - Heavy Metals, Cyanide and Other Inorganic Chemicals

+ 10 pts

What level of risk is associated with the highest and the next highest risk sources(s) of contaminants identified in Zones A and B? (see Risk Matrix below)

Risk Levels for HM, Cyanide, or OIC 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
Low(s)	2		2

	LOW 10 pts	**MEDIUM** 20 pts	**HIGH** 30 pts	**VERY HIGH** 40 pts
LOW	≥ 10 sources + 10 pts	≥ 10 sources + 5 pts	≥ 20 sources + 5 pts	----
MEDIUM	----	≥ 2 sources + 5 pts	≥ 5 sources + 5 pts	≥ 10 sources + 5 pts
HIGH	----	----	≥ 1 source + 10 pts	≥ 2 sources + 10 pts
VERY HIGH	----	----	----	≥ 1 source + 10 pts

Matrix Score 10

Note: Septic systems, sewerlines, and roads are each assigned a risk ranking for each 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

Are any significant HM, Cyanide, or OIC sources in Zone A?

NO

Risk unchanged

YES

Increase risk 1 - 10 pts

+ 2 pts

Chart 8. Contaminant risks for Thorne Bay - Heavy Metals, Cyanide and Other Inorganic Chemicals

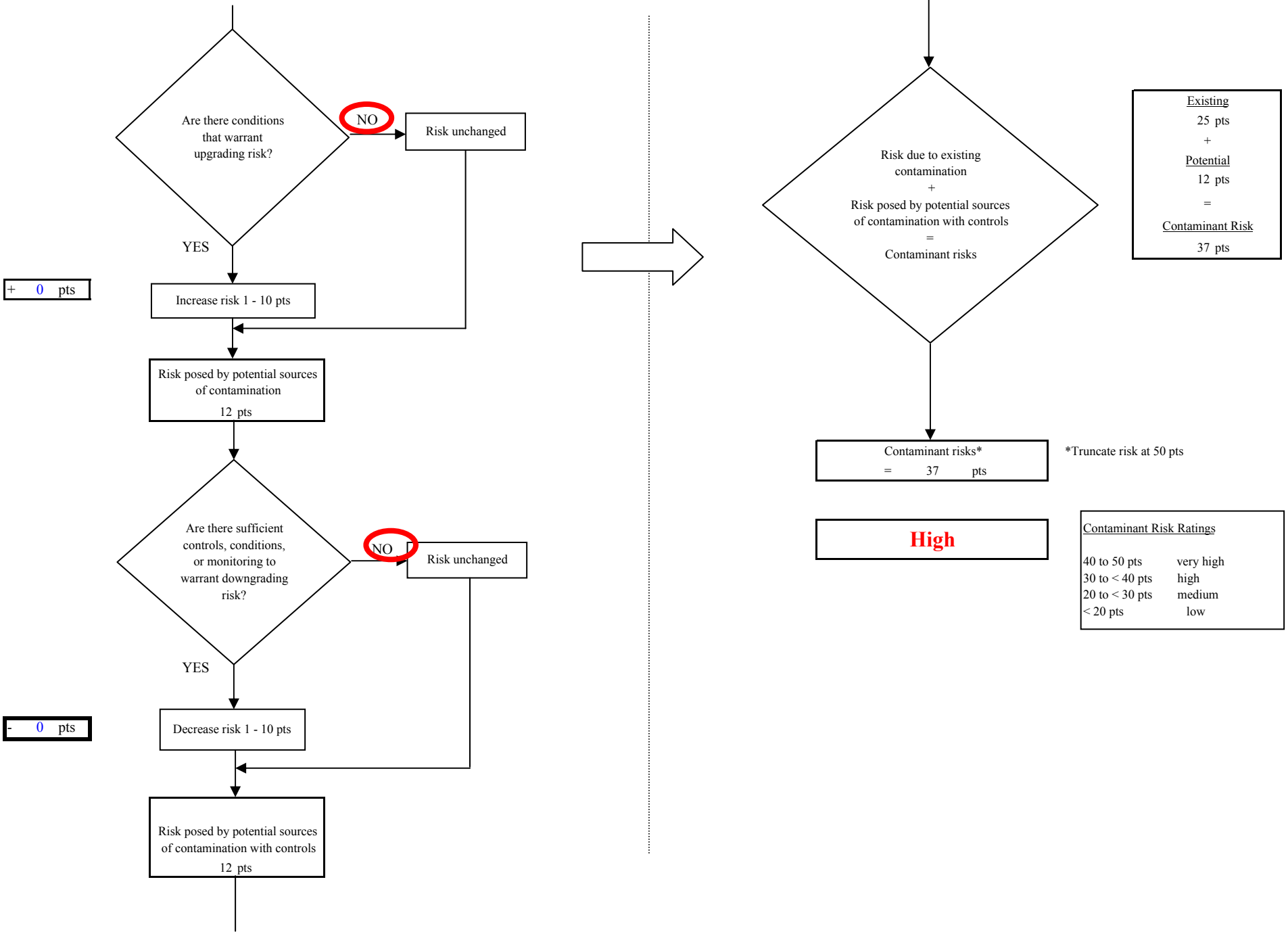


Chart 9. Vulnerability analysis for Thorne Bay - Heavy Metals, Cyanide and Other Inorganic Chemicals

