Source Water Assessment:

Hydrogeologic Susceptibility and Vulnerability Assessment for Islander Resort Drinking Water Source, Big Lake, Alaska

DRINKING WATER PROTECTION PROGRAM REPORT 27

September 2001

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By Ecology and Environment, Inc.

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By Ecology and Environment, Inc.

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

The Islander Resort well is a Class B (transient/noncommunity) drinking water source consisting of one well. The well is located in Big Lake, Alaska. Identified potential and current sources of contaminants for Islander Resort include residential septic systems, large capacity septic system injection wells, landfills, airports, furniture manufacturing shops, gasoline stations, printers and publishing shops, car washes, dye manufacturers, and underground fuel storage tanks. These identified potential and existing sources of contamination are considered sources of bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals. Overall, the Islander Resort public water source received vulnerability ratings of **Very High** for bacteria and viruses and nitrates and/or nitrites, and **High** for volatile organic chemicals.

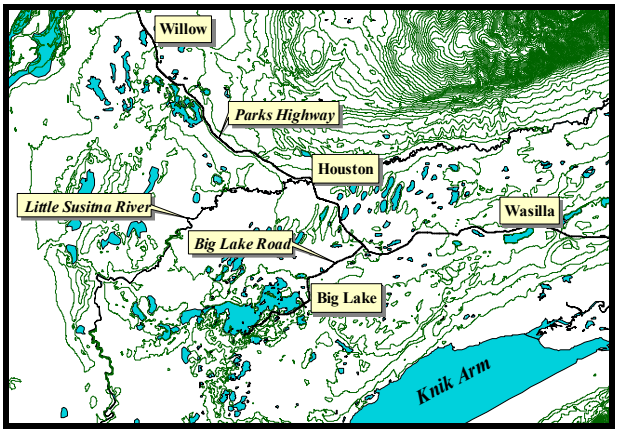

Figure 1. Index map showing the location of the Big Lake-Houston-Willow area.

INTRODUCTION

The purpose of this environmental assessment is to provide public water system owners/operators, communities, and local governments with information they can use to preserve the quality of Alaska's public drinking water supplies. This assessment was completed for the Islander Resort source of public drinking water. This source consists of one well in the Big Lake-Houston-Willow area (see Figure 1). This assessment, known under the Alaska Drinking Water Protection Program as *the Source Water Assessment*, utilized 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 was 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 BIG LAKE-HOUSTON-WILLOW AREA, ALASKA

Location

Big Lake, Houston, and Willow are part of the Matanuska-Susitna Borough. The borough encompasses 24,694 square miles and had a population of 59,322 in 2000. The borough is contained within the watersheds of the Matanuska and Susitna Rivers, which have their source in meltwater from glaciers in the Alaska Range, the Talkeetna Mountains, and the Chugach Mountains. Both rivers flow to tidewater in the Knik Arm of Upper Cook Inlet (*Jokela, Munter and Evans*, *1991*). The area bounded by the Matanuska and Susitna Rivers is commonly referred to as "the Mat-Su Valley," or simply "the Valley."

The three communities have experienced dramatic growth in the last 10 years. Big Lake and Houston nearly doubled their population from 1990 to 2000, while Willow saw an almost sixfold increase. Together, the three communities constitute nearly 10% of the borough's population.

Big Lake is accessed via Big Lake Road at Mile 52.3 of the George Parks Highway, 13 miles southwest of Wasilla. The numerous surface water bodies in Big Lake's 132-square-mile area make it an increasingly popular recreation destination. The population of Big Lake was 2,635 in 2000. Eighty-five percent of the households have private water wells and septic systems.

The remainder of those households haul water and use outhouses. A substantial number of Big Lake residences are recreational homes (*ACED Community Database, 2001*).

Houston, an incorporated city, is located on the Parks Highway, approximately 29 miles north of Anchorage. The city encompasses just more than 22 square miles and had a population of 1,202 in 2000. Sixty percent of the households have private drinking water wells and septic systems (*ACED Community Database, 2001*).

Willow is a community of 1,658 residents (2000 Census) located along the Parks Highway between Mile 60 and Mile 80.7. The community encompasses almost 685 square miles. Almost all of the households in Willow have private drinking water wells and septic systems, but approximately 60% of the homes are vacant or used only seasonally (*ACED Community Database, 2001*).

Climate

The Big Lake-Houston-Willow 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.

The mean daily temperature ranges from 59°F during summer to -2 °F during winter. The mean annual precipitation is approximately 24 inches, and the mean total snowfall is approximately 90 inches per year. The average snow depth during snowy months ranges from 25 inches to 38 inches *(Western Regional Climate Center, Willow West Station, 2000).*

Physiography and Groundwater Conditions

Surface elevations in the Matanuska-Susitna Borough range from sea level where the Knik and Matanuska Rivers enter Cook Inlet to more than 6,000 feet in the peaks that bound the area. Mostly glacial moraine and outwash deposits mantle the surface of the Mat-Su Valley.

The regional geology and groundwater conditions of the Mat-Su Valley vary greatly depending on location. The terrain is dominated by distinctive landforms created by repeated glacial advances and retreats during the Pleistocene epoch (2 million years to 10,000 years before present). The unconsolidated layers (layers of sediment that are not cemented together) comprise well-sorted sands and gravels. Most of the wells in the Mat-Su Valley are located in unconsolidated layers. These layers vary substantially in size and distribution throughout the Valley. In general, the unconsolidated layers increase in thickness throughout the Cook Inlet *(Jokela, Munter and Evans, 1991).* Throughout the area, numerous confining layers ranging from less than 1 foot to 60 feet thick separate the unconsolidated layers.

In the Mat-Su Valley, the groundwater is recharged mainly by snowmelt and precipitation infiltrating into the foothill slopes of the Talkeetna or Chugach Mountains, and by direct precipitation and snowmelt throughout the area.

Water wells in the Big Lake, Houston, and Willow areas are located in unconfined and confined aquifers. Studies indicate that the direction of groundwater flow in the Big Lake area is mainly toward the lake. The direction of groundwater flow in the upper unconfined aquifers is more variable because of the influence of surficial topography and close connection of those aquifers with surface water bodies *(Jokela, Munter, and Evans, 1991).* Less research has been completed for water wells in the Houston and Willow areas; however, available data suggest that groundwater tends to flow toward the Susitna River in the west, and locally toward major surface water bodies and smaller tributaries.

ISLANDER RESORT PUBLIC WATER SOURCE

The Islander Resort public water source is located in Big Lake, Alaska. The system is a Class B (transient/noncommunity) public drinking water source. The source consists of one well near the shore of Big Lake (see Appendix A, Map 1 inset). According to the well log, the Islander Resort well was drilled through sand and gravel to a total depth of 30 feet below land surface. The well is not screened and had a static water level of 2 feet below land surface at the time of drilling (date unknown).

This water source operates seasonally and on weekends. The Islander Resort drinking water source serves a population of approximately 20 non-residents through one service connection.

ASSESSMENT AND PROTECTION AREA FOR ISLANDER RESORT DRINKING WATER SOURCE

The Drinking Water Protection and Assessment Area that has been established for Islander Resort is the area that is most sensitive to contamination. This area has served as a basis for assessing the risk of contamination to the drinking water source. This zone around the drinking water source is the most critical area for the preservation of the quality of the drinking water for this

source. For simplicity, this area will be known as *the Drinking Water Protection Area* and will serve as the area of focus for voluntary protection efforts.

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 well logs from the surrounding area and from past studies *(Jokela, Munter, and Evans, 1991).* This analytical calculation was used as a guide in the first step to establish the protection area for Islander Resort. Additional methods were employed to account for any uncertainties in groundwater flow and aquifer characteristics to arrive at a meaningful and conservative protection area with respect to public health (see the *Guidance Manual for Class B 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. Certain of these zones correspond to a time-of-travel. *Time-of-travel* is the time required for water to move in the saturated zone of the ground from a specific point to the well. The Drinking Water Protection Areas for Islander Resort comprise four zones: Zone A, Zone E, Zone F, and Zone G (see Appendix B, Map 1). Zone A corresponds to the area between the well and the distance equal to one-fourth the distance of the two-year time-of-travel. Depending on where a contaminant source is located within Zone A, travel time for a contaminant to the well may be several days to several hours. Zone A also extends downgradient from the well to account for the area of the aquifer that is influenced by pumping of the well.

The Zone E protection area for Islander Resort corresponds to 1000 feet from Big Lake. The Zone F protection area extends to 1mile from Big Lake. Lastly, Zone G extends to the limit of the watershed for Big Lake.

INVENTORY OF POTENTIAL AND EXISTING CONTAMINANT SOURCES

One element of the Drinking Water Protection Program is an inventory of potential and existing sources of contamination within the protection area for Islander Resort. This inventory 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 also can occur within areas that have little or no development.

For the basis of this assessment, and all Class B public water system assessments, three categories of drinking water contaminants were inventoried:

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

Maps 2 through 5 in Appendix C depicts the contaminant source inventory for Islander Resort. Only highly and very highly potential existing sources of contamination are inventoried within Zones E, F, and G. A number of sources were identified in those zones. Below is a summary of the contaminant sources inventoried within the Islander Resort protection area:

- Residential septic systems,
- Large capacity septic system injection wells,
- Airports,
- Furniture manufacturing shops,
- Gasoline stations,
- Printers and publishing shops,
- Car washes,
- Landfills,
- Dye manufacturers, and
- Underground fuel storage tanks.

These potential contaminant sources present risks of any or all three categories to the Islander Resort drinking water source.

RANKING OF CONTAMINANT RISKS

Potential and existing sources of contamination were identified, sorted, and ranked according to the 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 furthermore are a function of the number and density of those types of contaminant sources as well as the proximity of those sources to the well.

VULNERABILITY OF ISLANDER RESORT DRINKING WATER SOURCES

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

- Natural susceptibility, and
- Contaminant risks.

Each of the three categories of drinking water contaminants was analyzed, and an overall vulnerability score of 0 to 100 was assigned:

Natural Susceptibility (0 – 50 points)

+

Contaminant Risks (0 – 50 points)

=

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

A score for 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)

Combining the susceptibility of the wellhead and the aquifer to contamination leads to a score (0 – 50 points) and rating of overall susceptibility (see Appendix D). Table 1 shows the overall susceptibility score and rating for Islander Resort.

Factors which typically drive the wellhead score include lack of grouting, which may allow potential contaminants to travel down the annulus of the well to the source aquifer; lack of a proper well cap; and vulnerability to inundation due to floods or improper grading of the land surface near the well. Chart 1 in Appendix D details the specific characteristics of the Islander Resort water source which affect this score.

Factors which affect the susceptibility of the aquifer score include other wells or boreholes nearby, which may constitute pathways for potential contaminants to the source aquifer; the thickness of the confining layer, if one exists; and the protectiveness of the vadose zone (the zone above the water table) in terms of its likely capability to prevent potential contaminants from reaching the aquifer. The protectiveness of the vadose zone is a function of the typical precipitation received in the region surrounding the water source, the slope of the land surface, the type of soils in the region, and the depth to the unconfined aquifer or the confining layer of a confined aquifer. Chart 2 in Appendix D details the specific factors comprising the score for this water source.

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

	Score	Rating
Susceptibility of the Wellhead	15	High
Susceptibility of the Aquifer	25	Very High
Natural Susceptibility	40	Very High

Contaminant risks to a drinking water source depend on the type, number or density, and distribution of contaminant sources. Sources containing risk factors for potential contamination to the Islander Resort source of public drinking water are listed on the previous page.

A score (0 – 50 points) and rating of contaminant risks (see Appendix D) are assigned based on the findings of the contaminant source inventory (see Appendix B, Tables 1 through 4). This portion of the analysis examines any existing or historical contamination that has been detected at the drinking water source through routine sampling. It also reviews contamination that has or may have occurred but has not arrived or been detected at the well. Table 2 summarizes the contaminant risks for each category of drinking water contaminants.

