Source Water Assessment -
Salvation Army
Anchorage, Alaska

Hydrogeologic Susceptibility and Vulnerability Analysis

DRINKING WATER PROTECTION PROGRAM REPORT 60

September 2001

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Hydrogeologic Susceptibility and Vulnerability Analysis

By Heather A. Hammond

Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

Salvation Army's Public Water System is a Class B (transient/non-community) drinking water source consisting of one well. Identified potential and current sources of contaminants for Salvation Army includes: activities along highways and roads, activities along recreation trails, septic systems, sewer lines, residential areas and Rabbit Creek Park. These identified potential and existing sources of contamination are considered sources of bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals. Overall, Salvation Army's public water source received a vulnerability rating of **Medium** for bacteria and viruses and volatile organic chemicals, and **High** for nitrates and/or nitrites.

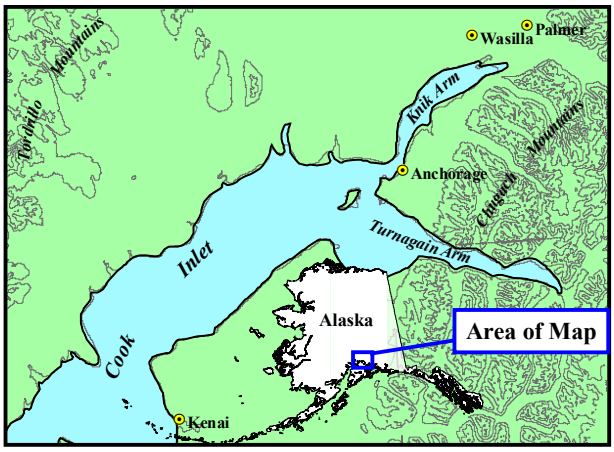

Figure 1. Index map showing the location of Anchorage, Alaska

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 Salvation Army's source of public drinking water. This source 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 above sea level.

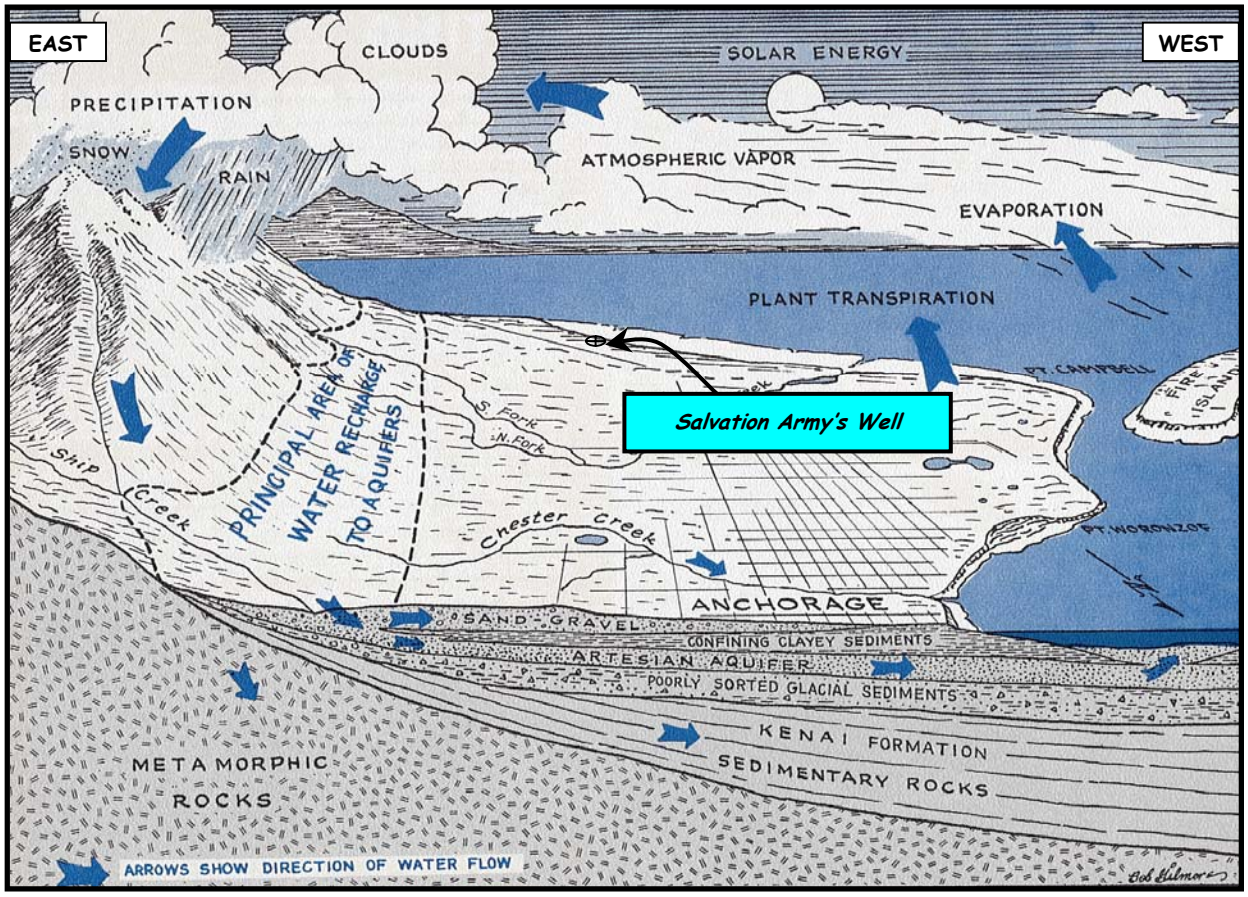

Figure 2. Generalized hydrologic cycle in the Anchorage area [*Barnwell, George, Dearborn,Weeks, and Zenone*, 1972].

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 the 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 the 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 enters 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, 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.

SALVATION ARMY'S PUBLIC DRINKING WATER SOURCE

Salvation Army's public water source is a Class B (transient/non-community) water system, which is owned and operated by the Salvation Army. The source consists of one well near the base of the Chugach Mountains and is at an elevation of 250 feet above sea level. The well is located approximately 122 feet south of DeArmoun Road (see Figure 3). According to the well log, Salvation Army's well penetrates till clay, and sand and gravel layers to a total depth of 152 feet below land surface. The well lacks proper grouting and had a static water level of 90 feet below land surface. It is unknown whether the well was screened at the time of drilling (September 1961).

Salvation Army's water system operates year round and serves approximately 55 non-residents through one service connection.

ASSESSMENT AND PROTECTION AREA FOR SALVATION ARMY'S DRINKING WATER SOURCE

The Drinking Water Protection and Assessment Area that has been established for Salvation Army 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 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

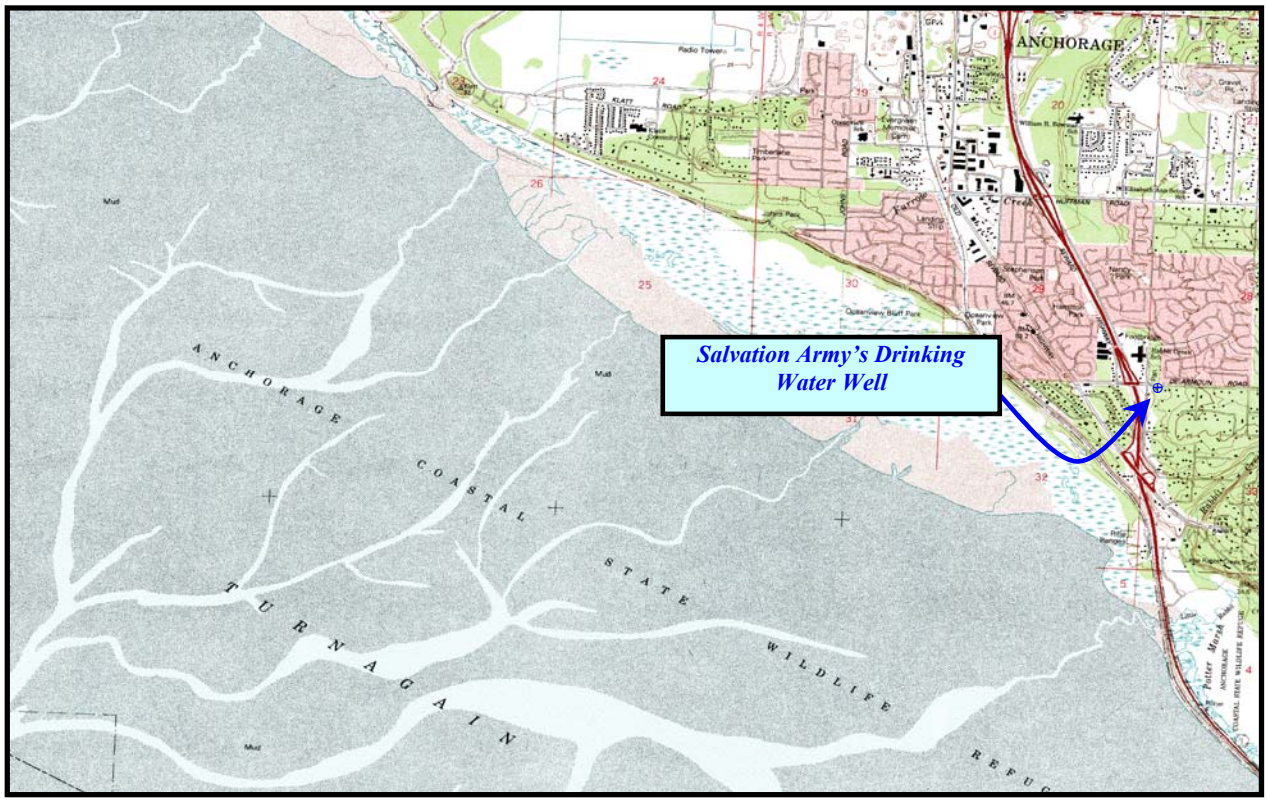

Figure 3. Map showing the location of the drinking water source for Salvation Army [Base: USGS Anchorage A8 SW].

simplicity, this area will be known as your Drinking Water Protection Area and will serve as the area of 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 and Turnagain Arm. An analytical calculation was used to calculate 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 Salvation Army's drinking water source. Additional methods were further employed to take into account any uncertainties in groundwater flow and aquifer characteristics to arrive at a meaningful and conservative protection area with respect to public health (Please refer to 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. 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 Salvation Army contains four zones, Zone A through Zone D (See Map 1 in Appendix A). Zone A corresponds to the area between the well 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 well may be on the order of several days to several hours. Zone A also extends downgradient from the well to take into account the area of the aquifer that is influenced by pumping of the well.

Zone B corresponds to a time-of-travel of less than two years. Zones C through 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 Salvation Army's Drinking Water Protection Area. 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 B public water system assessments, three categories of drinking water contaminants were inventoried. They include:

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

Maps 2 through 4 in Appendix C depict the Contaminant Source Inventory for Salvation Army. Inventoried potential sources of contamination within Zones A through D were activities along highways and roads, activities along recreation trails, septic systems, sewer lines, residential areas and Rabbit Creek Park (see Table 1 in Appendix B). Below is a summary of the contaminant sources inventoried within Salvation Army's protection area:

- Highways and roads;
- Recreation trails;
- Septic systems;
- Sewer lines;
- Residential areas; and
- Rabbit Creek Park.