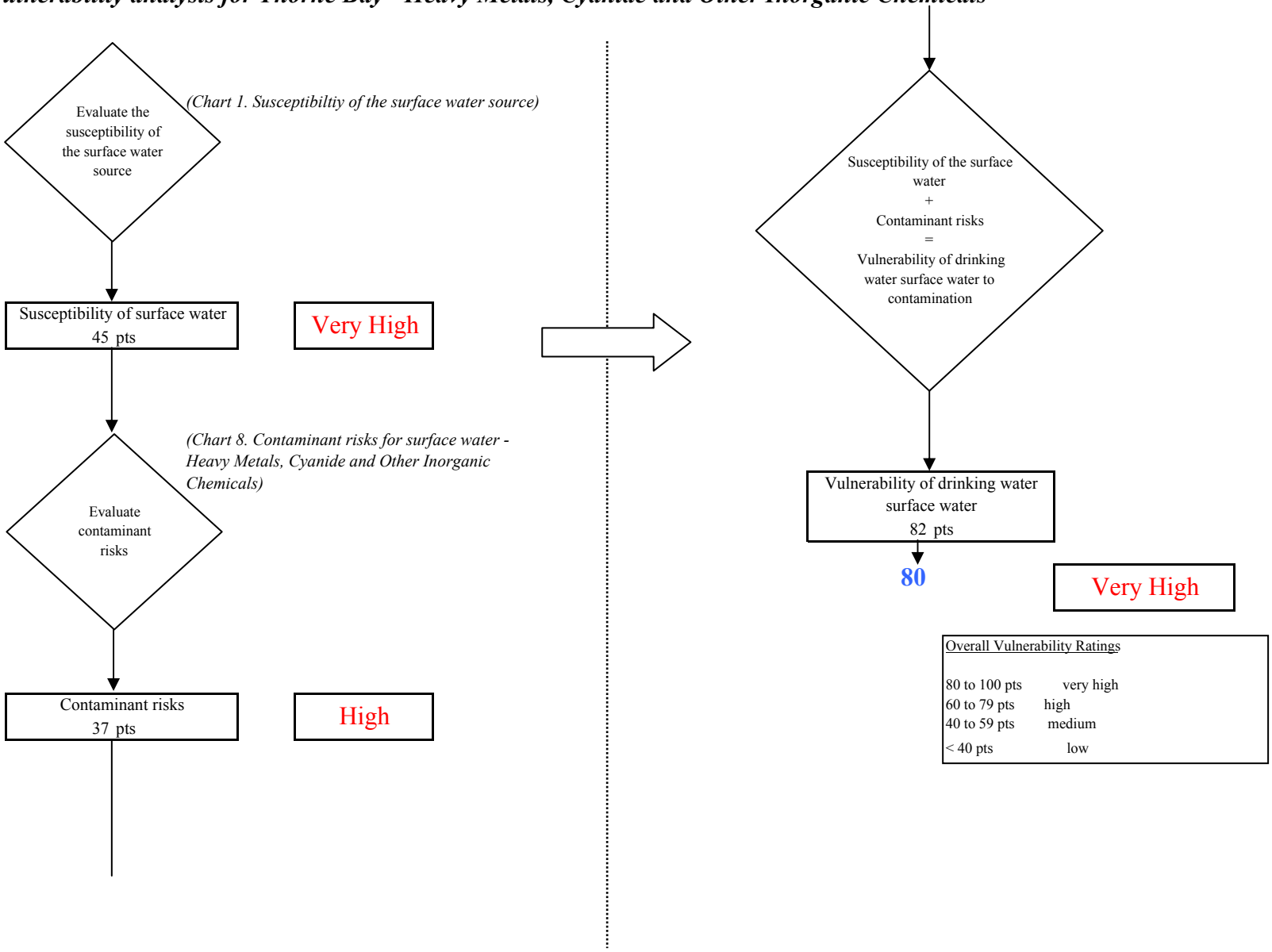


Chart 10. Contaminant risks for Thorne Bay - Synthetic Organic Chemicals

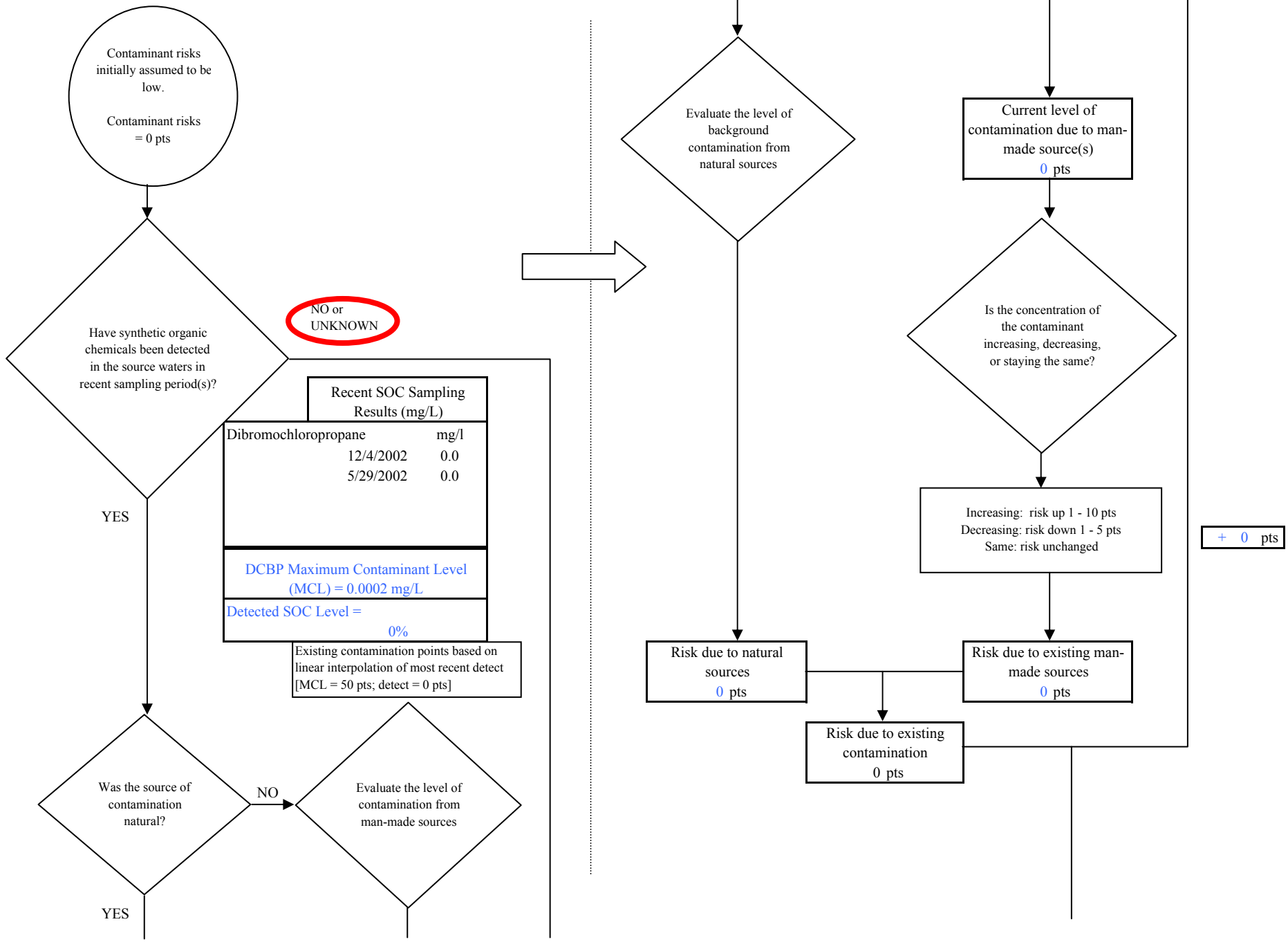


Chart 10. Contaminant risks for Thorne Bay - Synthetic Organic Chemicals

+ 0 pts

What level of risk is associated with the highest and the next highest risk sources(s) of contaminants identified in Zones A and B? (see Risk Matrix below)

Risk Levels for SOC Sources identified in Zones A and C

	Zone A	Zone B	Total
Very Highs(s)	0	0	0
High(s)	0	0	0
Medium(s)	0	0	0
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 0

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 = 0 pts

Are any significant SOC sources in Zone A?