Table 2. Contaminant Risks

Contaminant Risks	Score	Rating
Bacteria and Viruses	40	Very High
Nitrates and/or Nitrites	45	Very High
Volatile Organic Chemicals	22	Medium

Appendix D contains eight 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 examining the construction of the well and its surrounding area. Chart 2 analyzes the susceptibility of the aquifer to contamination by examining 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 and 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, and Charts 5 through 8 contain the contaminant risks and vulnerability analysis for nitrates and/or nitrites and volatile organic chemicals.

Vulnerability of the drinking water source to contamination is the combination of susceptibility of the aquifer and the well with contaminant risks. Table 3 contains the overall vulnerability scores (0 – 100) and ratings for each of the three categories of drinking water contaminants (see Appendix D). The scores are rounded off to the nearest 5.

Table 3. Overall Vulnerability of Islander Resort Public Drinking Water Source to Contamination, by Category

Category	Score	Rating
Bacteria and Viruses	80	Very High
Nitrates and/or Nitrites	85	Very High
Volatile Organic Chemicals	60	High

Appendix A, Tables 2 through 4, contain the ranking of potential and existing sources of contamination with respect to bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals.

SUMMARY

This source water assessment was completed for the Islander Resort source of public drinking water. The overall vulnerability of this source to contamination is **Very High** for bacteria and viruses and nitrates and/or nitrites, and **High** volatile organic chemicals. This assessment of contaminant risks can be used as a foundation for local voluntary protection efforts and as a basis for continuous efforts on the part of regulatory agencies to protect public health. This source water assessment is anticipated to be updated every five years to reflect any changes in the vulnerability and/or susceptibility of the public drinking water source.

REFERENCES CITED

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Jokela, J.B., Munter, J.A., and Evans, J.G., 1991, Ground-water resources of the Palmer-Big Lake area, Alaska: a conceptual model. Division of Geological & Geophysical Surveys Reports of Investigations 90-4, State of Alaska Department of Natural Resources, Fairbanks, AK.

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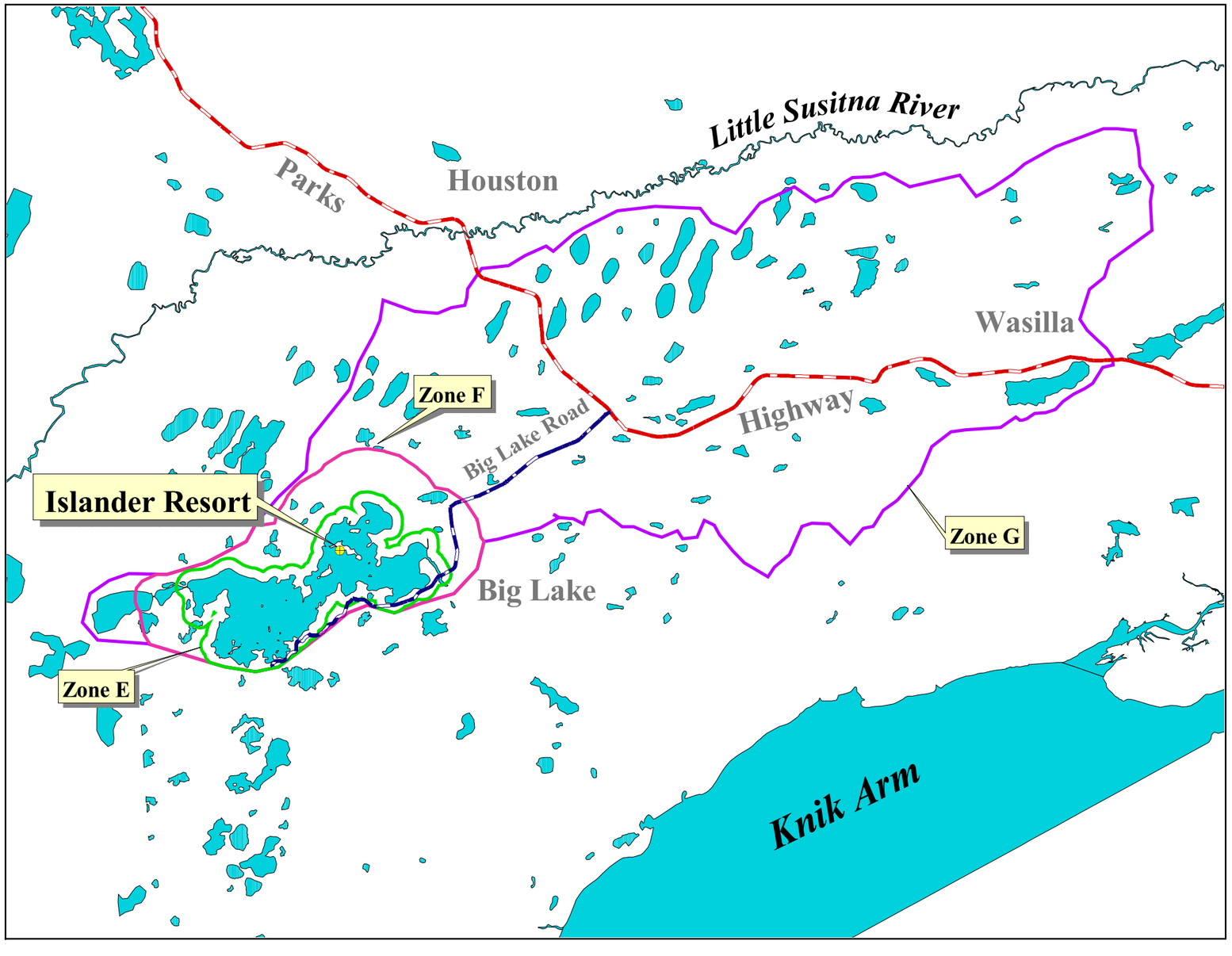
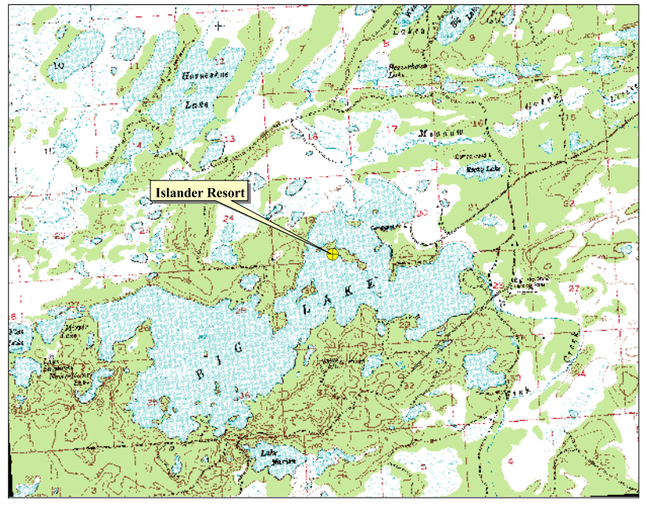
APPENDIX A

Islander Resort
Drinking Water Protection Area

Drinking Water Protection Area for Islander Resort



Islander Resort well
Big Lake Road
Parks Highway
Zone E (1000 Feet from Big Lake)
Zone F (1 Mile from Big Lake)
Zone G (Big Lake Watershed)
Lakes



3 0 3 6 Miles

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Map 1

APPENDIX B

Contaminant Source Inventory and Risk Ranking for Islander Resort

Contaminant Source Inventory for Islander Resort

Contaminant Source Category	Contaminant Source ID	CS ID tag	Zone	Location	Map	Comments
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	LONG ISLAND	2	
Septic systems (serves one single-family home)	R2	R2-1	A	LONG ISLAND	2	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal	D10	D10-2-56	E	WITHIN 1000 FEET OF BIG LAKE	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal	D10	D10-57-88	F	1 MILE FROM BIG LAKE	3	
Airports	X14	X14-1	F	BIG LAKE AIRPORT	3	
Furniture manufacturing, repair, and finishing shops	C14	C14-1	G	OLDE WORLD RESTORATION	5	
Furniture manufacturing, repair, and finishing shops	C14	C14-2	G	GRIZZLY WOODWORKING	5	
Furniture manufacturing, repair, and finishing shops	C14	C14-3	G	GEPETTO'S WOODWORKING	5	
Gasoline stations (without repair shop)	C15	C15-1	G	7-11 GROCERY & GAS	4	
Gasoline stations (without repair shop)	C15	C15-2	G	WASILLA CHEVRON	5	
Gasoline stations (without repair shop)	C15	C15-3	G	PETROLANE	5	
Gasoline stations (without repair shop)	C15	C15-4-5	G	UNKNOWN FACILITY, TESORO	5	
Gasoline stations (with repair shop)	C16	C16-1	G	WILLIAMS	5	
Printers, publishers, copiers	C37	C37-1	G	RHOBUX GRAPHIC ARTS	5	
Printers, publishers, copiers	C37	C37-2	G	POSTNET	5	

Contaminant Source Category	Contaminant Source ID	CS ID tag	Zone	Location	Map	Comments
Printers, publishers, copiers	C37	C37-3	G	RUNNING DOG PUBLICATIONS	5	
Car washes with engine or undercarriage cleaning	C8	C8-1	G	WASILLA CAR WASH	5	
Car washes with engine or undercarriage cleaning	C8	C8-2	G	HANDS OFF TOUCHLESS CAR WASH	5	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal	D10	D10-89-412	G	BIG LAKE WATERSHED	4	
Landfills (municipal; Class III)	D51	D51-1	G	BIG LAKE LANDFILL	4	
Gasoline stations (with repair shop)	C16	G16-2	G	GMS OF ALASKA	5	
Dye or ink manufacturing	I12	I12-1	G	ALASKA DYEWORKS	5	
Tanks, gasoline (underground)	T12	T12-1	G	7-11 GROCERY & GAS	4	
Tanks, gasoline (underground)	T12	T12-13	G	GMS OF ALASKA	5	
Tanks, gasoline (underground)	T12	T12-2-6	G	WASILLA CHEVRON SERVICE PARKS VINE	5	
Tanks, gasoline (underground)	T12	T12-7-11	G	WILLIAMS, UNKNOWN FACILITY, TESORO	5	
Tanks, diesel (underground)	T8	T8-1	G	7-11 GROCERY & GAS	4	
Tanks, diesel (underground)	T8	T8-2-4	G	WASILLA CHEVRON SERVUCE PARKS VINE	5	
Tanks, diesel (underground)	T8	T8-5-7	G	WILLIAMS, UNKNOWN FACILITY, TESORO	5	
Tanks, diesel (underground)	T8	T8-8	G	GMS OF ALASKA	5	
Airports	X14	X14-2	G	WASILLA AIRPORT	5	

Potential and Existing Sources of Contamination for Islander Resort
Bacteria and Viruses

Contaminant Source Category	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Analysis	Location	Map	Comments
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	High	1	LONG ISLAND	2	
Septic systems (serves one single-family home)	R2	R2-1	A	Very Low	2	LONG ISLAND	2	

Table 3 **PWSID 220692.001**

Potential and Existing Sources of Contamination for Islander Resort
Nitrates and Nitrites

Contaminant Source Category	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Analysis	Location	Map	Comments
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	High	1	LONG ISLAND	2	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-2-56	E	High	2	WITHIN 1000 FEET OF BIG LAKE	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-57-88	F	High	3	1 MILE FROM BIG LAKE	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-89-412	G	High	4	BIG LAKE WATERSHED	4	
Landfills (municipal; Class III)	D51	D51-1	G	High	5	BIG LAKE LANDFILL	4	
Septic systems (serves one single-family home)	R2	R2-1	A	Very Low	6	LONG ISLAND	2	

Potential and Existing Sources of Contamination for Islander Resort
Volatile Organic Chemicals (VOCs)