These potential contaminant sources present risk for all three categories of drinking water contaminants for Salvation Army's drinking water source.

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 well.

VULNERABILITY OF SALVATION ARMY'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 three 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)

Salvation Army's well penetrates layers of till and clay (confining unit), which may provide a protective barrier against the movement of contaminants in the subsurface. Static water level is 90 feet below land surface. The well log does not indicate that the well was grouted at the time of drilling. Therefore, there is no protective barrier against contaminants traveling along the top of the water table from entering the water source along the well casing.

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 shows the overall Susceptibility score and rating for Salvation Army.

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

	Score	Rating
Susceptibility of the Wellhead	25	Very High
Susceptibility of the Aquifer	11	Medium
Natural Susceptibility	36	High

Contaminant risks to a drinking water source depend on the type, number or density, and distribution of contaminant sources. Highways and roads and septic systems contribute the highest risk for potential contamination to Salvation Army's source of public drinking water.

A score (0 – 50 points) and rating of Contaminant Risks (See Appendix D) is assigned based on the findings of the Contaminant Source Inventory (Appendix B - Table 1 – Table 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 through Table 4 summarizes the Contaminant Risks for each category of drinking water contaminants.

Table 2. Contaminant Risks

Contaminant Risks	Score	Rating
Bacteria and Viruses	22	Medium
Nitrates and/or Nitrites	28	Medium
Volatile Organic Chemicals	13	Low

Appendix D contains eight charts, which together form the 'Vulnerability Analysis' for a source water assessment for a Class B public drinking water source. Chart 1 analyzes the 'Susceptibility of the Wellhead' to contamination by looking at the construction of the well and its surrounding area. Chart 2 analyzes the 'Susceptibility of the Aquifer' to contamination by looking at the naturally occurring attributes of the water source and influences on the groundwater system that might lead to contamination. Chart 3 analyzes 'Contaminant Risks' for the drinking water source with respect to bacteria and viruses. The 'Contaminant Risks' portion of the analysis considers potential sources of contaminants as well as a review of contamination that has or may have occurred but has not arrived or been detected at the well. Lastly, Chart 4 contains the

Vulnerability Analysis for Bacteria and Viruses'. Charts 5 through 8 contain the Contaminant Risks and Vulnerability Analysis for nitrates and nitrites, and volatile organic chemicals, respectively.

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). Note: scores are rounded off to the nearest five.

Table 3. Overall Vulnerability of Salvation Army's Public Drinking Water Source to Contamination by Category

Category	Score	Rating
Bacteria and Viruses	55	Medium
Nitrates and Nitrites	65	High
Volatile Organic Chemicals	50	Medium

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

Nitrates and/or nitrites are found in natural background concentration at the site, as elsewhere in the Alaska. Sampling history of Salvation Army's source waters indicate low concentrations of nitrates (See Chart 5 – Contaminant Risks for nitrates and/or nitrites in Appendix D). Existing nitrate contamination is approximately 1.8 mg/L or 18% of the allowable limit (MCL) for this contaminant. The Maximum Contaminant Level or 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 in soil, moving at approximately the same rate as water.

Recent sampling history indicates a slight increase in nitrate concentration since the early 1990's. The cause of this increase is unknown at this time. However, the increase could be attributed to the recent increase in human development and the installation of septic systems within the Drinking Water Protection Area. Though existing contamination was detected at the site in natural background concentrations for nitrates, the amount detected remains at very safe levels with respect to human health.

The overall vulnerability score for bacteria and viruses and volatile organic chemicals for Salvation Army's source of drinking water is medium. Activities associated with highways and roads, sewer lines and septic systems within the protection area drive the score for these contaminant categories. Because roads do pose potential for fuel spills to occur, highways and roads are ranked as very low potential sources of volatile organic chemicals along with bacteria and viruses and nitrates and/or nitrites.

Other low potential and existing sources of bacteria and viruses and volatile organic chemicals for Salvation Army's source of drinking water include activities associated with Rabbit Creek Park and residential areas.

The overall vulnerability score for nitrates and/or nitrites for Salvation Army's drinking water source is high. The density of sewer lines in Zones B and C along with septic systems and residential areas drive the score for nitrates and/or nitrites.
Other low potential and existing sources of nitrates and/or nitrites for Salvation Army's source waters include activities associated recreation trails, Rabbit Creek Park and highways and roads.

SUMMARY

A *Source Water Assessment* has been completed for Salvation Army's source of public drinking water. The overall vulnerability of this source to contamination is **Medium** for bacteria and viruses and volatile organic chemicals and **High** for nitrates and/or nitrites. 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 Salvation Army to protect public health. It is anticipated that *Source Water Assessments* will be updated every five years to reflect any changes in the vulnerability and/or susceptibility of the public drinking water source.

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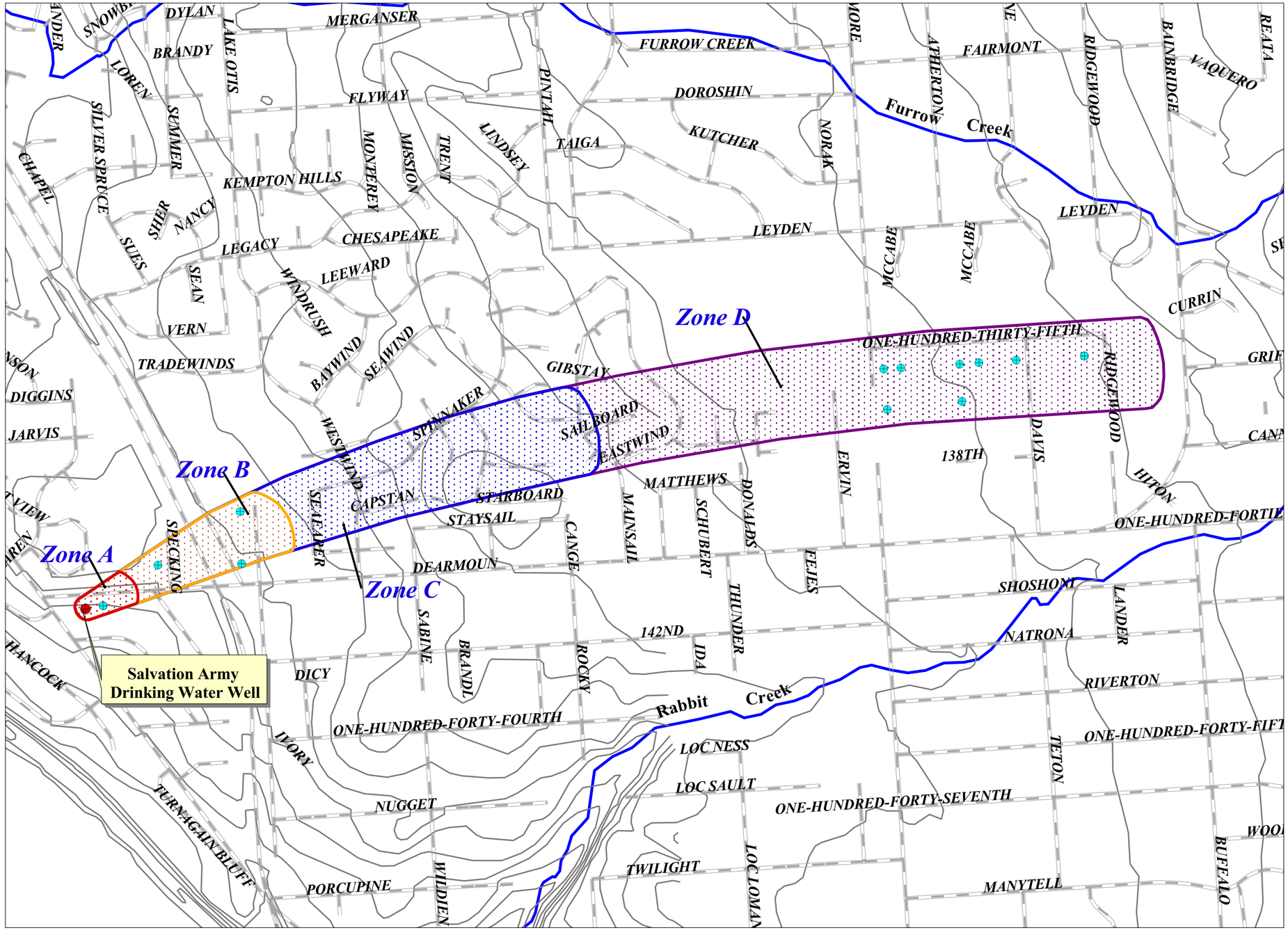
APPENDIX A

Salvation Army's
Drinking Water Protection Area

Drinking Water Protection Area for Salvation Army



- Salvation Army DW Well
- MOA Private 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

- Anchorage Roads
- Elevation Contours
- Anchorage Streams

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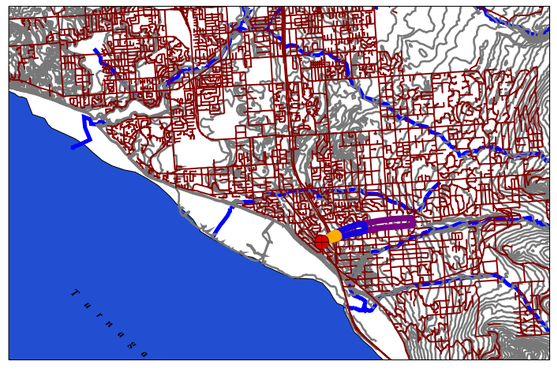

Map 1

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APPENDIX B

Contaminant Source Inventory and Risk Ranking for Salvation Army

Table 1

Contamiant Source Inventory for Salvation Army

PWSID 214471.001

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Location	Map	Comments
Residential Areas	R1	R1-1	A	Residential areas located within Zone A	3	
Septic systems (serves one or more single-family homes)	R2	R2-1	A	Located along Dearmoun Road	3	
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Dearmoun Road	2	
Dog walking areas/foot trails	X46	X46-1	A	North of well in Zone A	2	
Dog walking areas/foot trails	X46	X46-2	A	North of Dearmoun road in Zone A	2	
Domestic wastewater collection systems (sewer lines or lift stations)	D1	D1-1	B	Sewer lines along Brayton Drive	3	
Residential Areas	R1	R1-2	B	Residential areas located within Zone B	3	
Septic systems (serves one or more single-family homes)	R2	R2-2	B	Located along Specking Ave.	3	
Septic systems (serves one or more single-family homes)	R2	R2-3	B	Located along Brayton Drive	3	
Septic systems (serves one or more single-family homes)	R2	R2-4	B	Located along Brayton Drive	3	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Specking Ave.	2	
Highways and roads, paved (cement or asphalt)	X20	X20-3	B	Specking Ave.	2	
Highways and roads, paved (cement or asphalt)	X20	X20-4	B	New Seward Highway	2	
Highways and roads, paved (cement or asphalt)	X20	X20-5	B	Brayton Drive	2	
Highways and roads, paved (cement or asphalt)	X20	X20-6	B	Lake Otis Parkway	2	
Highways and roads, paved (cement or asphalt)	X20	X20-7 - 20	B	Roads located within Zone C	2	
Dog walking areas/foot trails	X46	X46-3	B	West of Specking Ave.	2	
Dog walking areas/foot trails	X46	X46-4	B	West of Brayton Drive	2	
Dog walking areas/foot trails	X46	X46-5	B	East of Brayton Drive	2	
Municipal or city parks (with green areas)	X4	X4-1	B, C	Loacted in Zones B and C	3	