NO

Risk unchanged

YES

Increase risk 1 - 10 pts

+ 0 pts

Chart 10. Contaminant risks for Thorne Bay - Synthetic Organic Chemicals

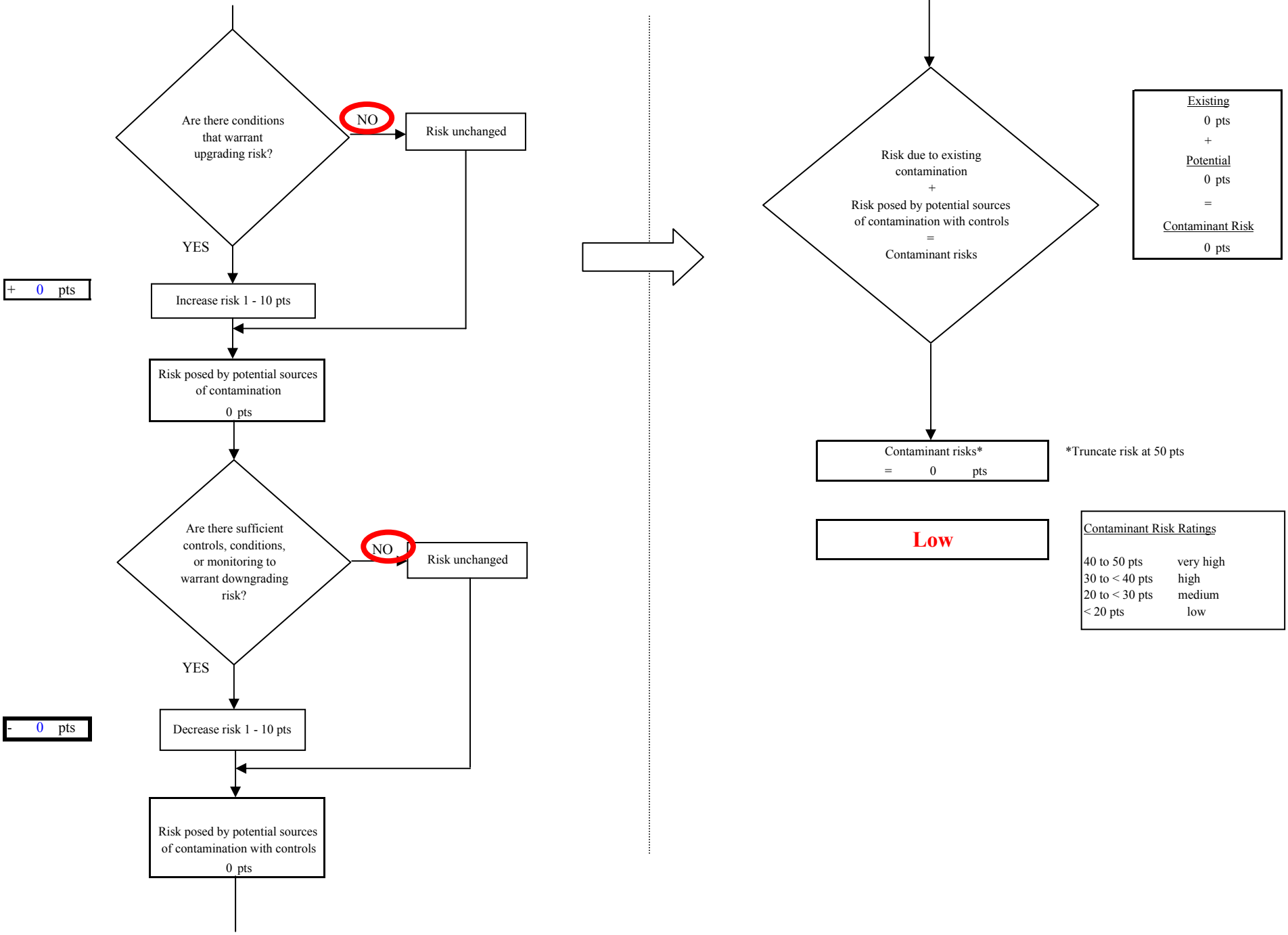


Chart 11. Vulnerability analysis for Thorne Bay - Synthetic Organic Chemicals