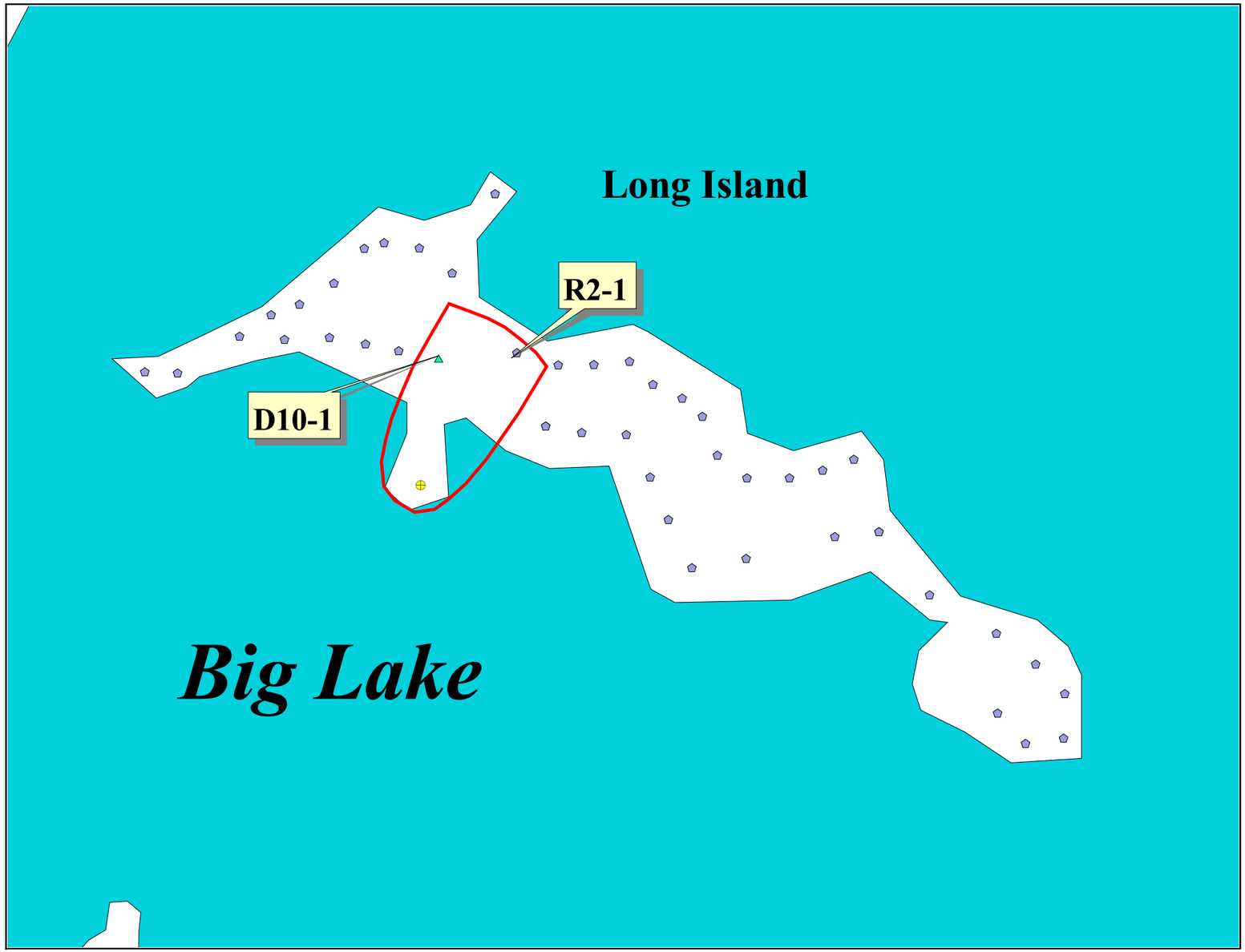
Contaminant Source Category	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Analysis	Location	Map	Comments
Airports	X14	X14-1	F	High	1	BIG LAKE AIRPORT	3	
Furniture manufacturing, repair, and finishing shops	C14	C14-1	G	High	2	OLDE WORLD RESTORATION	5	
Furniture manufacturing, repair, and finishing shops	C14	C14-2	G	High	3	GRIZZLY WOODWORKING	5	
Furniture manufacturing, repair, and finishing shops	C14	C14-3	G	High	4	GEPETTO'S WOODWORKING	5	
Gasoline stations (without repair shop)	C15	C15-1	G	High	5	7-11 GROCERY & GAS	4	
Gasoline stations (without repair shop)	C15	C15-2	G	High	6	WASILLA CHEVRON	5	
Gasoline stations (without repair shop)	C15	C15-3	G	High	7	PETROLANE	5	
Gasoline stations (without repair shop)	C15	C15-4-5	G	High	8	UNKNOWN FACILITY, TESORO	5	
Gasoline stations (with repair shop)	C16	C16-1	G	High	9	WILLIAMS	5	
Printers, publishers, copiers	C37	C37-1	G	High	10	RHOBUX GRAPHIC ARTS	5	
Printers, publishers, copiers	C37	C37-2	G	High	11	POSTNET	5	
Printers, publishers, copiers	C37	C37-3	G	High	12	RUNNING DOG PUBLICATIONS	5	
Car washes with engine or undercarriage cleaning	C8	C8-1	G	High	13	WASILLA CAR WASH	5	
Car washes with engine or undercarriage cleaning	C8	C8-2	G	High	14	HANDS OFF TOUCHLESS CAR WASH	5	
Landfills (municipal; Class III)	D51	D51-1	G	High	15	BIG LAKE LANDFILL	4	
Gasoline stations (with repair shop)	C16	G16-2	G	High	16	GMS OF ALASKA	5	
Dye or ink manufacturing	I12	I12-1	G	High	17	ALASKA DYEWORKS	5	
Tanks, gasoline (underground)	T12	T12-1	G	High	18	7-11 GROCERY & GAS	4	

Contaminant Source Category	Contaminant Source ID	CS ID tag	Zone	Risk Ranking for Analysis	Overall Rank after Analysis	Location	Map	Comments
Tanks, gasoline (underground)	T12	T12-13	G	High	19	GMS OF ALASKA	5	
Tanks, gasoline (underground)	T12	T12-2-6	G	High	20	WASILLA CHEVRON SERVICE PARKS VINE EXTENSION	5	
Tanks, gasoline (underground)	T12	T12-7-11	G	High	21	WILLIAMS, UNKNOWN FACILITY, TESORO	5	
Tanks, diesel (underground)	T8	T8-1	G	High	22	7-11 GROCERY & GAS	4	
Tanks, diesel (underground)	T8	T8-2-4	G	High	23	WASILLA CHEVRON SERVUCE PARKS VINE EXTENSION	5	
Tanks, diesel (underground)	T8	T8-5-7	G	High	24	WILLIAMS, UNKNOWN FACILITY, TESORO	5	
Tanks, diesel (underground)	T8	T8-8	G	High	25	GMS OF ALASKA	5	
Airports	X14	X14-2	G	High	26	WASILLA AIRPORT	5	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-1	A	Low	27	LONG ISLAND	2	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-2-56	E	Low	28	WITHIN 1000 FEET OF BIG LAKE	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-57-88	F	Low	29	1 MILE FROM BIG LAKE	3	
Injection wells (Class V) Large-Capacity Septic System (Drainfield Disposal Method)	D10	D10-89-412	G	Low	30	BIG LAKE WATERSHED	4	
Septic systems (serves one single-family home)	R2	R2-1	A	Very Low	31	LONG ISLAND	2	

APPENDIX C

Islander Resort
Drinking Water Protection Area
and Potential and Existing Contaminant Sources

Drinking Water Protection Area for Islander Resort and Potential and Existing Sources of Contamination



- Islander Resort well
- Septic Systems

Potential Contaminant Sources

- Car washes with engine or undercarriage cleaning
- Dye or ink manufacturing
- Furniture manufacturing, repair, and finishing shops
- Gasoline stations (with repair shop)
- Gasoline stations (without repair shop)
- Injection wells (Class V) Large-Capacity Septic System
- Printers, publishers, copiers
- Tanks, diesel (underground)
- Tanks, gasoline (underground)
- Zone A (Few Months' Travel Time)
- Lakes

0.08 0 0.08 0.16 Miles

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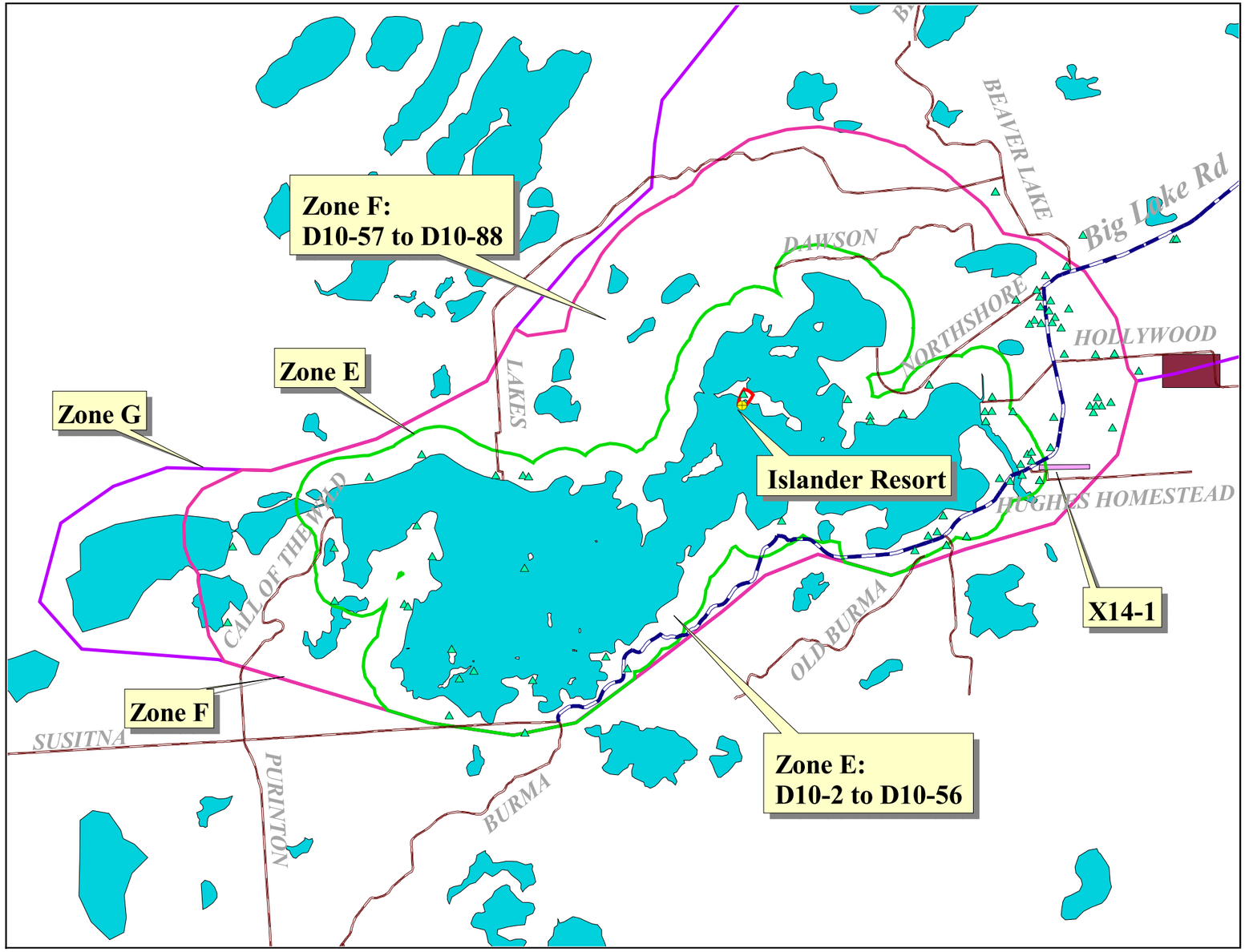
Map 2

Drinking Water Protection Area for Islander Resort and Potential and Existing Sources of Contamination



- Islander Resort well

Potential Contaminant Sources

- Car washes with engine or undercarriage cleaning
- Dye or ink manufacturing
- Furniture manufacturing, repair, and finishing shops
- Gasoline stations (with repair shop)
- Gasoline stations (without repair shop)
- Injection wells (Class V) Large-Capacity Septic System
- Printers, publishers, copiers
- Tanks, diesel (underground)
- Tanks, gasoline (underground)
- Big Lake Road
- Zone A (Few Months' Travel Time)
- Zone E (1000 Feet from Big Lake)
- Zone F (1 Mile from Big Lake)
- Zone G (Big Lake Watershed)
- Lakes
- Airports
- Solid Waste Facilities