Domestic wastewater collection systems (sewer lines or lift stations)	D1	D1-2 - 19	C	Sewer lines located within Zone C	3	
Residential Areas	R1	R1-3	C	Residential areas located within Zone C	3	
Dog walking areas/foot trails	X46	X46-6	C	West of Westwind Drive	4	
Dog walking areas/foot trails	X46	X46-7	C	Along Westwind Drive	4	
Dog walking areas/foot trails	X46	X46-8	C	East of Westwind Drive	4	

Table 2

Contaminant Source Inventory and Risk Ranking for
Salvation Army
Sources of Bacteria and Viruses

PWSID 214471.001

Contaminant Source Type	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank After Analysis	Location	Map Number	Comments
Septic systems (serves one or more single-family homes)	R2	R2-1	A	Low	1	Located along Dearmoun Road	3	
Residential Areas	R1	R1-1	A	Low	2	Residential areas located within Zone A	3	
Dog walking areas/foot trails	X46	X46-1	A	Very Low	3	North of well in Zone A	2	
Septic systems (serves one or more single-family homes)	R2	R2-2	B	Very Low	4	Located along Specking Ave.	3	
Residential Areas	R1	R1-2	B	Low	5	Residential areas located within Zone B	3	
Domestic wastewater collection systems (sewer lines or lift stations)	D1	D1-1	B	Very Low	6	Sewer lines along Brayton Drive	3	
Septic systems (serves one or more single-family homes)	R2	R2-3	B	Very Low	7	Located along Brayton Drive	3	
Septic systems (serves one or more single-family homes)	R2	R2-4	B	Very Low	8	Located along Brayton Drive	3	
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Very Low	9	Dearmoun Road	2	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Very Low	10	Specking Ave.	2	
Dog walking areas/foot trails	X46	X46-2	A	Very Low		North of Dearmoun road in Zone A	2	
Highways and roads, paved (cement or asphalt)	X20	X20-3	B	Very Low		Specking Ave.	2	
Highways and roads, paved (cement or asphalt)	X20	X20-4	B	Very Low		New Seward Highway	2	
Highways and roads, paved (cement or asphalt)	X20	X20-5	B	Very Low		Brayton Drive	2	
Highways and roads, paved (cement or asphalt)	X20	X20-7 - 20	B	Very Low		Roads located within Zone C	2	
Dog walking areas/foot trails	X46	X46-3	B	Very Low		West of Specking Ave.	2	
Dog walking areas/foot trails	X46	X46-4	B	Very Low		West of Brayton Drive	2	
Dog walking areas/foot trails	X46	X46-5	B	Very Low		East of Brayton Drive	2	
Municipal or city parks (with green areas)	X4	X4-1	B, C	Low		Loacted in Zones B and C	3	
Domestic wastewater collection systems (sewer lines or lift stations)	D1	D1-2 - 19	C	Medium		Sewer lines located within Zone C	3	

Residential Areas	R1	R1-3	C	Very Low		Residential areas located within Zone C	3	
Dog walking areas/foot trails	X46	X46-6	C	Very Low		West of Westwind Drive	2	
Dog walking areas/foot trails	X46	X46-7	C	Very Low		Along Westwind Drive	2	
Dog walking areas/foot trails	X46	X46-8	C	Very Low		East of Westwind Drive	2	
Highways and roads, paved (cement or asphalt)	X20	X20-6	B	Very Low		Lake Otis Parkway	2	

Table 3

Contaminant Source Inventory and Risk Ranking for Salvation Army
Sources of Nitrates/Nitrites

PWSID 214471.001

Contaminant Source Type	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank After Analysis	Location	Map Number	Comments
Septic systems (serves one or more single-family homes)	R2	R2-1	A	Low	1	Located along Dearmoun Road	3	
Residential Areas	R1	R1-1	A	Low	2	Residential areas located within Zone A	3	
Dog walking areas/foot trails	X46	X46-1	A	Very Low	3	North of well in Zone A	2	
Septic systems (serves one or more single-family homes)	R2	R2-2	B	Very Low	4	Located along Specking Ave.	3	
Domestic wastewater collection systems (sewer lines or lift stations)	D1	D1-1	B	Medium	6	Sewer lines along Brayton Drive	3	
Septic systems (serves one or more single-family homes)	R2	R2-3	B	Very Low	7	Located along Brayton Drive	3	
Septic systems (serves one or more single-family homes)	R2	R2-4	B	Very Low	8	Located along Brayton Drive	3	
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Very Low	9	Dearmoun Road	2	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Very Low	10	Specking Ave.	2	
Dog walking areas/foot trails	X46	X46-2	A	Very Low		North of Dearmoun road in Zone A	2	
Residential Areas	R1	R1-2	B	Low		Residential areas located within Zone B	3	
Highways and roads, paved (cement or asphalt)	X20	X20-3	B	Very Low		Specking Ave.	2	
Highways and roads, paved (cement or asphalt)	X20	X20-4	B	Very Low		New Seward Highway	2	
Highways and roads, paved (cement or asphalt)	X20	X20-5	B	Very Low		Brayton Drive	2	
Highways and roads, paved (cement or asphalt)	X20	X20-6	B	Very Low		Lake Otis Parkway	2	
Highways and roads, paved (cement or asphalt)	X20	X20-7 - 20	B	Very Low		Roads located within Zone C	2	
Dog walking areas/foot trails	X46	X46-3	B	Very Low		West of Specking Ave.	2	
Dog walking areas/foot trails	X46	X46-4	B	Very Low		West of Brayton Drive	2	
Dog walking areas/foot trails	X46	X46-5	B	Very Low		East of Brayton Drive	2	
Municipal or city parks (with green areas)	X4	X4-1	B, C	Low		Loacted in Zones B and C	3	

Domestic wastewater collection systems (sewer lines or lift stations)	D1	D1-2 - 19	C	Medium		Sewer lines located within Zone C	3	
Residential Areas	R1	R1-3	C	Low		Residential areas located within Zone C	3	
Dog walking areas/foot trails	X46	X46-6	C	Very Low		West of Westwind Drive	2	
Dog walking areas/foot trails	X46	X46-7	C	Very Low		Along Westwind Drive	2	
Dog walking areas/foot trails	X46	X46-8	C	Very Low		East of Westwind Drive	2	

Table 4

Contaminant Source Inventory and Risk Ranking for Salvation Army
Sources of Volatile Organic Chemicals

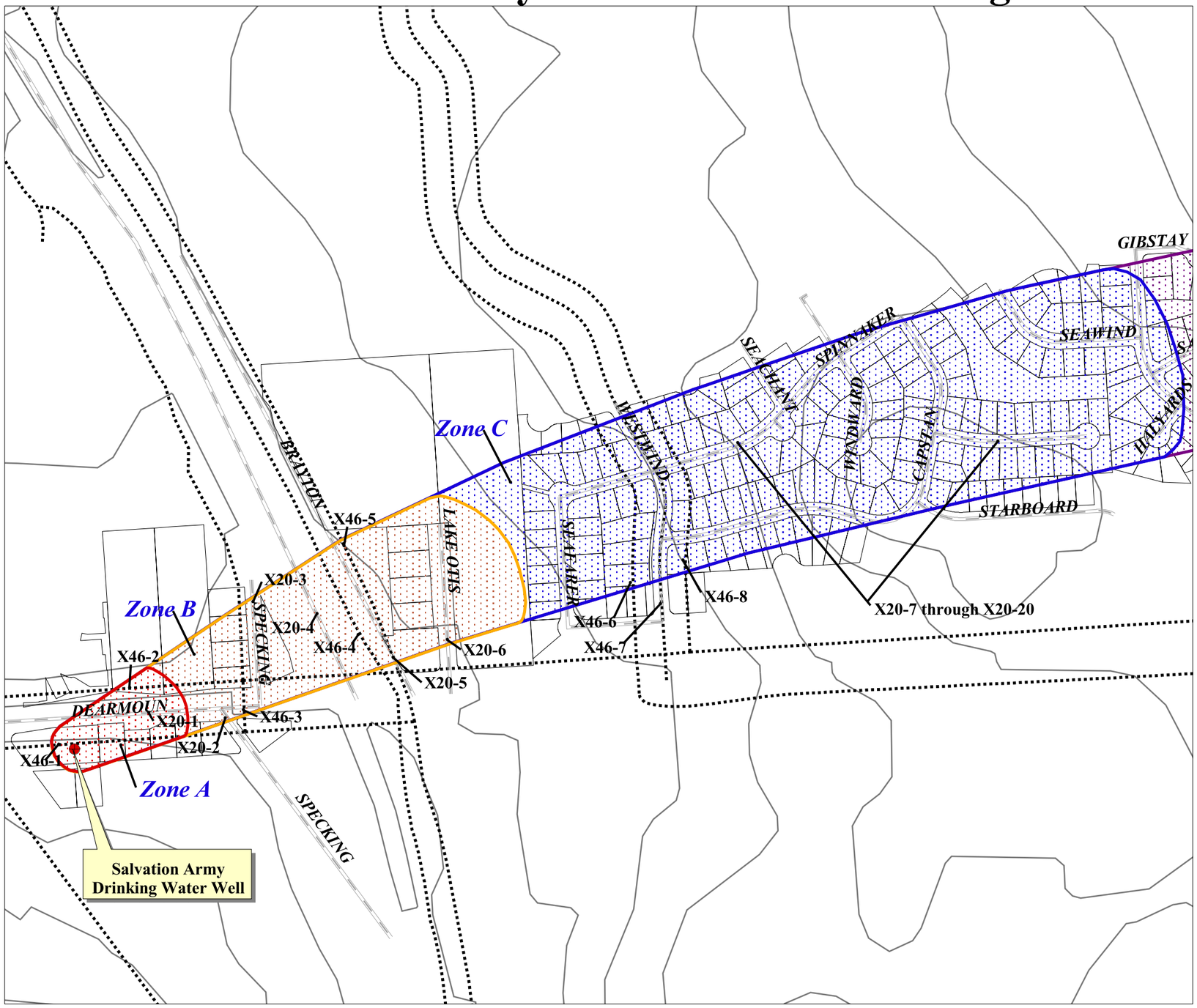
PWSID 214471.001

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	X20-4	B	Low	1	New Seward Highway	2	
Highways and roads, paved (cement or asphalt)	X20	X20-1	A	Low	2	Dearmoun Road	2	
Highways and roads, paved (cement or asphalt)	X20	X20-6	B	Low	3	Lake Otis Parkway	2	
Highways and roads, paved (cement or asphalt)	X20	X20-2	B	Low	4	Specking Ave.	2	
Highways and roads, paved (cement or asphalt)	X20	X20-3	B	Low	5	Specking Ave.	2	
Highways and roads, paved (cement or asphalt)	X20	X20-5	B	Low	6	Brayton Drive	2	
Septic systems (serves one or more single-family homes)	R2	R2-1	A	Very Low	7	Located along Dearmoun Road	3	
Septic systems (serves one or more single-family homes)	R2	R2-2	B	Very Low	8	Located along Specking Ave.	3	
Domestic wastewater collection systems (sewer lines or lift stations)	D1	D1-1	B	Low	9	Sewer lines along Brayton Drive	3	
Septic systems (serves one or more single-family homes)	R2	R2-3	B	Very Low	10	Located along Brayton Drive	3	
Residential Areas	R1	R1-1	A	Low		Residential areas located within Zone A	3	
Residential Areas	R1	R1-2	B	Low		Residential areas located within Zone B	3	
Septic systems (serves one or more single-family homes)	R2	R2-4	B	Medium		Located along Brayton Drive	3	
Highways and roads, paved (cement or asphalt)	X20	X20-7 - 20	B	Low		Roads located within Zone C	2	
Municipal or city parks (with green areas)	X4	X4-1	B, C	Low		Loacted in Zones B and C	3	
Domestic wastewater collection systems (sewer lines or lift stations)	D1	D1-2 - 19	C	Low		Sewer lines located within Zone C	3	
Residential Areas	R1	R1-3	C	Low		Residential areas located within Zone C	3	