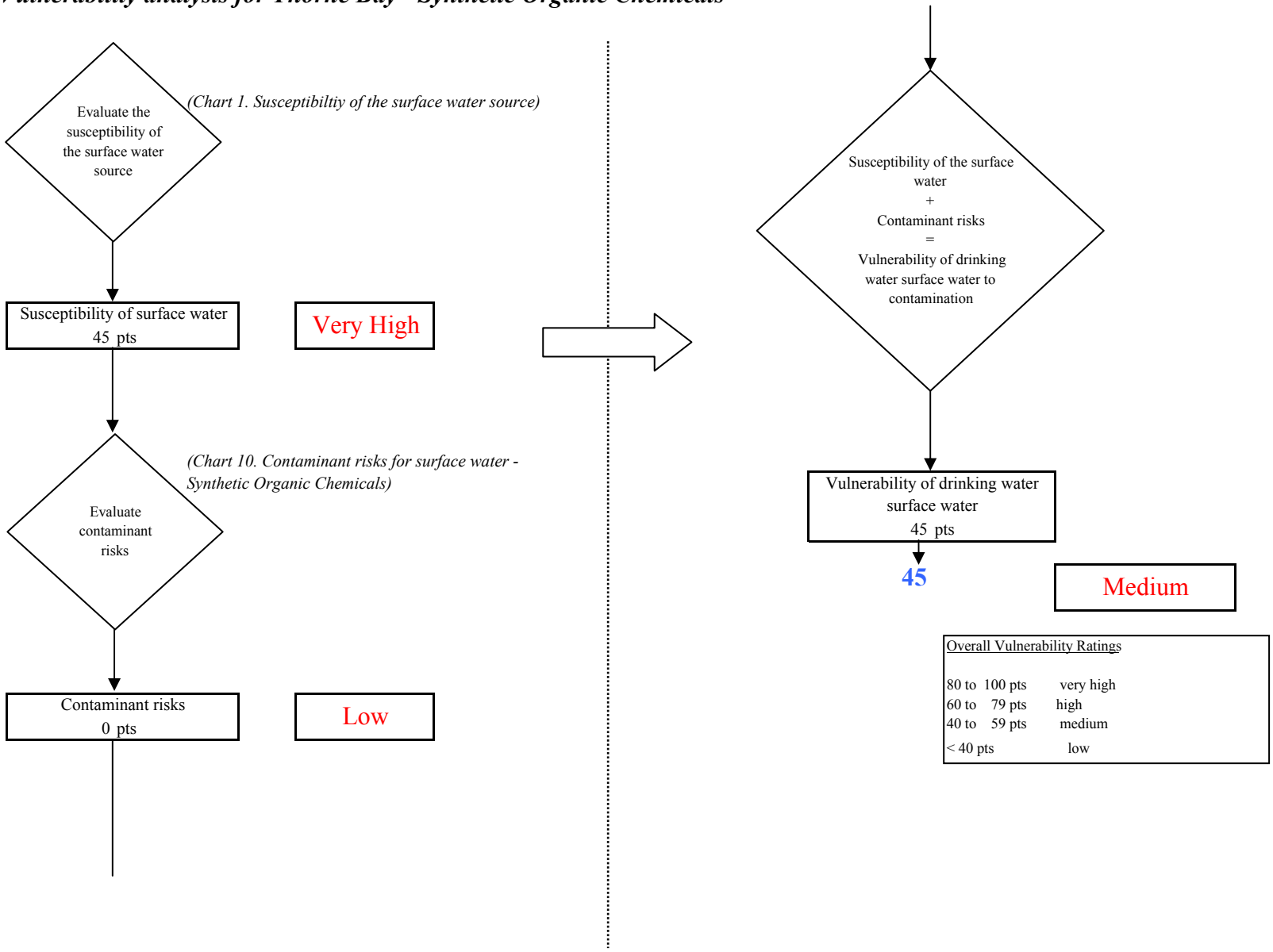


Chart 12. Contaminant risks for Thorne Bay - Other Organic Chemicals

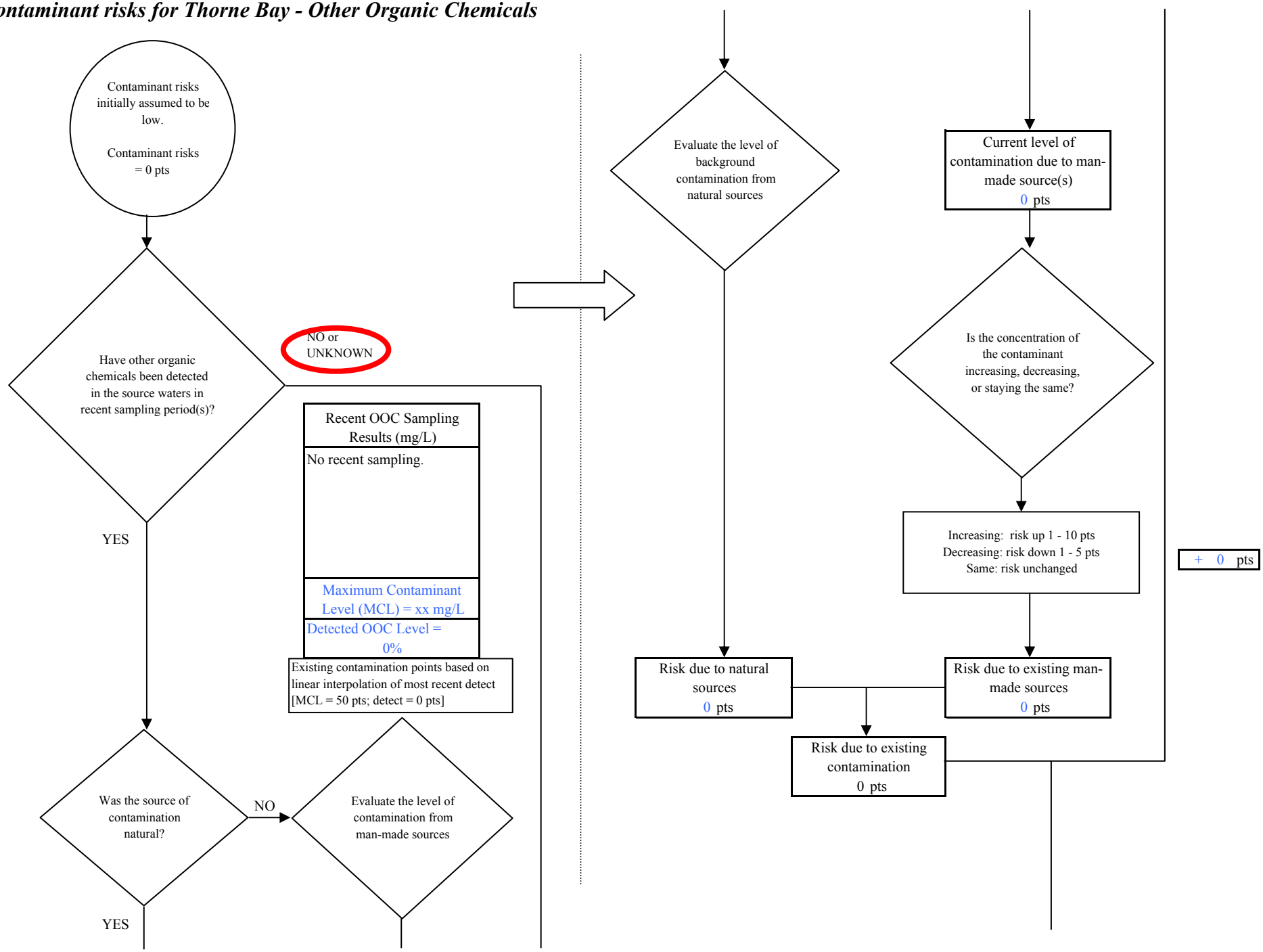
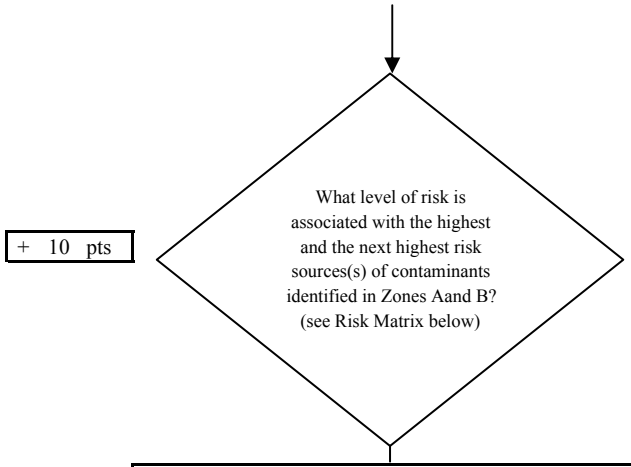


Chart 12. Contaminant risks for Thorne Bay - Other Organic Chemicals



+ 10 pts

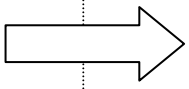
Risk Levels for OOC Sources identified in Zones A and B

	Zone A	Zone B	Total
Very Highs(s)	0	0	0
High(s)	0	0	0
Medium(s)	0	0	0
Low(s)	1	0	1

	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.