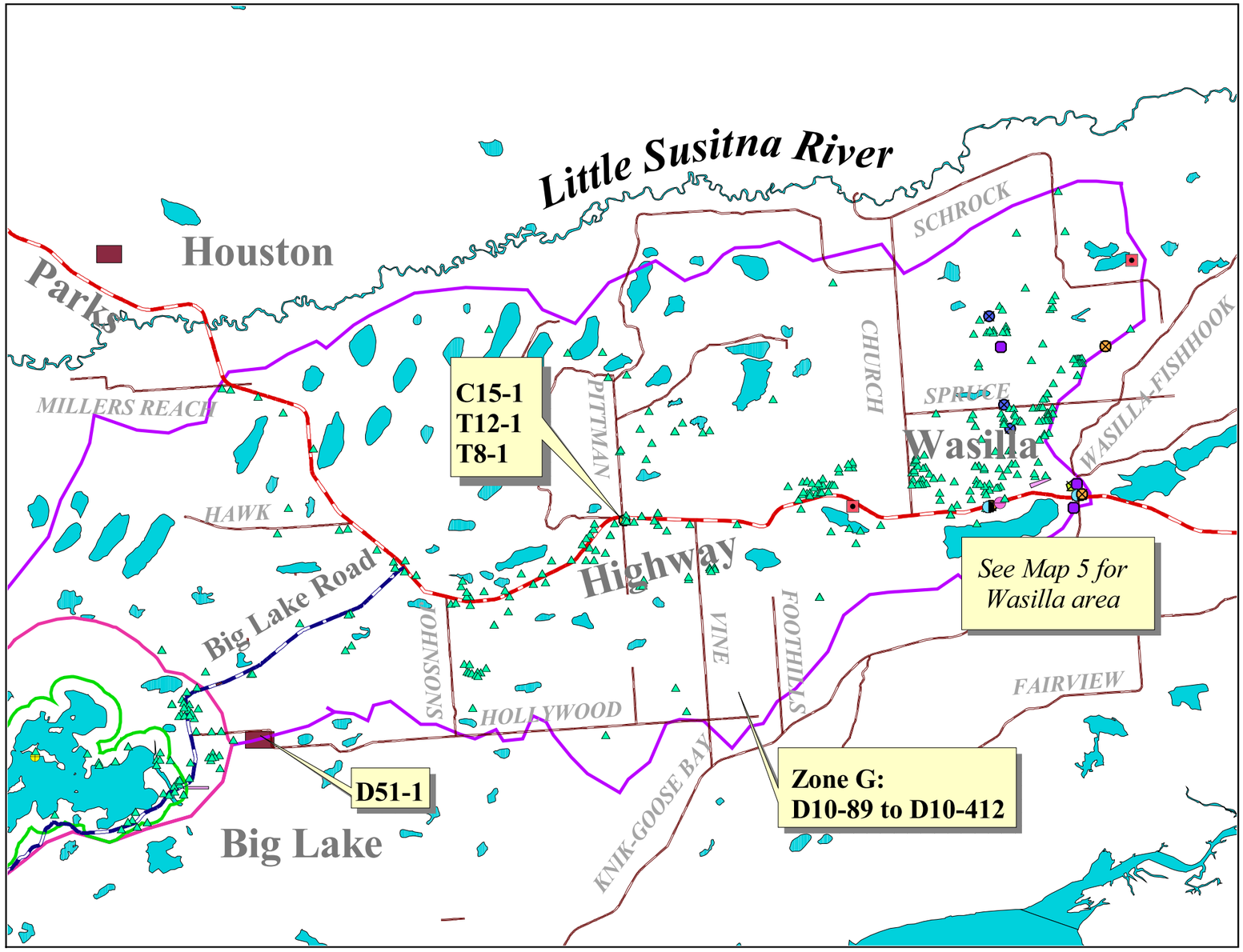
0.7 0 0.7 1.4 Miles

PWSID 220692.001

N W E S

Map 3

Drinking Water Protection Area for Islander Resort and Potential and Existing Sources of Contamination



- Islander Resort well

Potential Contaminant Sources

- Car washes with engine or undercarriage cleaning
- Dye or ink manufacturing
- Furniture manufacturing, repair, and finishing shops
- Gasoline stations (with repair shop)
- Gasoline stations (without repair shop)
- Injection wells (Class V) Large-Capacity Septic System
- Printers, publishers, copiers
- Tanks, diesel (underground)
- Tanks, gasoline (underground)
- Big Lake Road
- Parks Highway
- Zone E (1000 Feet from Big Lake)
- Zone F (1 Mile from Big Lake)
- Zone G (Big Lake Watershed)
- Lakes
- Airports
- Solid Waste Facilities

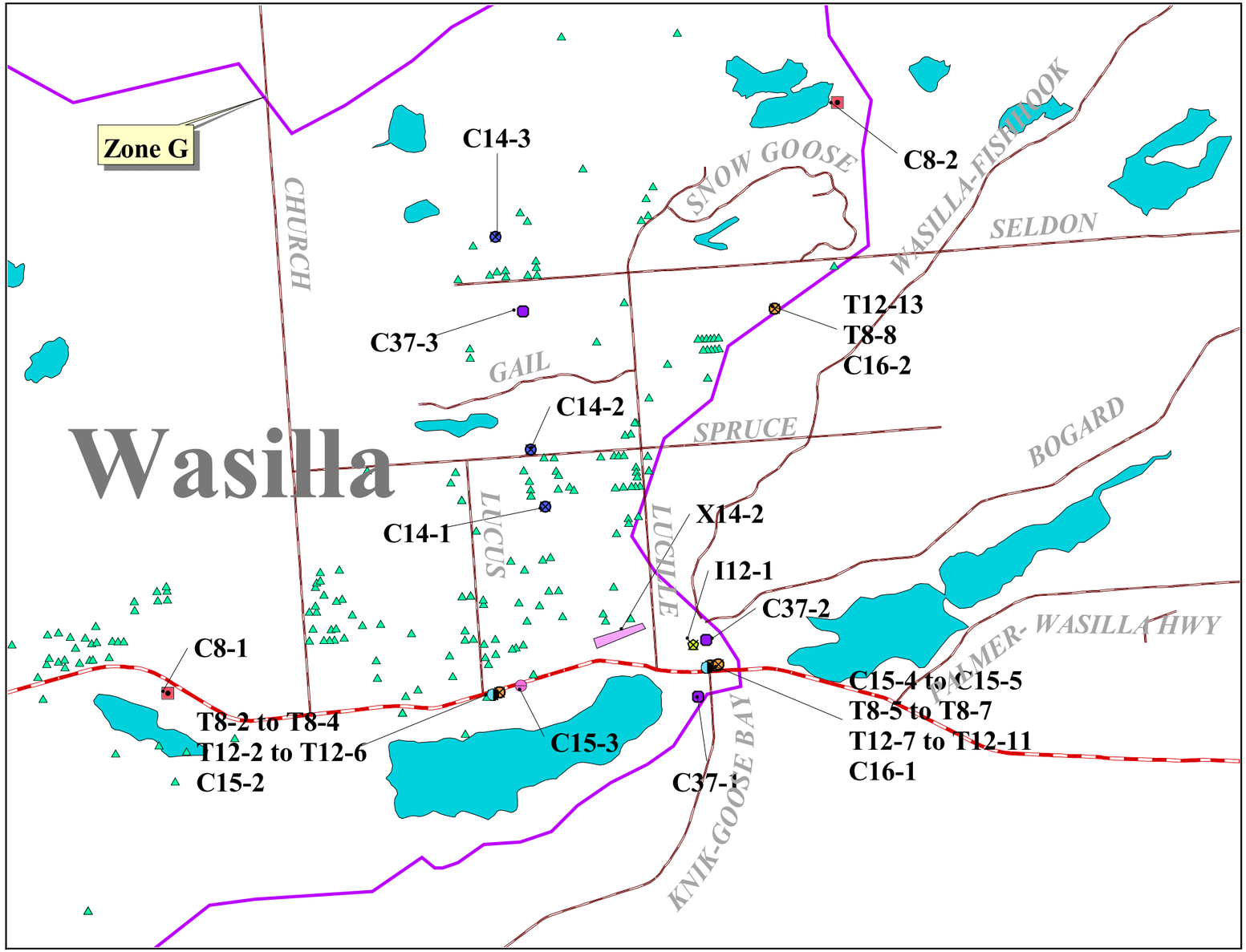
2 0 2 4 Miles

PWSID 220692.001

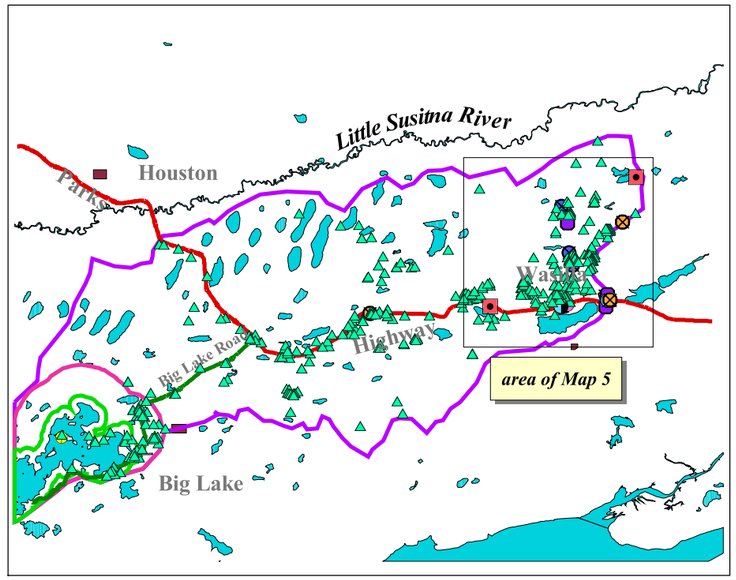
N W E S

Map 4

Drinking Water Protection Area for Islander Resort and Potential and Existing Sources of Contamination



Potential Contaminant Sources
- Car washes with engine or undercarriage cleaning
- Dye or ink manufacturing
- Furniture manufacturing, repair, and finishing shops
- Gasoline stations (with repair shop)
- Gasoline stations (without repair shop)
- Injection wells (Class V) Large-Capacity Septic System
- Printers, publishers, copiers
- Tanks, diesel (underground)
- Tanks, gasoline (underground)
- Parks Highway
- Zone G (Big Lake Watershed)
- Lakes
- Airports