APPENDIX C

Salvation Army's
Drinking Water Protection Area
and Potential & Existing Contaminant Sources

Drinking Water Protection Area for
Salvation Army and Potential & Existing Contaminant Sources



- Salvation Army 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
- MOA Roads (X20)
- Trails (X46)
- Elevation Contours

1000 0 1000 2000 Feet

N W E S

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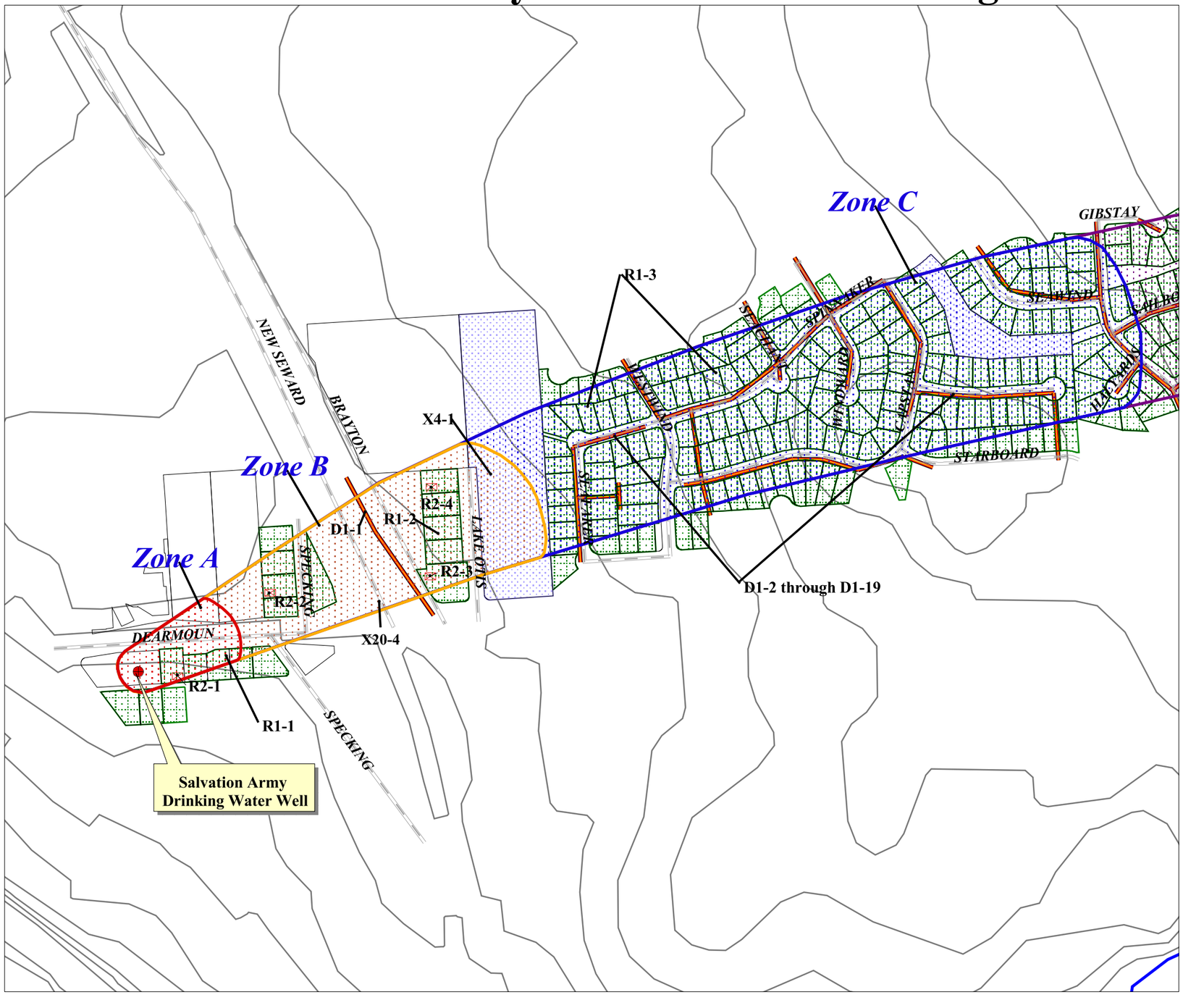
Map 2

Drinking Water Protection Area for
Salvation Army and Potential & Existing Contaminant Sources



- Salvation Army 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

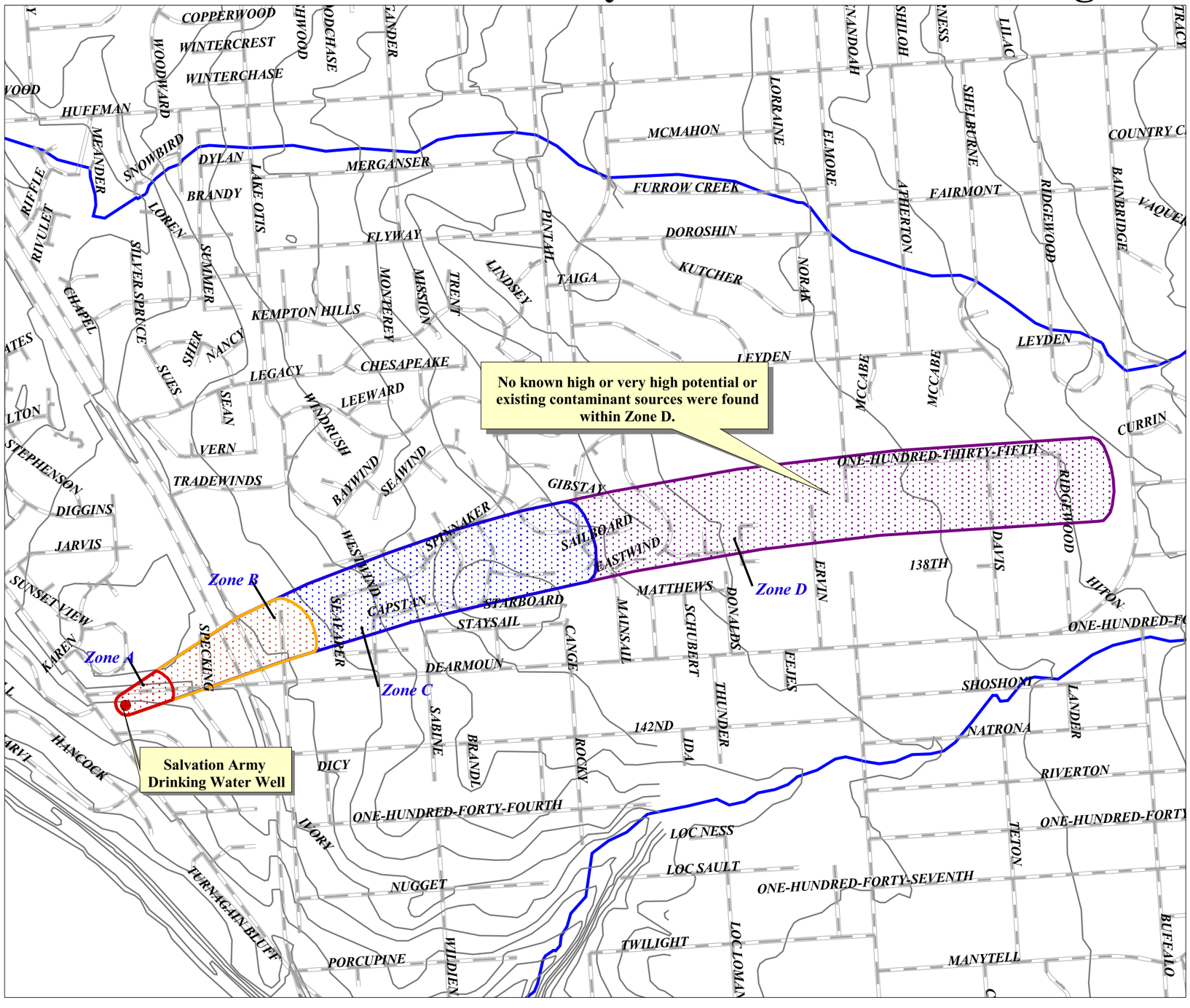
Zone D Protection Area
- Less Than 10 Years Travel Time
- MOA Land Parcels
- Rabbit Creek Park (X4)
- Lawns and Gardens (R1)
- MOA Roads (X20)
- Sewer Lines (D1)
- Septic Systems (R2)
- Elevation Contours
- Anchorage Streams

N
W E
S

PWSID 214471.001

Map 3

Drinking Water Protection Area for
Salvation Army and Potential & Existing Contaminant Sources



- Salvation Army 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
- Anchorage Roads
- Elevation Contours
- Anchorage Streams