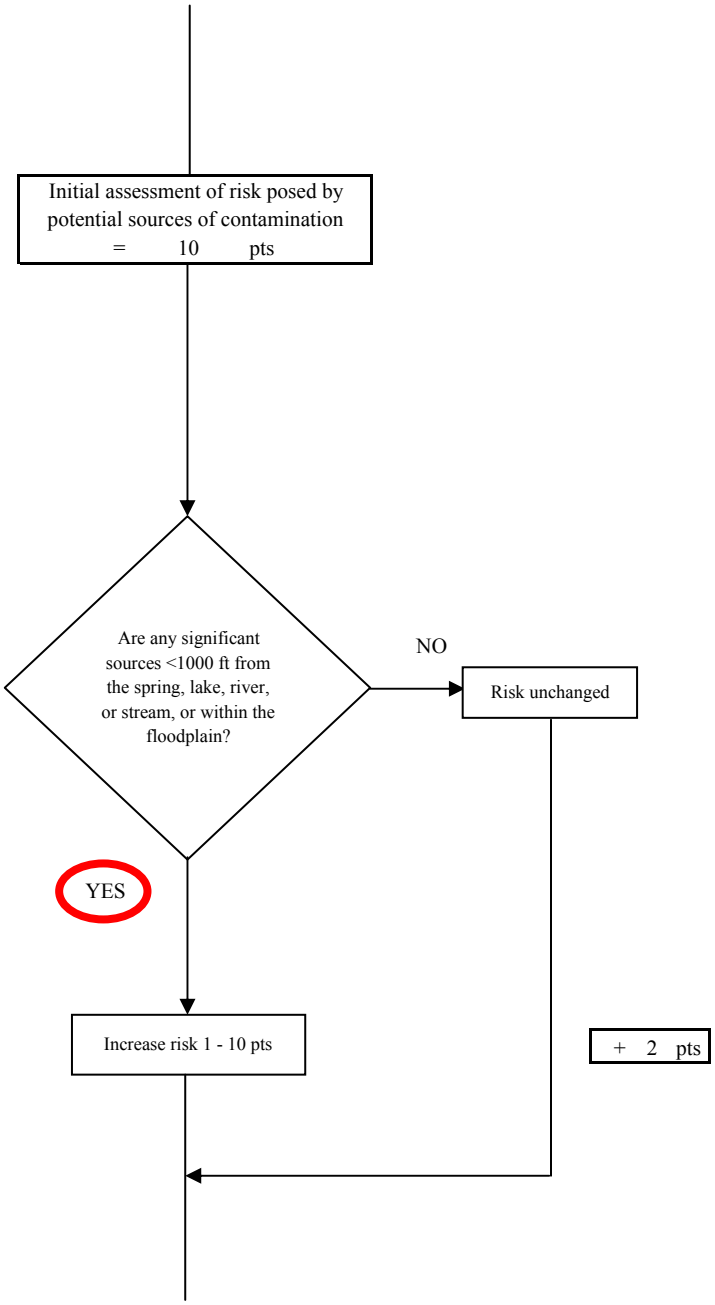
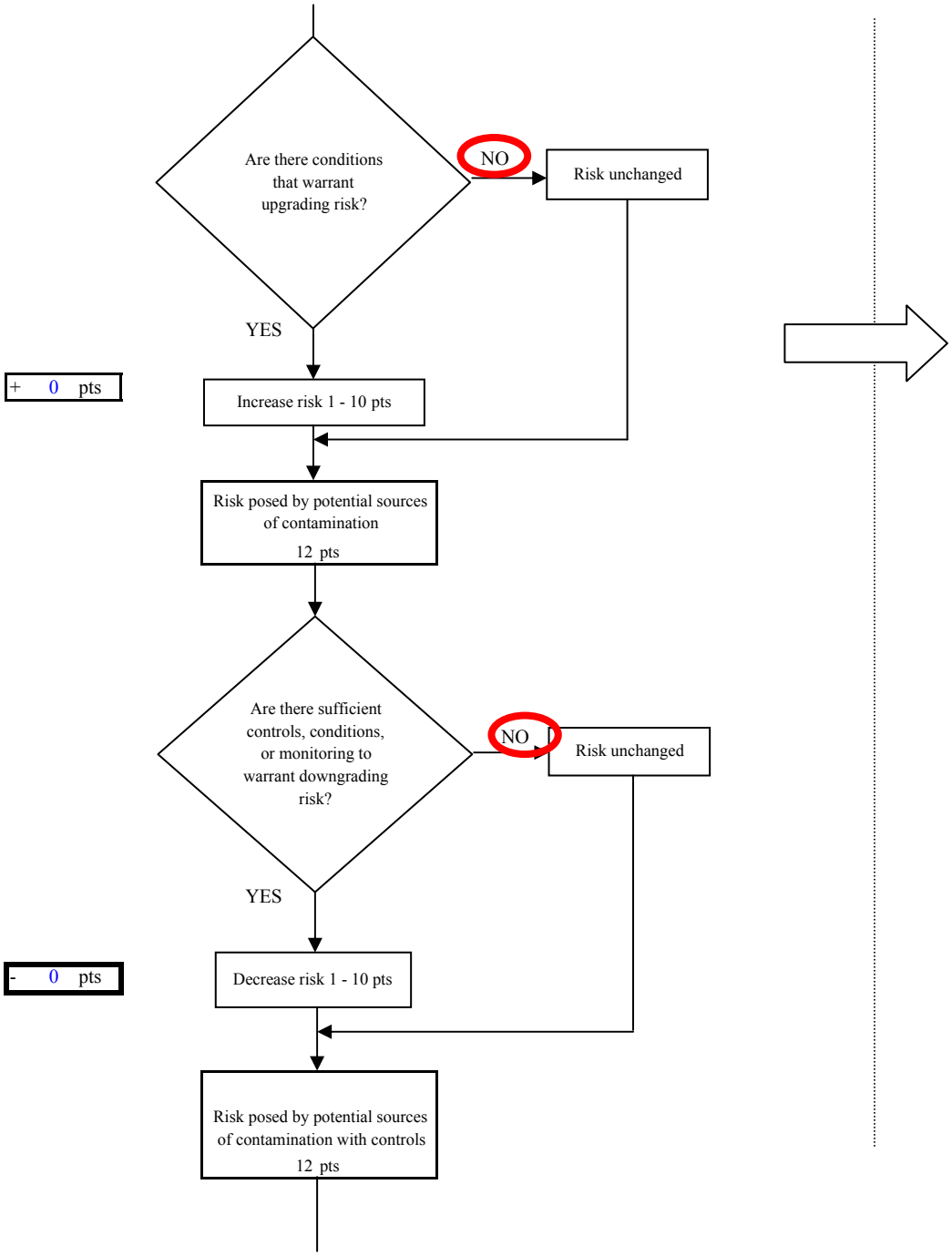