0.7 0 0.7 1.4 Miles

PWSID 220692.001

N W E S

Map 5

APPENDIX D

Vulnerability Analysis for Islander Resort Public Drinking Water Source

Chart 1. Susceptibility of the wellhead – Islander Resort

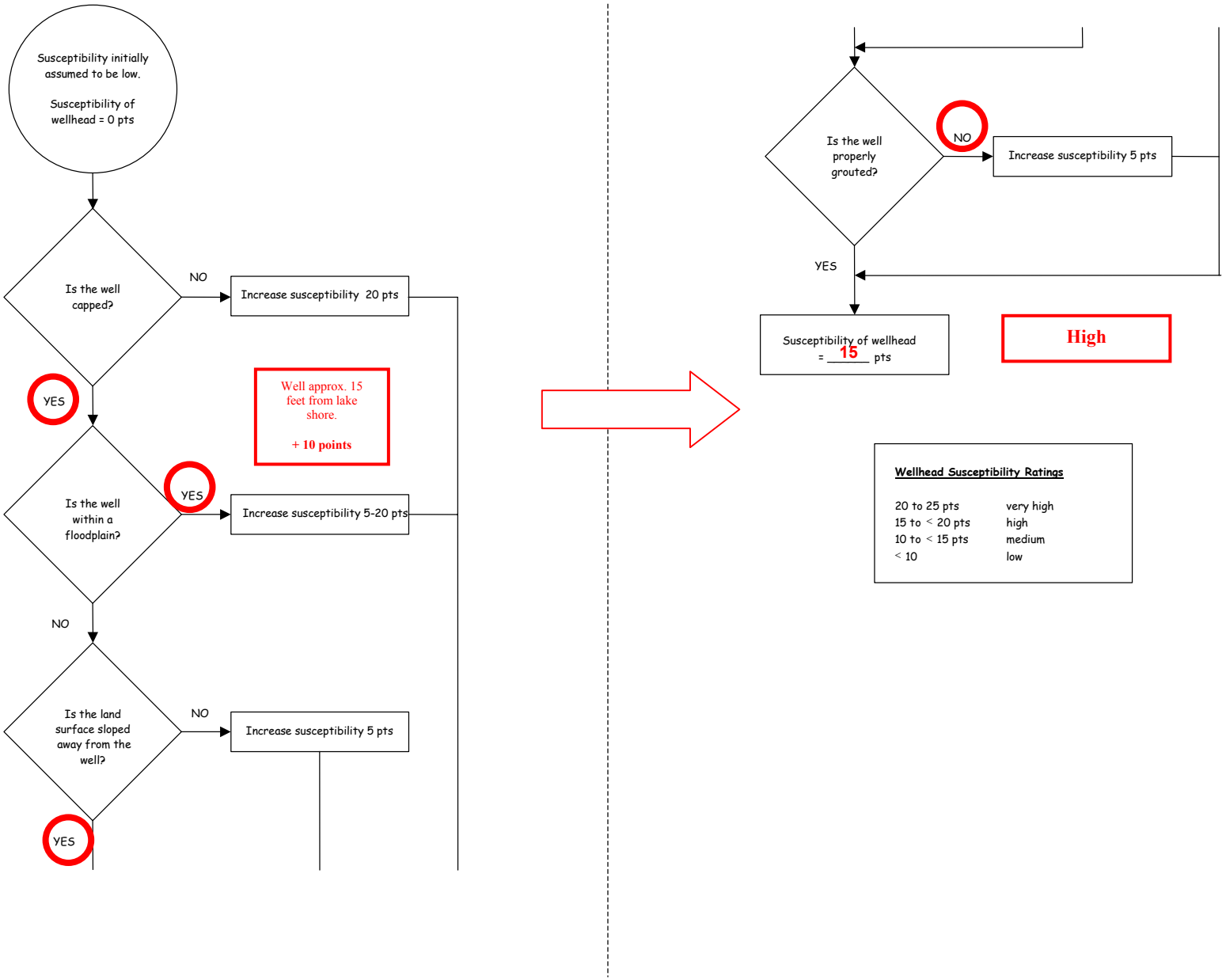
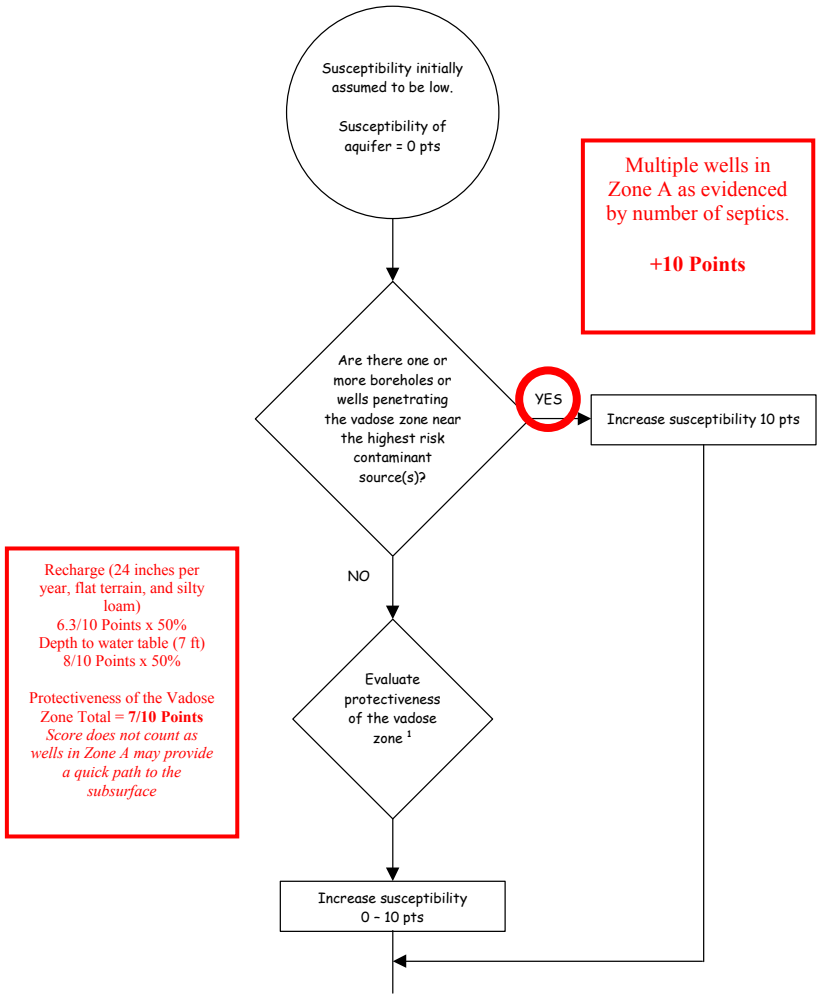
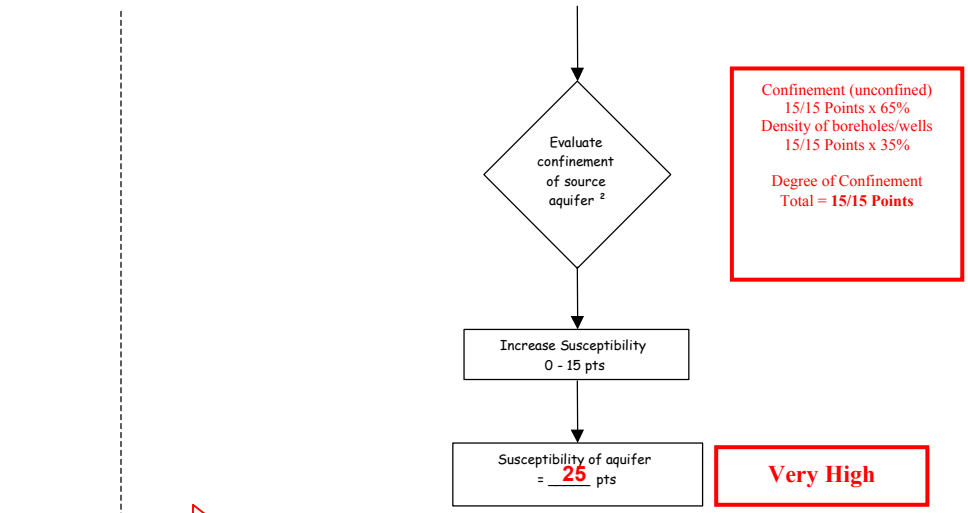


Chart 2. Susceptibility of the aquifer – Islander Resort





1. **Protectiveness of the Vadose Zone**
   - net recharge (function of precipitation, slope of land surface, & permeability of soils)
     [0 – 10 pts; 50% weight]
   - depth to water table (unconfined aquifer) or top of confining layer (confined aquifer)
     [interpolate linearly: 100' – 20', 0 – 5 pts; 20' – 0', 5 – 10 pts; 50% weight]

2. **Degree of Confinement**
   - confined verses unconfined aquifer
     [confined: K ≤ 10^{-6} cm/s, minimum thickness of at least one layer = 20 ft, interpolate linearly 100' – 20', 0 – 10 pts; unconfined = 10 - 15 pts; 65% weight]
   - density of boreholes and wells penetrating the confining layer (confined aquifer) or the water table (unconfined aquifer)
     [confined: 0 – 15 pts; unconfined = 10-15 pts; 35% weight]

Aquifer Susceptibility Ratings

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

Chart 3. Contaminant risks for Islander Resort – Bacteria & Viruses

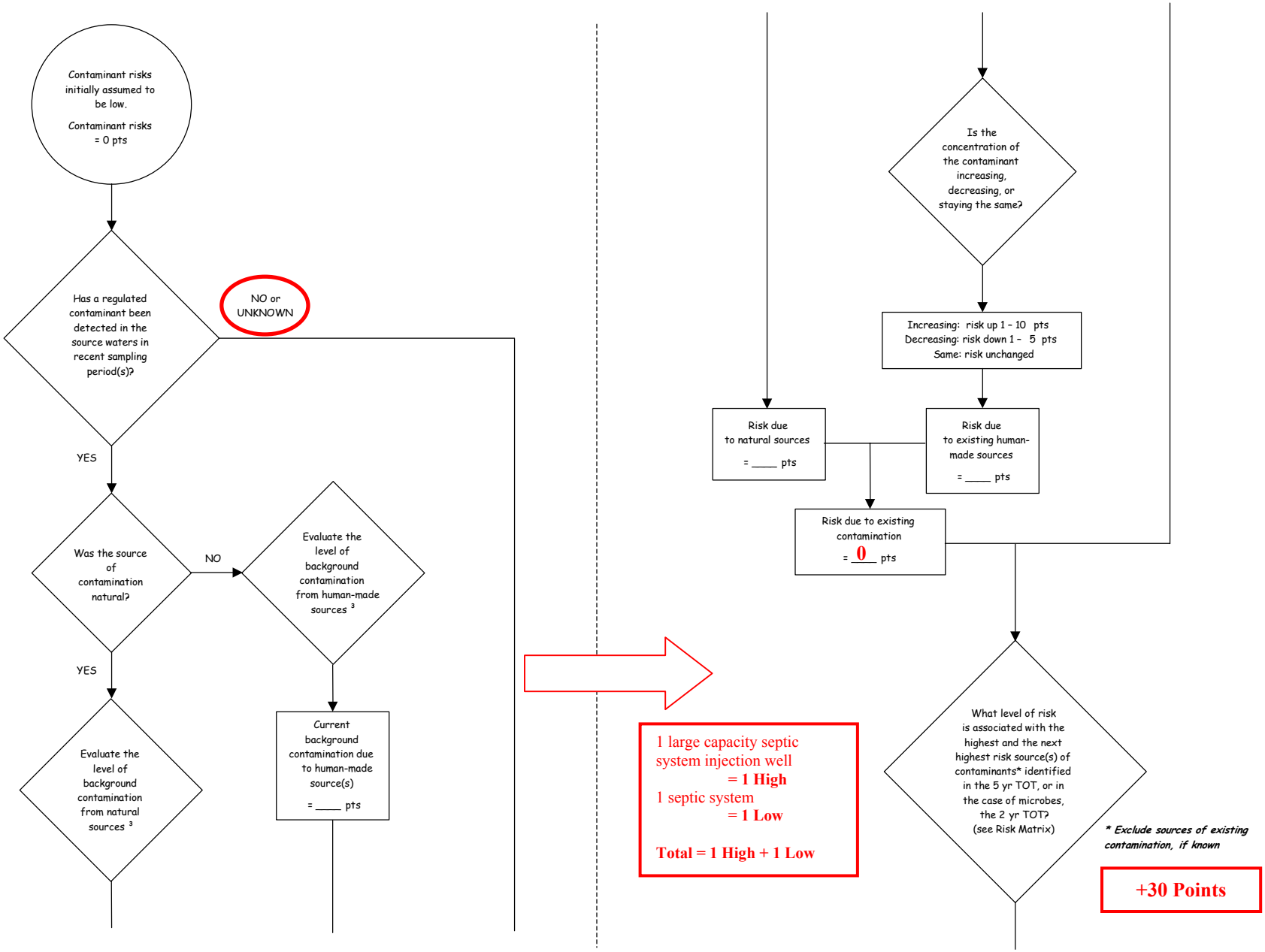


Chart 3. Contaminant risks for Islander Resort – Bacteria & Viruses (Continued)