N
W E
S

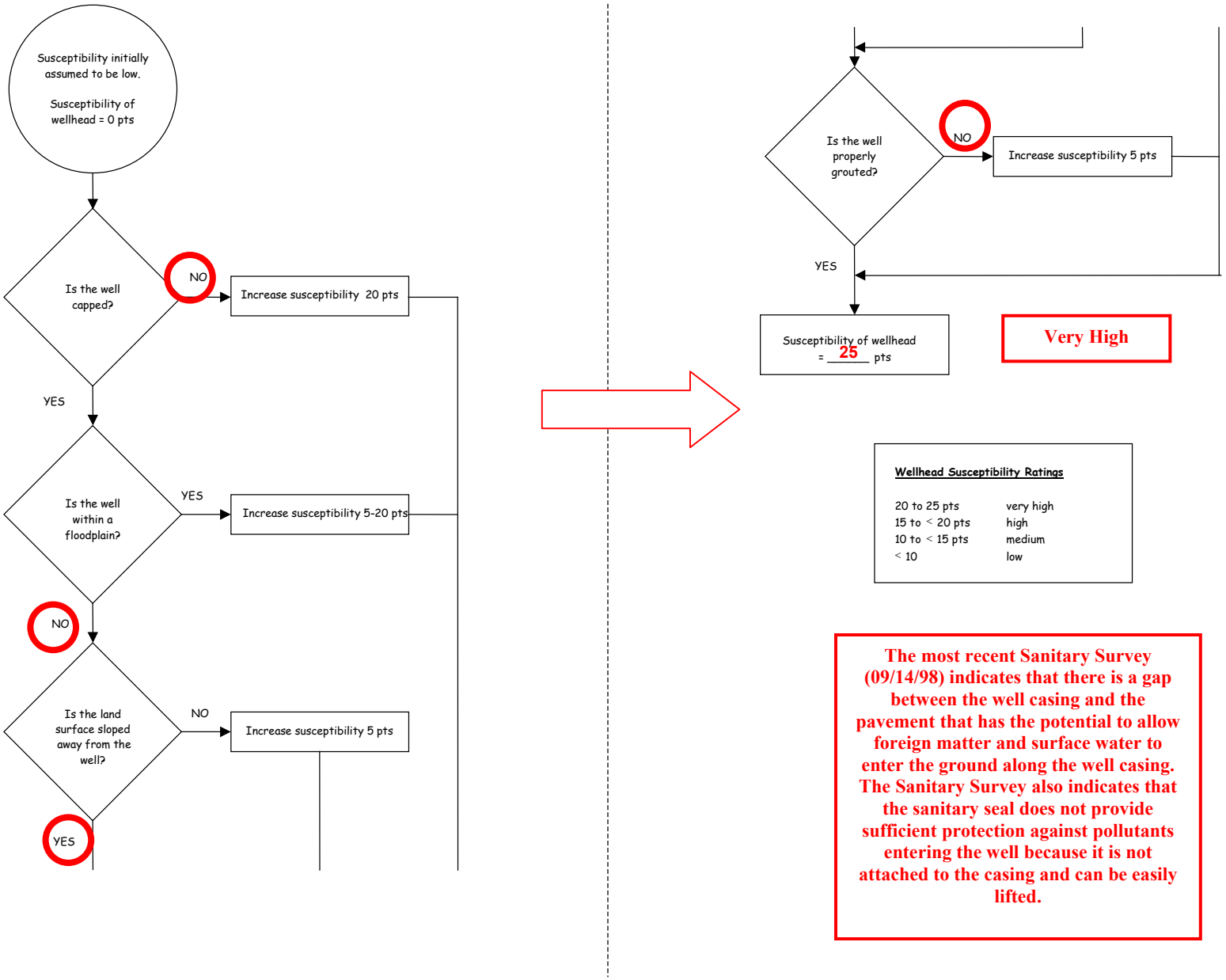
PWSID 214471.001

Map 4

APPENDIX D

Vulnerability Analysis for Salvation Army's Public Drinking Water Source

Chart 1. Susceptibility of the wellhead – Salvation Army

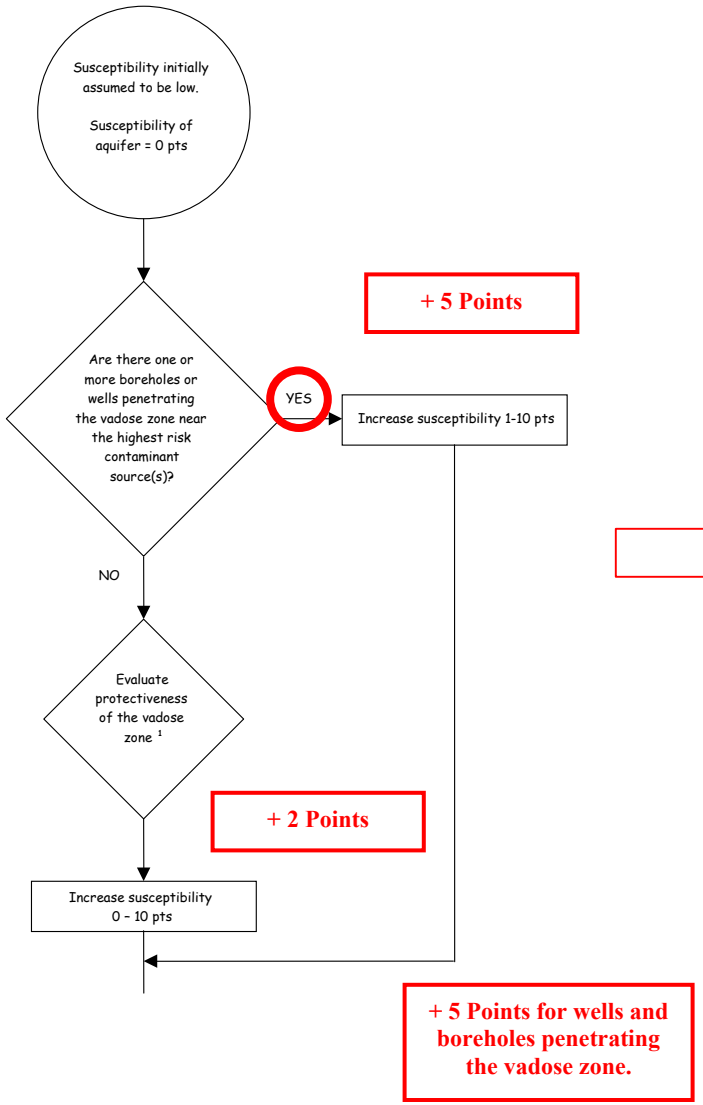


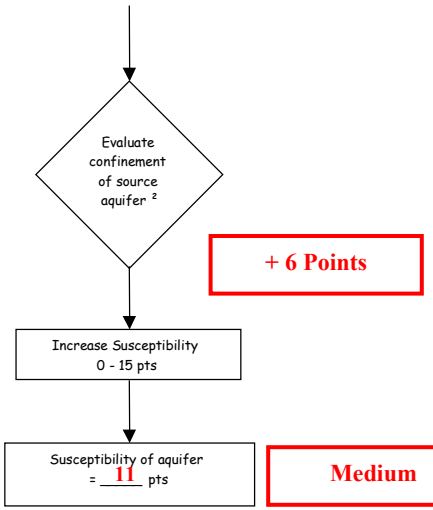
Wellhead Susceptibility Ratings

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

The most recent Sanitary Survey (09/14/98) indicates that there is a gap between the well casing and the pavement that has the potential to allow foreign matter and surface water to enter the ground along the well casing. The Sanitary Survey also indicates that the sanitary seal does not provide sufficient protection against pollutants entering the well because it is not attached to the casing and can be easily lifted.

Chart 2. Susceptibility of the aquifer – Salvation Army





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]

Recharge (20-30 inches per year, base of Chugach Mountains) 3/10 = 1 Point

Depth to top of confining unit (45 feet) 3/10 = 1 Point

Protectiveness of the Vadose Zone Total = **2/10 Points**

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 = 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 = 15 pts; 35% weight]

Confinement (49 feet of till and clay) 6/15 = 4 Points

Density of boreholes/wells 5/15 = 2 Points

Degree of Confinement Total = **6/15 Points**

Aquifer Susceptibility Ratings

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

Medium

Chart 3. Contaminant risks for Salvation Army – Bacteria & Viruses

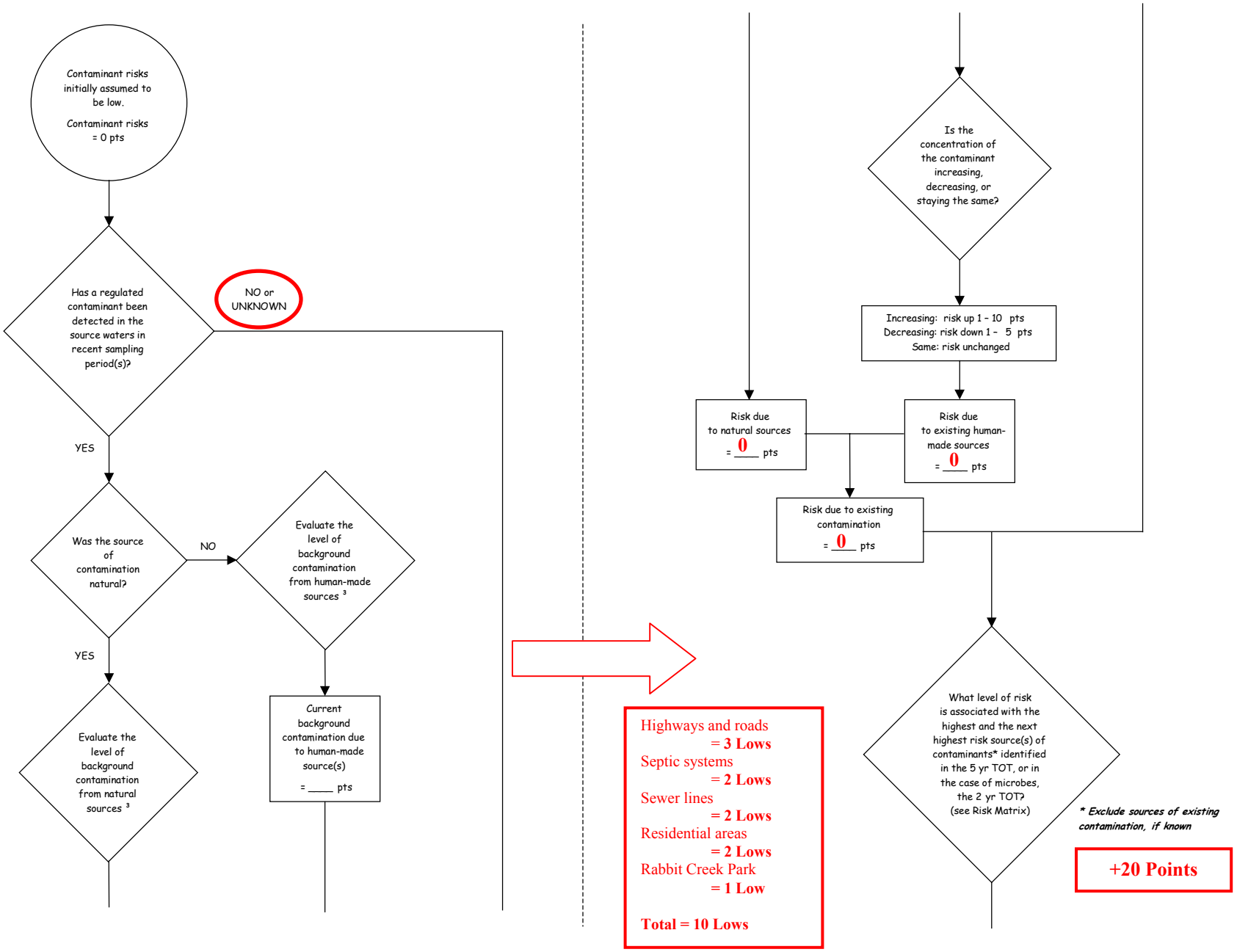


Chart 3. Contaminant risks for Salvation Army – Bacteria & Viruses (Continued)