Chart 12. Contaminant risks for Thorne Bay - Other Organic Chemicals



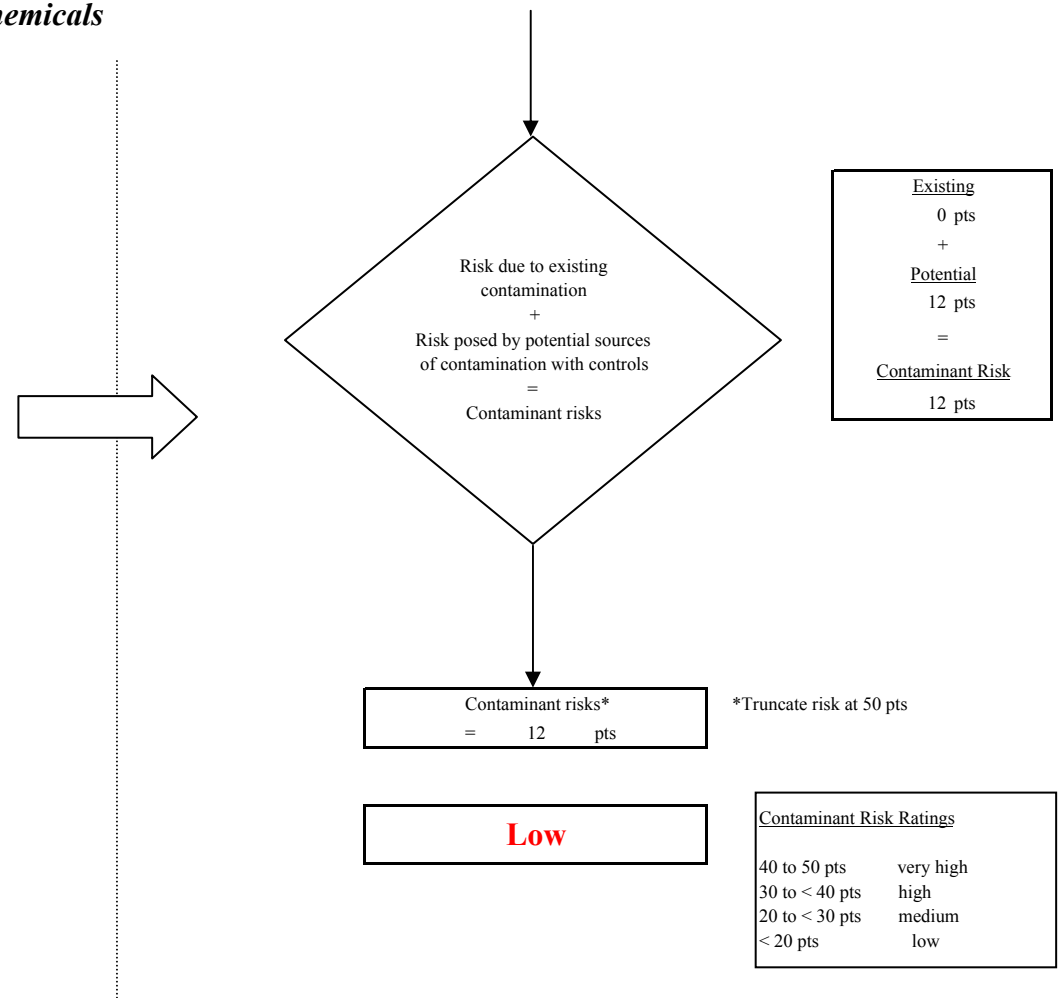


Chart 13. Vulnerability analysis for Thorne Bay - Other Organic Chemicals