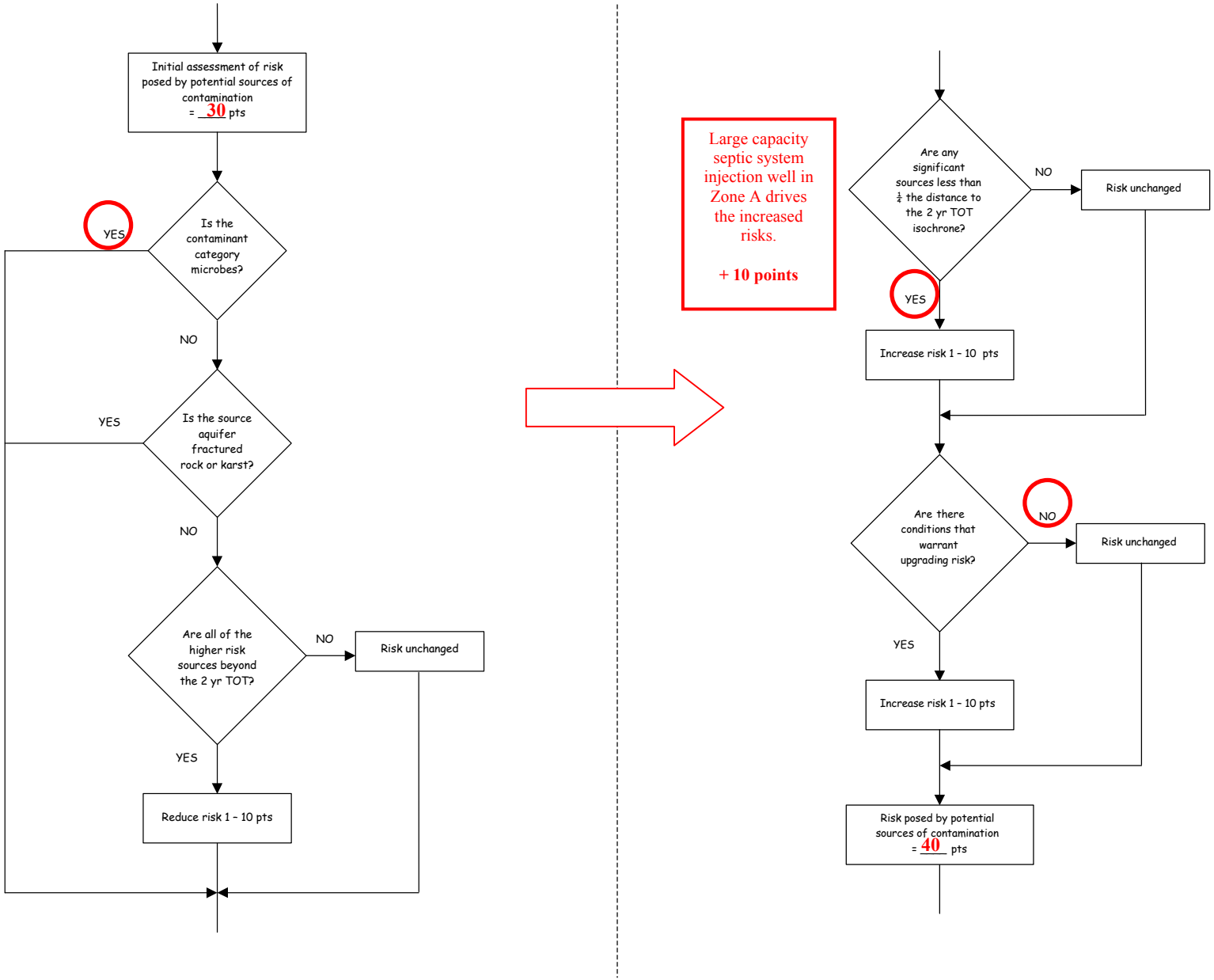
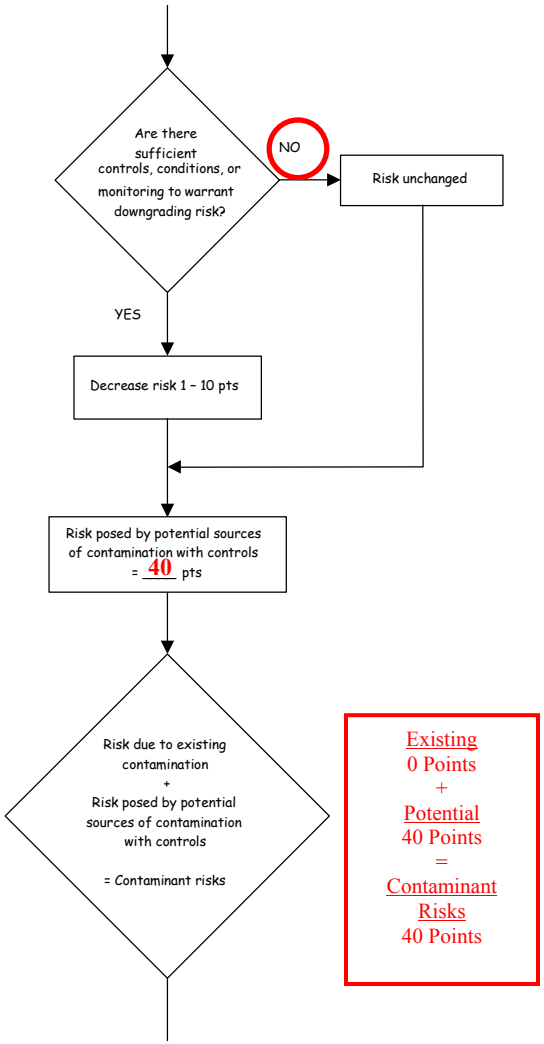


Chart 3. Contaminant risks for Islander Resort – Bacteria & Viruses (Continued)



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

** Truncate risk at 50 pts*

Contaminant risks* = 40 pts

Very High

3. Level of Background Contamination

> MCL	21 - 50 pts
0.5 MCL to < MCL	11 - 20 pts
0.2 MCL to < 0.5 MCL	6 - 10 pts
'detect' to < 0.2 MCL	0 - 5 pts

Contaminant Risk Ratings

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

Table 1. Risk Matrix for Contaminant Sources for Islander Resort – Bacteria & Viruses

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	LOW 10 pts	MEDIUM 20 pts	HIGH 30 pts	VERY HIGH 40 pts
Low	≥ 10 sources + 10 pts	≥ 10 sources + 5 pts	≥ 20 sources + 5 pts	—
Medium	—	≥ 2 sources + 5 pts	≥ 5 sources + 5 pts	≥ 10 sources + 5 pts
High	—	—	1 source + 10 pts	≥ 2 sources + 10 pts
Very High	—	—	—	1 source + 10 pts