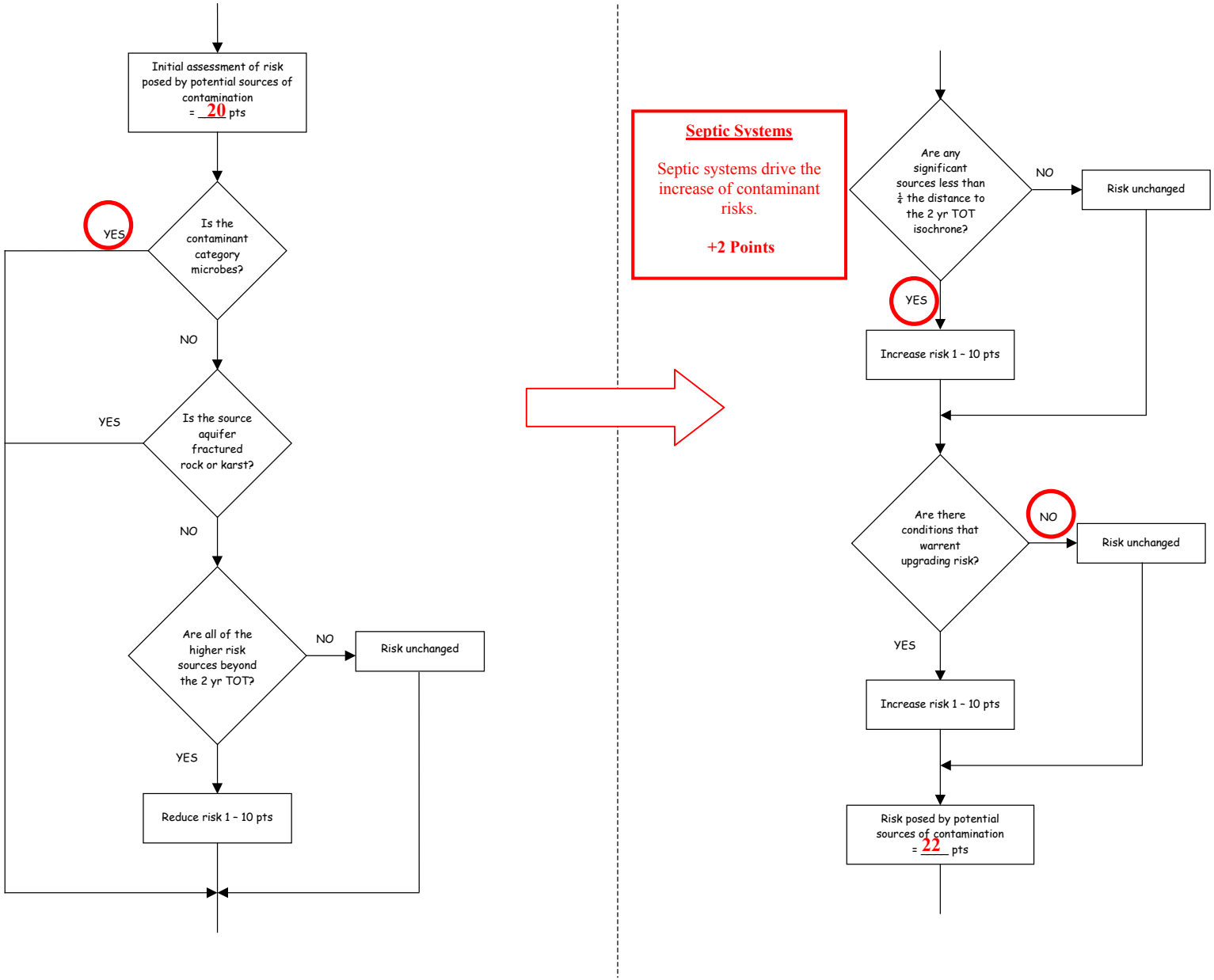
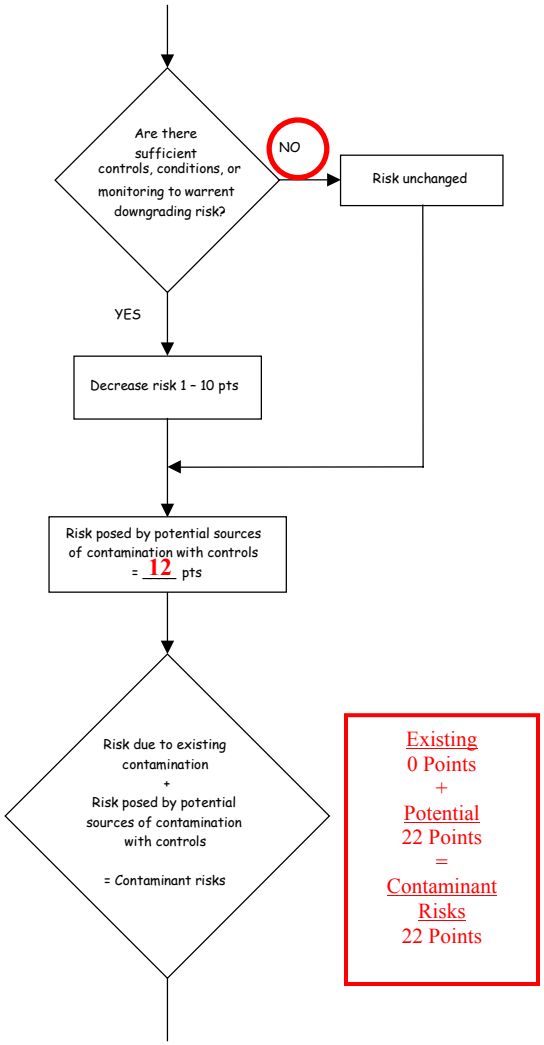


Chart 3. Contaminant risks for Salvation Army – Bacteria & Viruses (Continued)



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

** Truncate risk at 50 pts*

Contaminant risks* = 22 pts

Medium

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 Salvation Army – Bacteria & Viruses

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)

Highways and roads, septic systems, sewer lines, residential areas, Rabbit Creek Park	**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 Salvation Army – Bacteria & Viruses

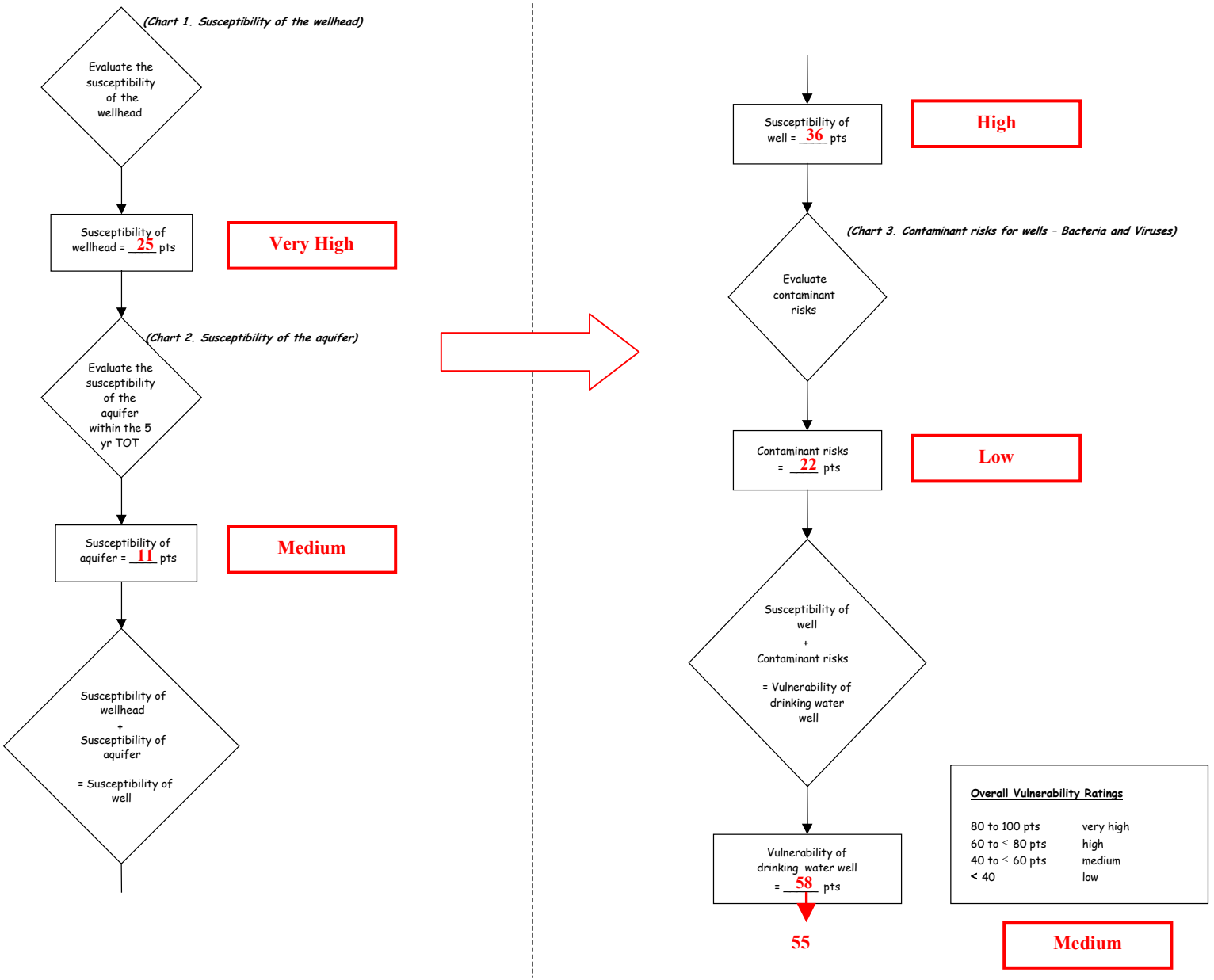


Chart 5. Contaminant risks for Salvation Army – Nitrates and Nitrites

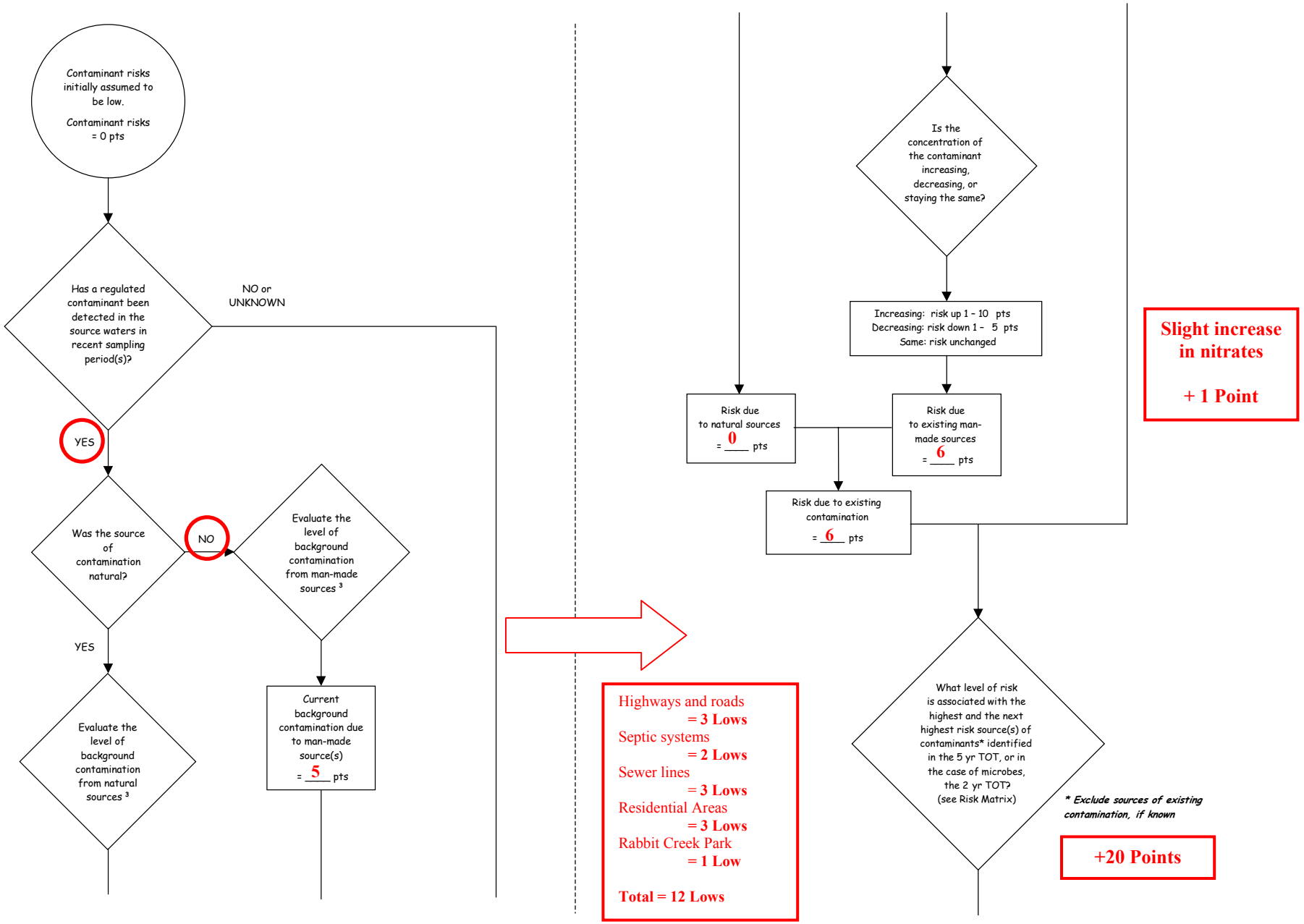


Chart 5. Contaminant risks for Salvation Army – Nitrates and Nitrites (Continued)

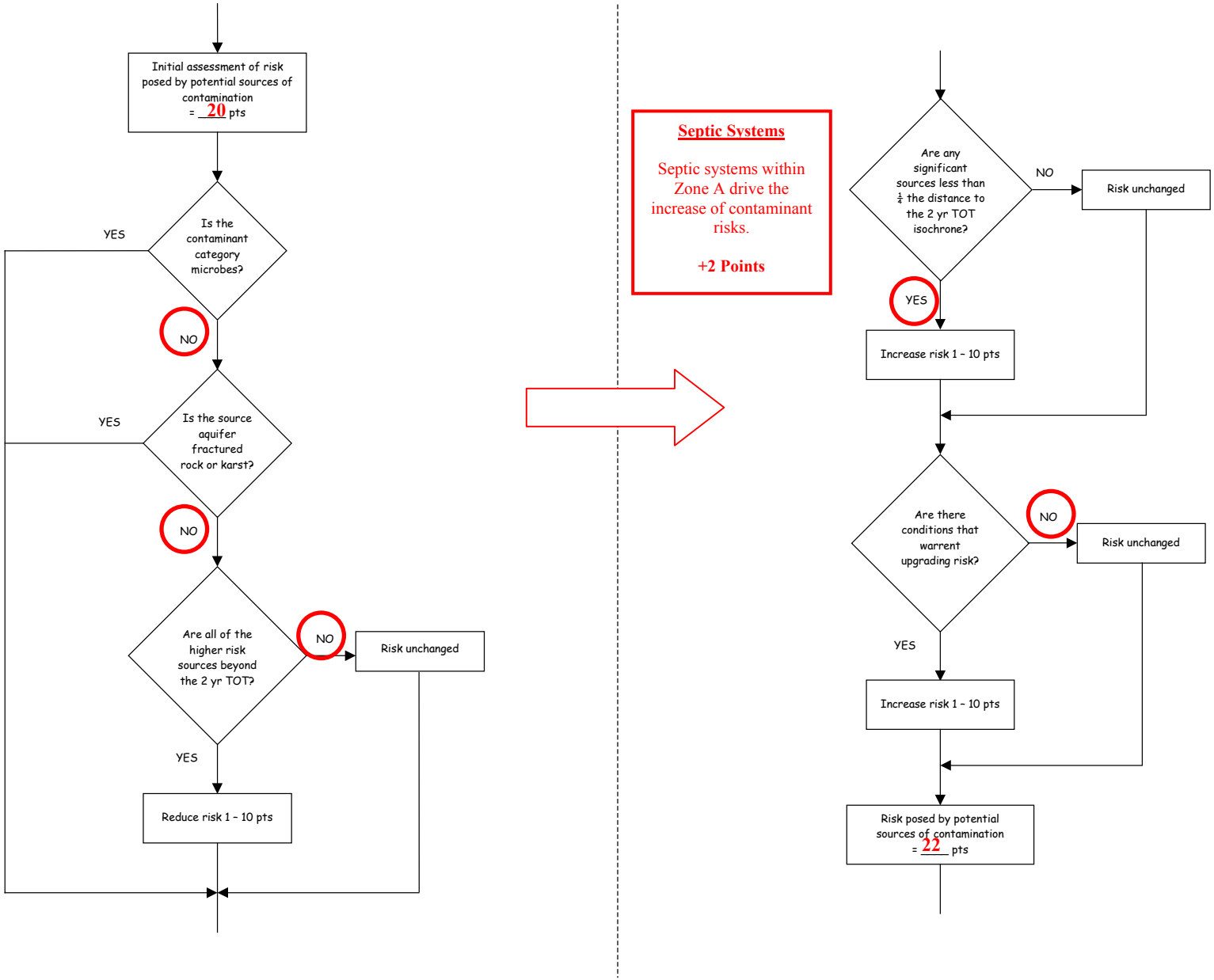
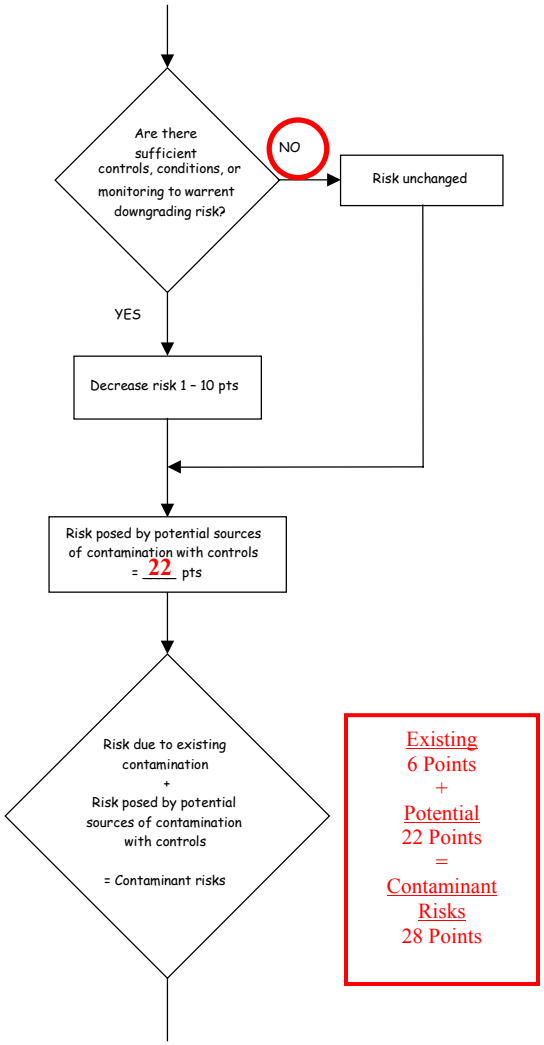


Chart 5. Contaminant risks for Salvation Army – Nitrates and Nitrites (Continued)



Existing
6 Points
+
Potential
22 Points
=
Contaminant
Risks
28 Points

* *Truncate risk at 50 pts*

Contaminant risks*
= 28 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

Nitrate
1.8 mg/L (06/05/00)
1.7 mg/L (10/16/97)
1.6 mg/L (01/17/96)
1.3 mg/L (01/25/95)
1.3 mg/L (11/18/93)
1.2 mg/L (10/13/92)

Maximum Contaminant Level (MCL) = 10mg/L

1.8/10
= 0.18 or 18% of MCL

+5 Points

Table 2. Risk Matrix for Contaminant Sources for Salvation Army – Nitrates and Nitrites

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)

Horse and foot trails, dirt roads	**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 Salvation Army – Nitrates and Nitrites