Chart 4. Vulnerability analysis for Islander Resort – Bacteria & Viruses

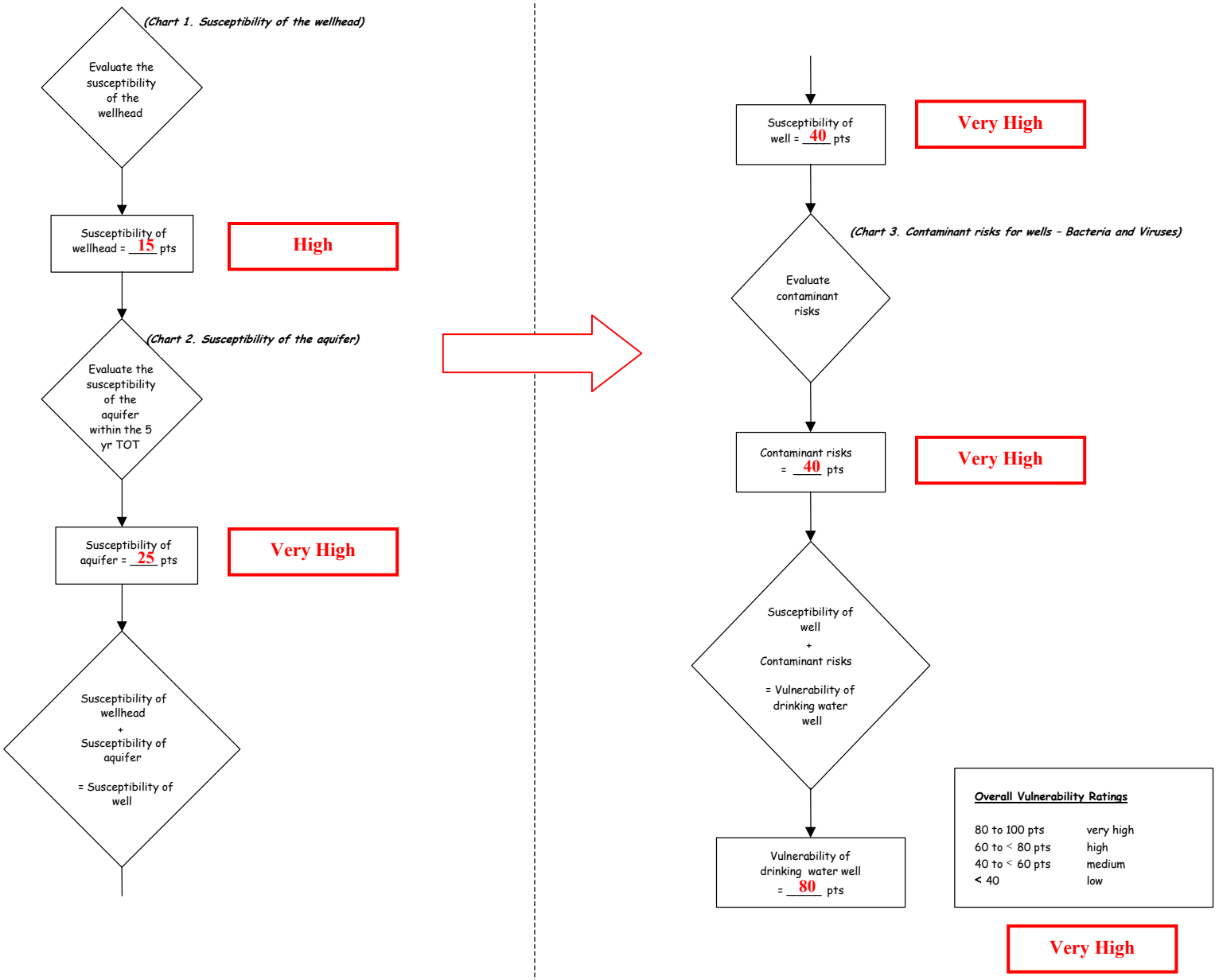


Chart 5. Contaminant risks for Islander Resort – Nitrates and Nitrites

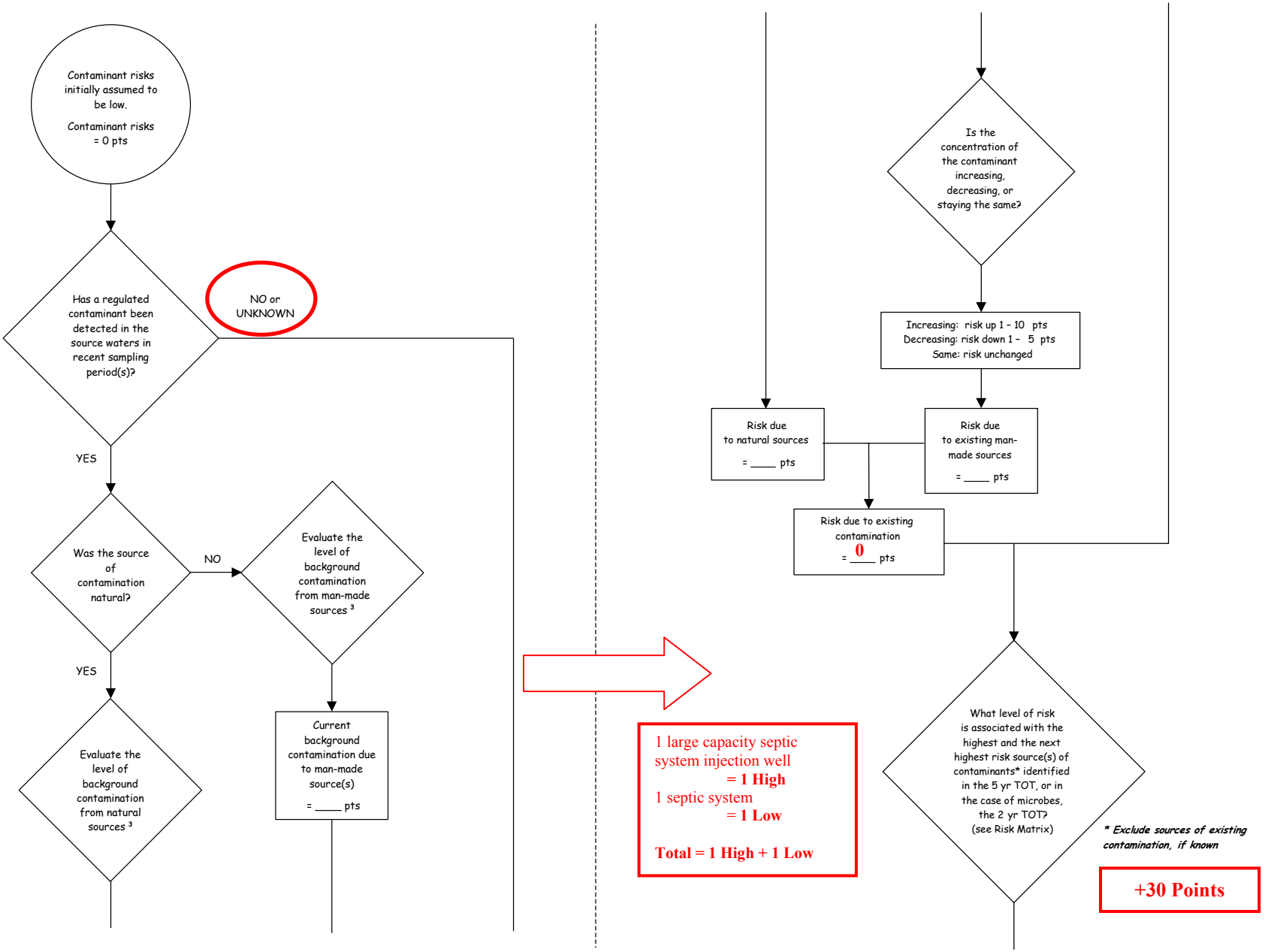


Chart 5. Contaminant risks for Islander Resort– Nitrates and Nitrites (Continued)

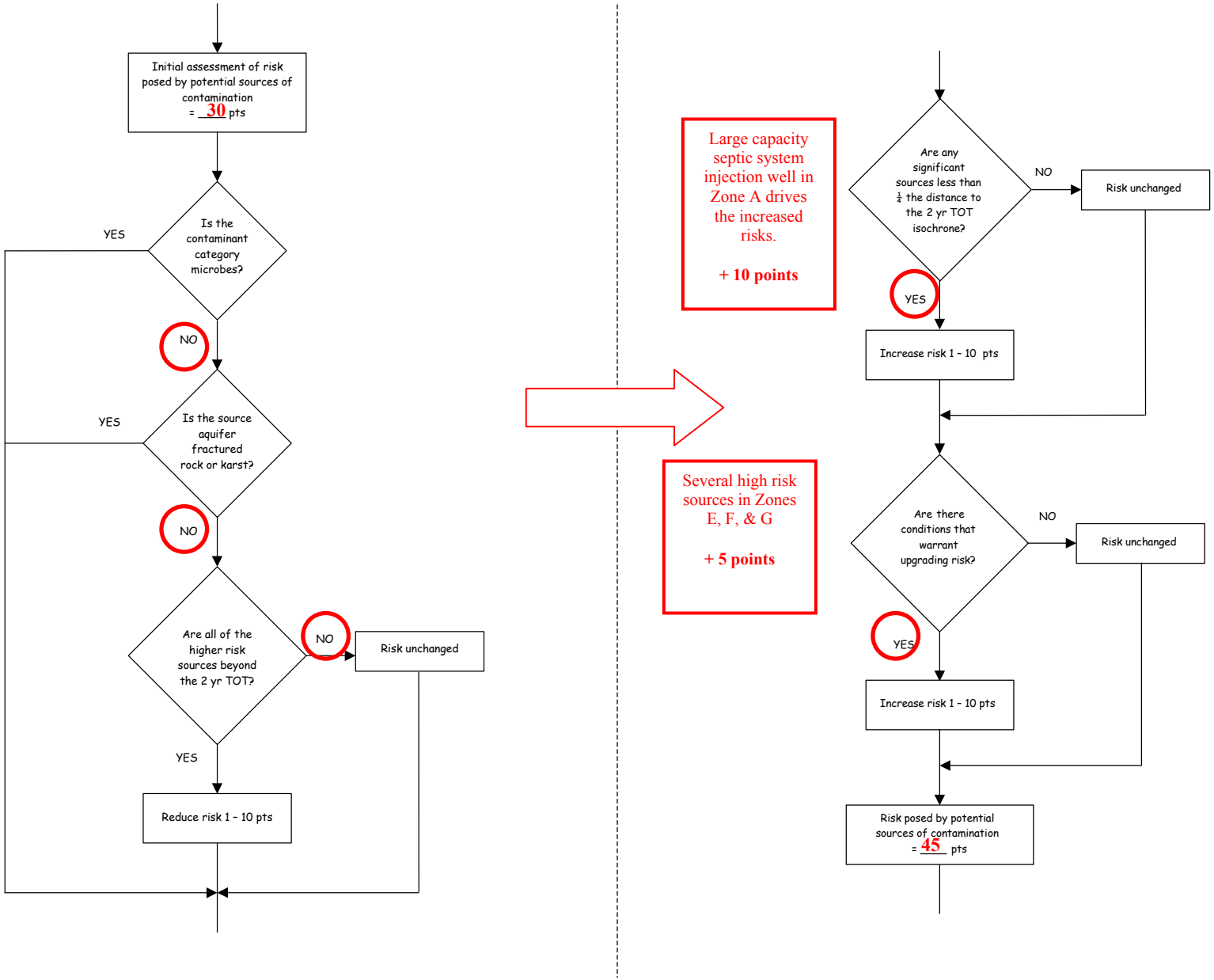
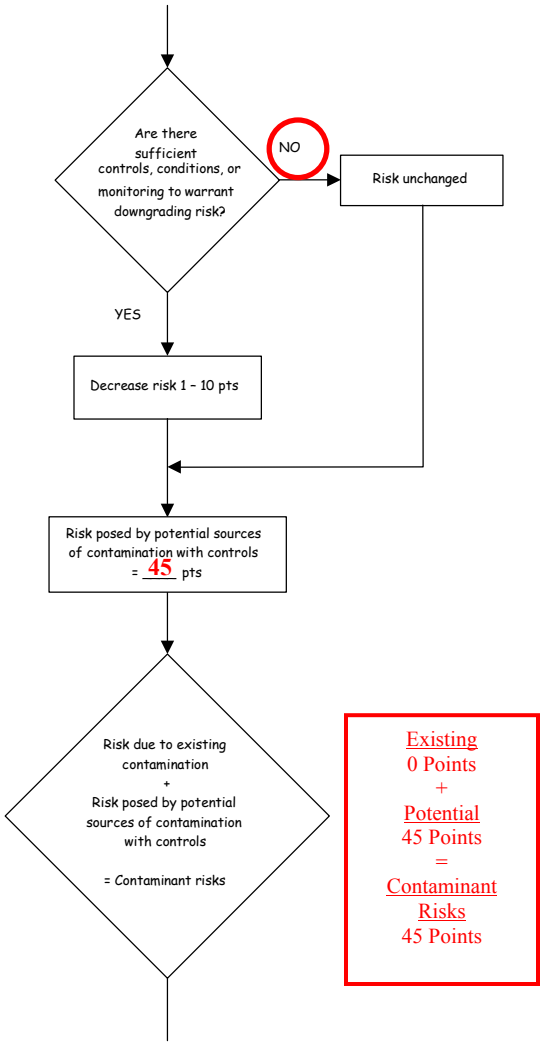
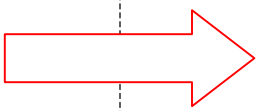
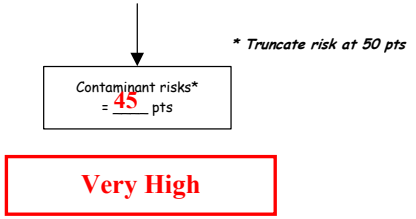


Chart 5. Contaminant risks for Islander Resort – Nitrates and Nitrites (Continued)



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





3. Level of Background Contamination

> MCL	50 pts
0.5 MCL to < MCL	20 pts
0.2 MCL to < 0.5 MCL	10 pts
'detect' to < 0.2 MCL	5 pts

Contaminant Risk Ratings

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

Nitrate
ND 12/20/00
ND 12/4/99
ND 4/5/99
ND 12/9/96
ND 8/23/95
ND 7/8/94

Maximum Contaminant Level (MCL)
= 10mg/L
all non-detect

+0 Points

Table 2. Risk Matrix for Contaminant Sources for Islander Resort - Nitrates and Nitrites

Level of Risk Associated with the Highest Risk Sources

	LOW **10 pts**	**MEDIUM** **20 pts**	**HIGH** **30 pts**	**VERY HIGH** **40 pts**
Low	> 10 sources + 10 pts	> 10 sources + 5 pts	> 20 sources + 5 pts	---
Medium	---	> 2 sources + 5 pts	> 5 sources + 5 pts	> 10 sources + 5 pts
High	---	---	1 source + 10 pts	> 2 sources + 10 pts
Very High	---	---	---	1 source + 10 pts

Chart 6. Vulnerability analysis for Islander Resort – Nitrates and Nitrites

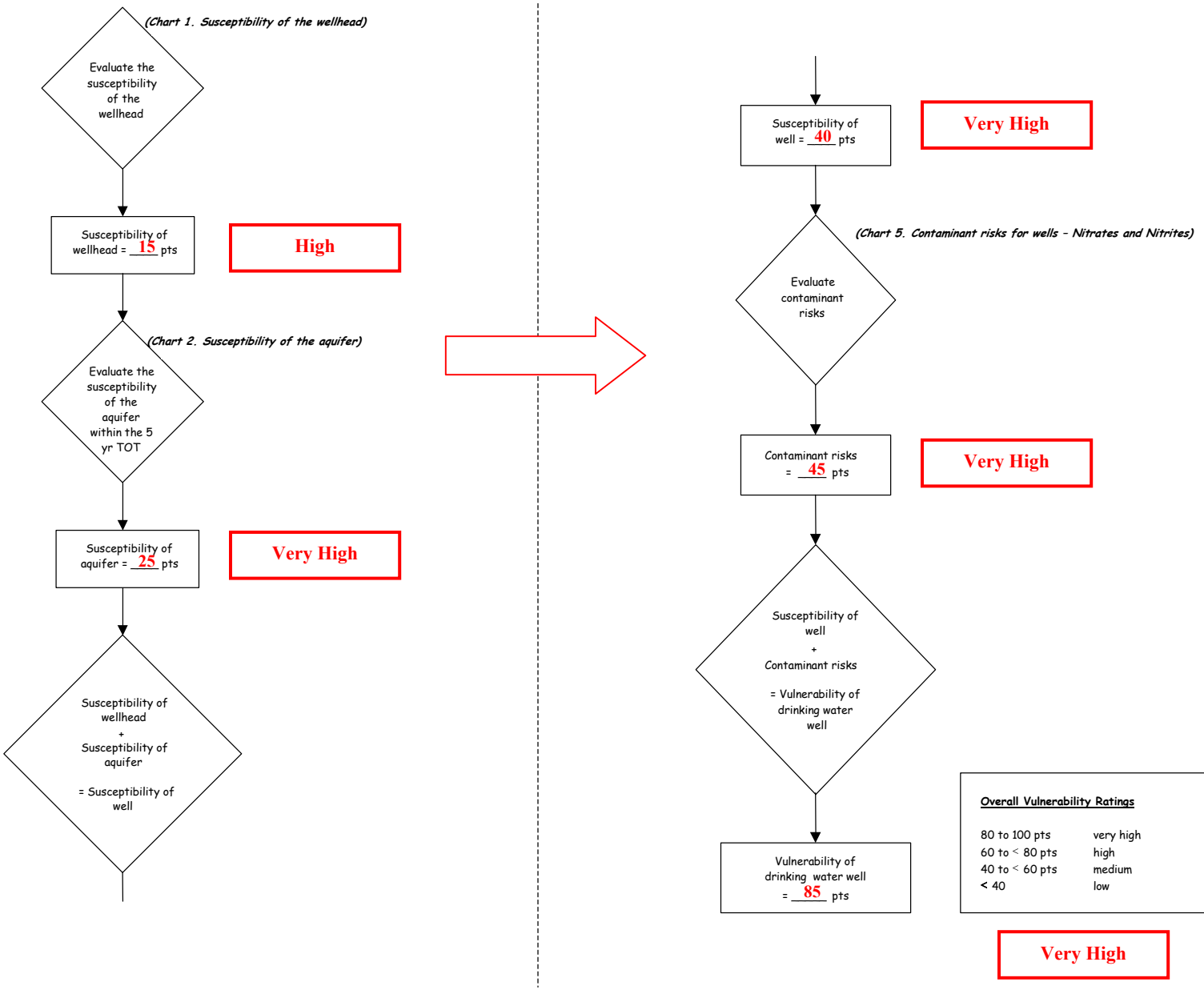


Chart 7. Contaminant risks for Islander Resort – Volatile Organic Chemicals

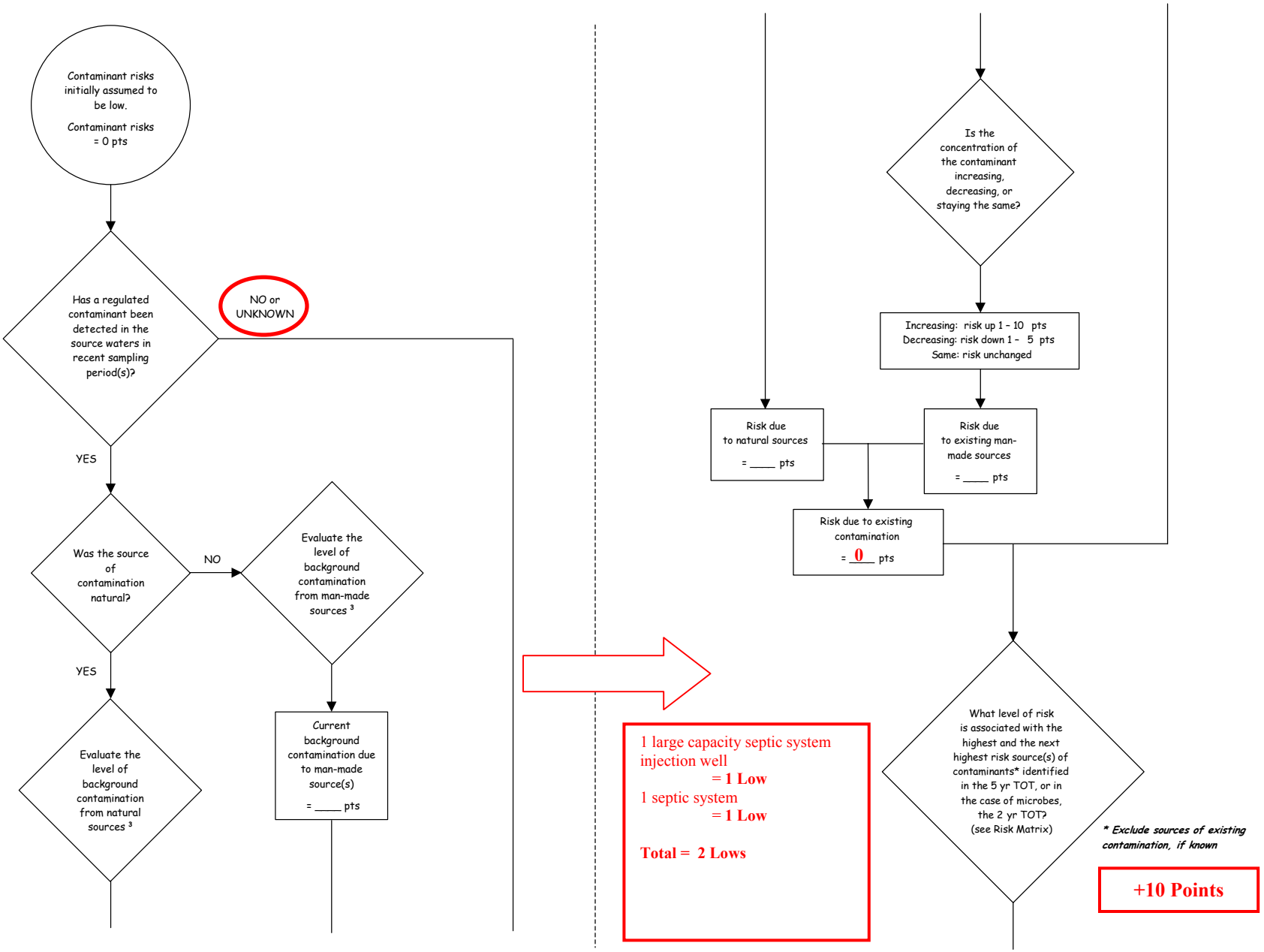


Chart 7. Contaminant risks for Islander Resort – Volatile Organic Chemicals (Continued)

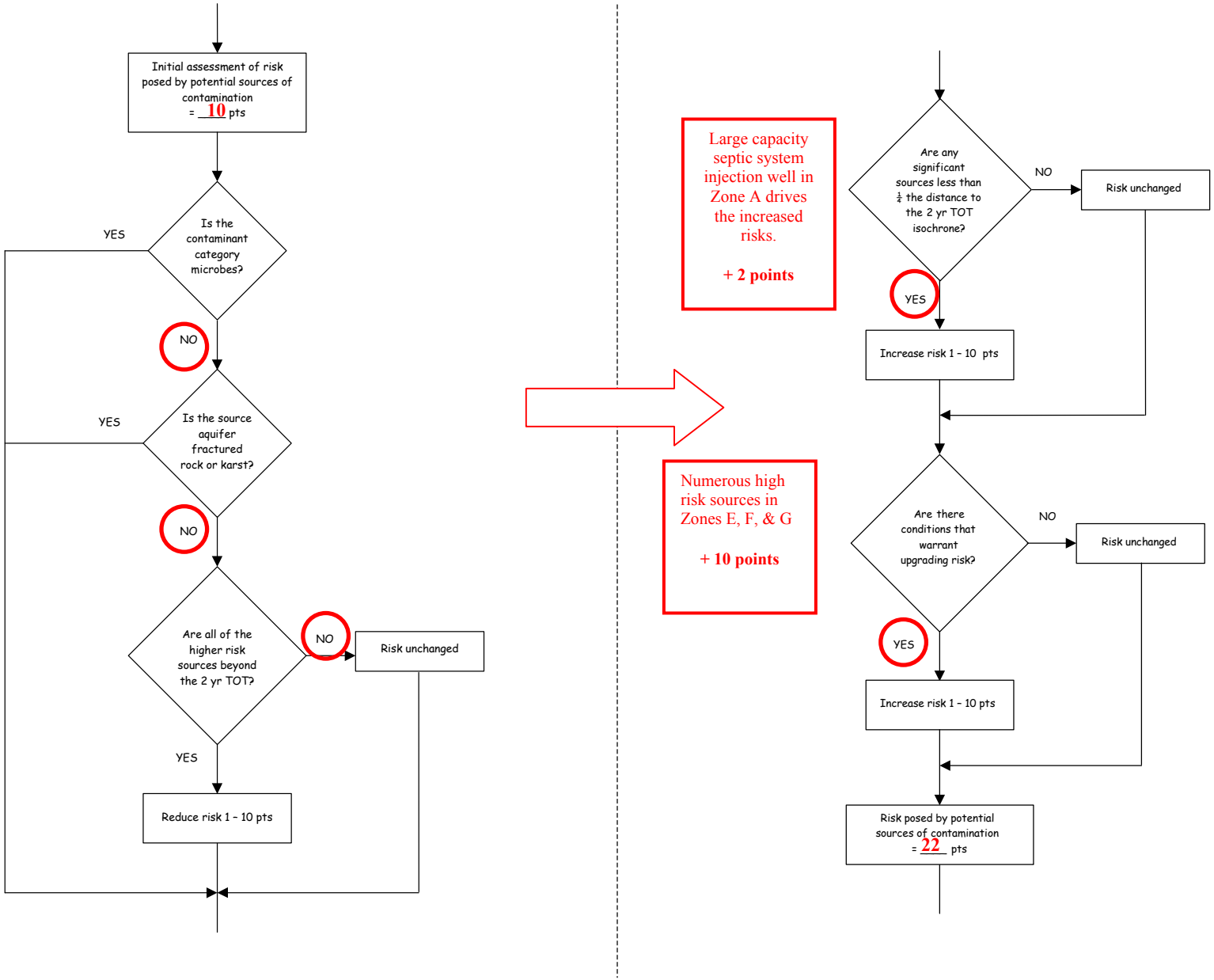
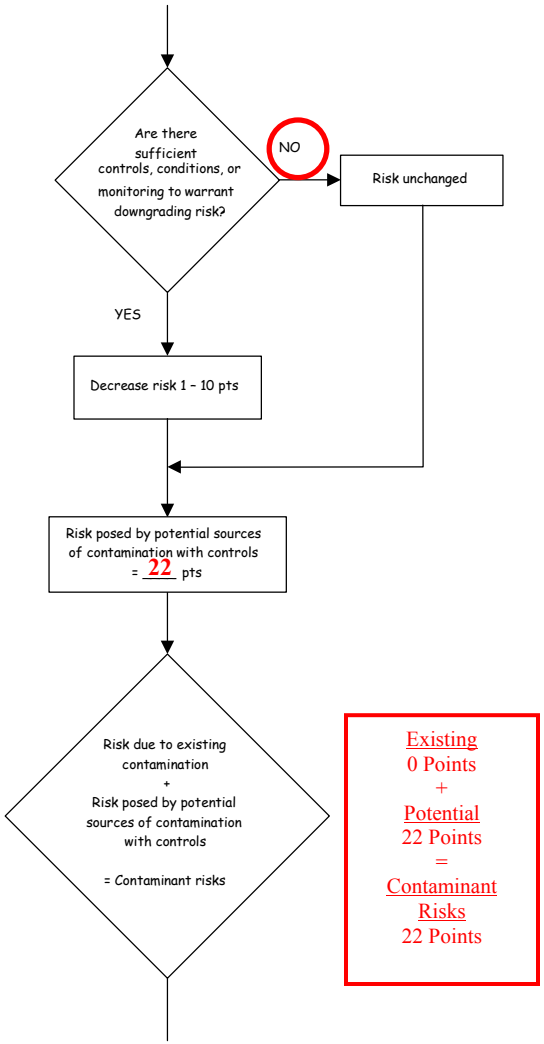
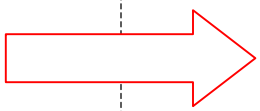
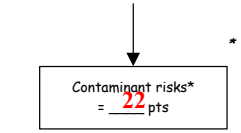


Chart 7. Contaminant risks for Islander Resort – Volatile Organic Chemicals (Continued)



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





** Truncate risk at 50 pts*

Medium

3. Level of Background Contamination

> MCL	50 pts
0.5 MCL to < MCL	20 pts
0.2 MCL to < 0.5 MCL	10 pts
'detect' to < 0.2 MCL	5 pts

Contaminant Risk Ratings

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

Table 3. Risk Matrix for Contaminant Sources for Islander Resort – Volatile Organic Chemicals

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	LOW 10 pts	MEDIUM 20 pts	HIGH 30 pts	VERY HIGH 40 pts
Low	> 10 sources + 10 pts	> 10 sources + 5 pts	> 20 sources + 5 pts	---
Medium	---	> 2 sources + 5 pts	> 5 sources + 5 pts	> 10 sources + 5 pts
High	---	---	1 source + 10 pts	> 2 sources + 10 pts
Very High	---	---	---	1 source + 10 pts

Chart 8. Vulnerability analysis for Islander Resort – Volatile Organic Chemicals