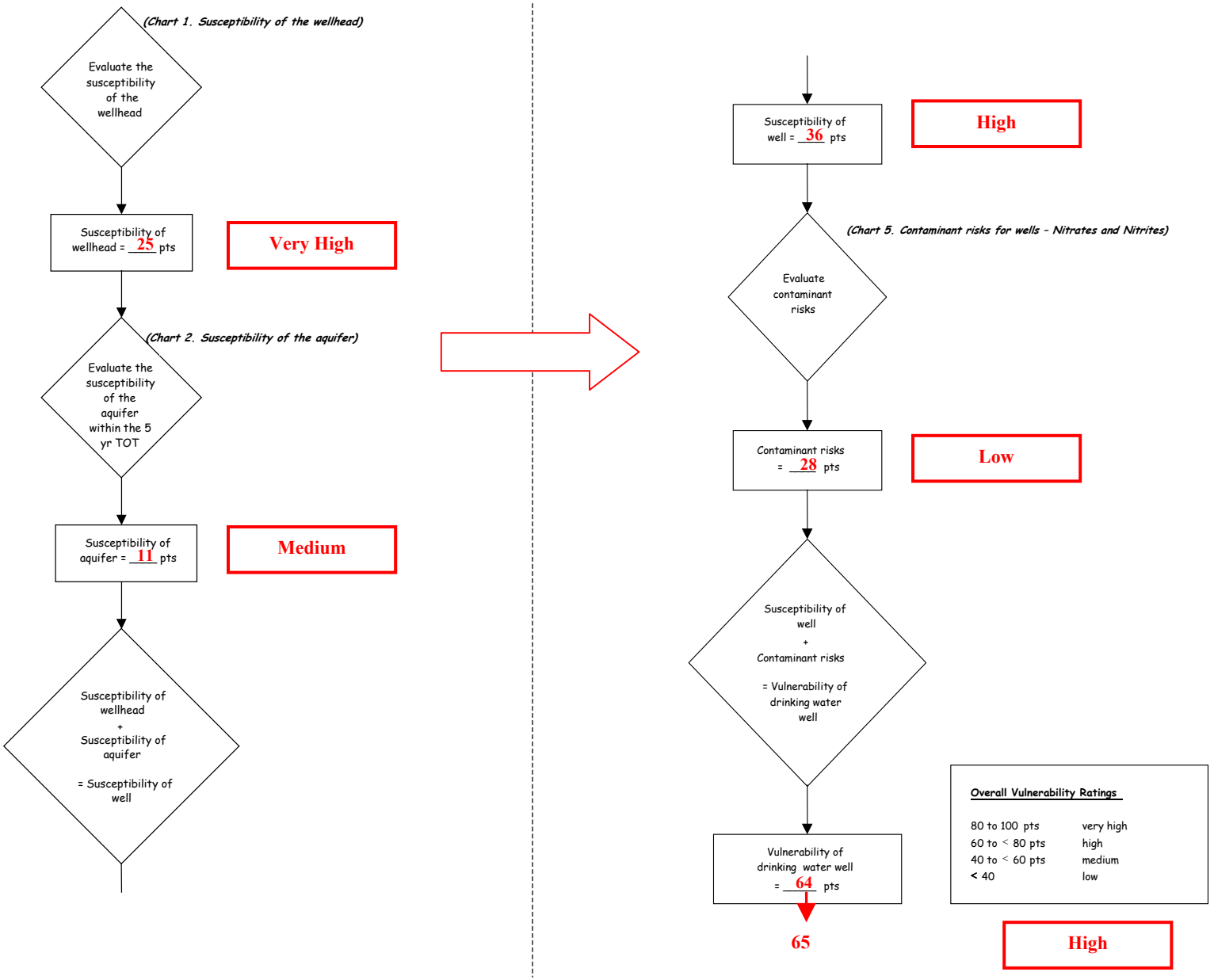


Chart 7. Contaminant risks for Salvation Army – Volatile Organic Chemicals

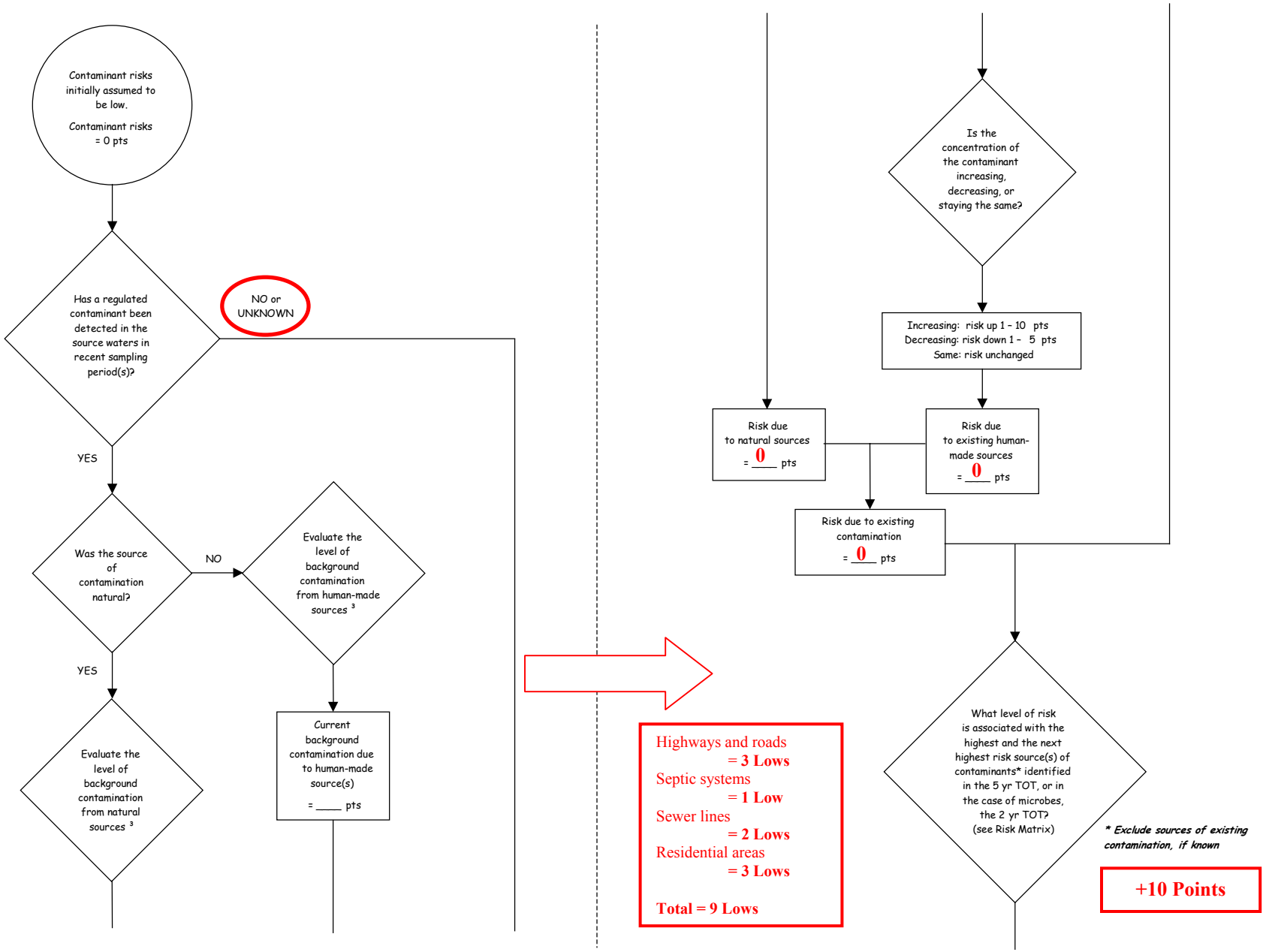


Chart 7. Contaminant risks for Salvation Army – Volatile Organic Chemicals (Continued)

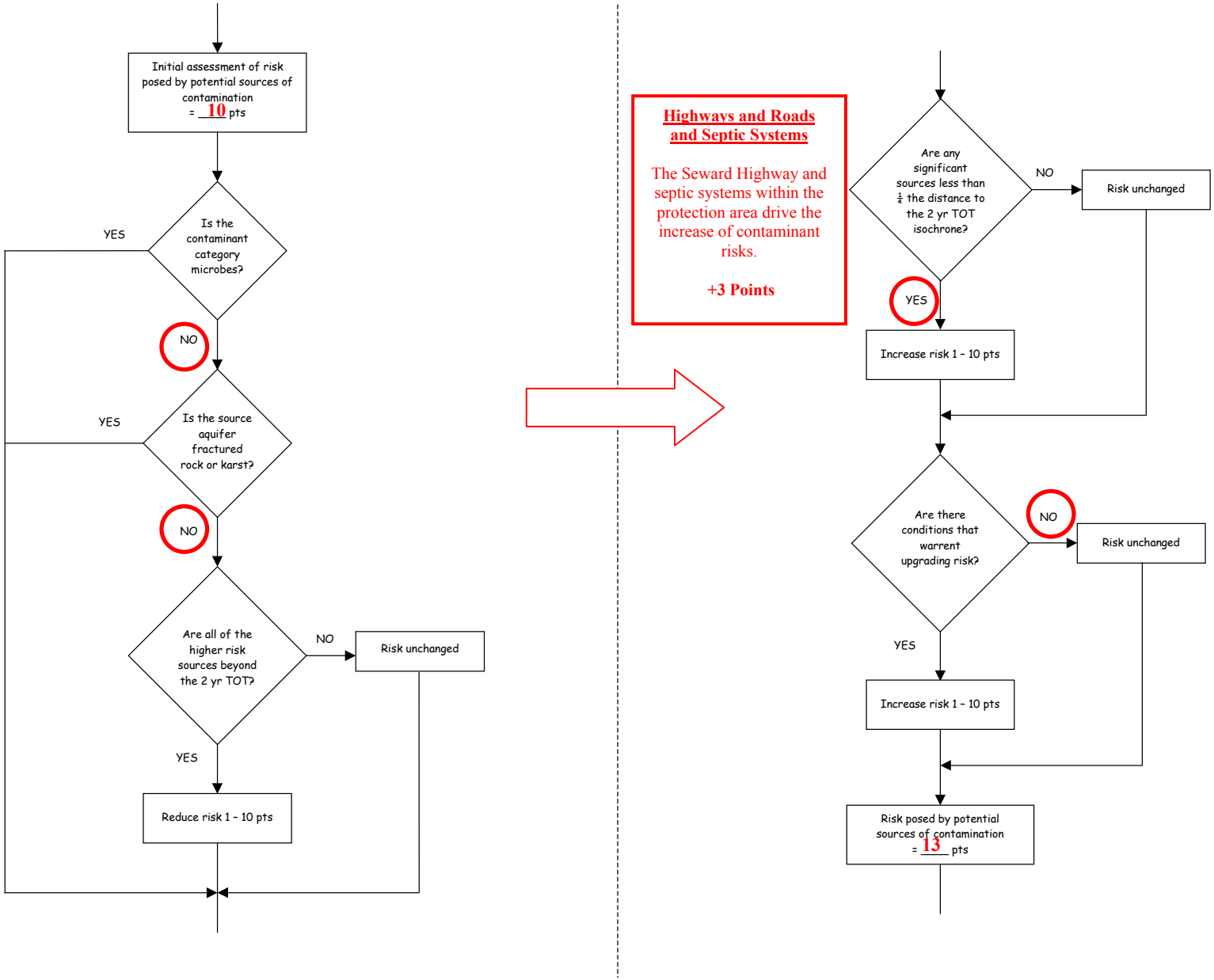
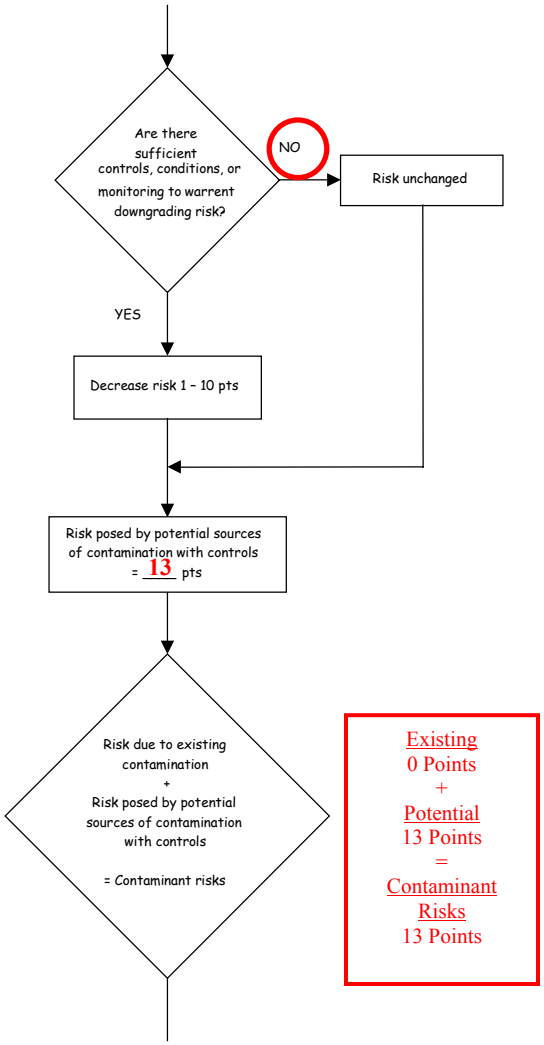
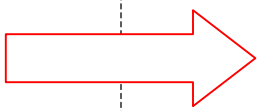


Chart 7. Contaminant risks for Salvation Army– Volatile Organic Chemicals (Continued)



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



** Truncate risk at 50 pts*

Contaminant risks*
= 13 pts

Low

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 3. Risk Matrix for Contaminant Sources for Salvation Army – Volatile Organic Chemicals

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)

Highways and roads, septic systems, sewer lines, residential areas	**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 Salvation Army – Volatile Organic Chemicals