Hydrogeologic Susceptibility and Vulnerability Assessment for Trinity Lutheran Church Drinking Water Well, Palmer, Alaska

DRINKING WATER PROTECTION PROGRAM REPORT 91

September 2001

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By Catherine Baxter, B.E.S.T. Resource

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Drinking Water Protection Program
Alaska Department of Environmental Conservation

EXECUTIVE SUMMARY

The Trinity Lutheran Church is a Class B (transient/noncommunity) drinking water source consisting of one well. Identified potential and current sources of contaminants for Trinity Lutheran Church include: roads, residential septic systems and lawns and gardens. These existing and potential sources of contamination are considered a source of bacteria and viruses, nitrates and/or nitrites, and volatile organic chemicals. Overall, Trinity Lutheran Church public water source received a vulnerability rating of **Medium** for bacteria and viruses and nitrates and/or nitrites, and **Low** for volatile organic chemicals.

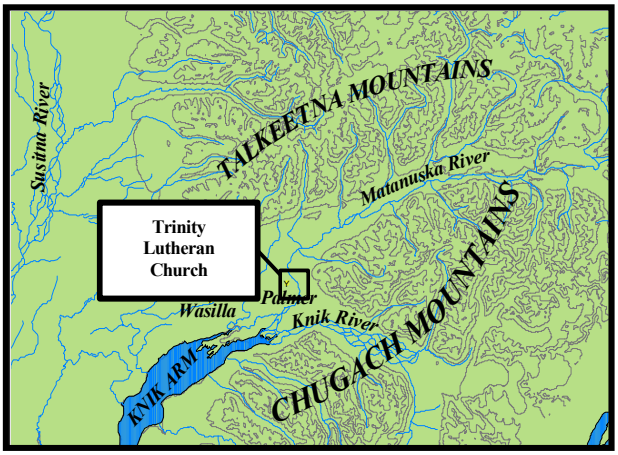

Figure 1. Index map showing the location of well assessment

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 Trinity Lutheran Church source of public drinking water. This source consists of one well in the Palmer area (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 MATANUSKA-SUSITNA VALLEY-AREA, ALASKA

Location

The Matanuska-Susitna Valley is part of the lowland lying about 50 miles north of Anchorage in south-central Alaska. The well described in this report is part of the Matanuska River Watershed. This study area is roughly bounded on the north by the Talkeetna Mountains; on the west by Wasilla Creek; on the south by the Knik River; and on the east by the Chugach Mountains. The area covers approximately 150 square miles.

Climate

The climate of the Matanuska-Susitna Valley is the result of a combination of marine and continental influences. The 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 is approximately 15 inches per year. On the average, the Valley receives a total snow accumulation of 58 inches per year. Precipitation generally increased inland toward the Talkeetna Mountains where annual precipitation may exceed 60 inches. Mean daily temperature ranges from 67^{o} F during July to 5^{o} F in January [*Western Regional Climate Center*, 2000].

Physiography and Groundwater Conditions

The Matanuska-Susitna Valley is surrounded by rugged mountains that rise abruptly from the valley floor. The Chugach Mountains at the southern edge of the valley reach altitudes greater than 6300 feet. These mountains are composed primarily of metamorphosed sedimentary marine and volcanic rocks, and greenstone of Mesozoic age. Along the northern edge of the valley, peaks in the Talkeetna Mountains reach altitudes of 3000 to 5000 feet. The Talkeenta Mountains are composed mainly of igneous rocks, chiefly granitic intrusives (Mesozoic?) and subordinate lavas and tuffs; Cretaceous and Tertiary sedimentary rocks form the south flank of the mountains. Although the altitude of the valley floor ranges from sea level at Knik Arm to 1000 feet at the base of Wishbone Hill, the local relief is commonly not more than 100 to 200 feet.

The Matanuska and Knik River's drain the area. These rivers are braided glacial outwash streams having wide floodplains. Drainage is poor in many interstream tracts resulting in large areas of swampy ground with shallow lakes occupying depressions.

The Matanuska-Susitna Valley is floored with unconsolidated deposits, chiefly glacial drift, that represents several episodes of glacial advances and retreats. The drift includes till, outwash stream deposits, and estuarine and lake deposits. Physiographic features formed by these deposits in or adjacent to the study area include end moraine, lateral moraines, eskers, crevasse fillings, and other pitted features, river terraces, outwash floodplains and an extensive estuarine flat (Trainer, 1960).

The glacial till and bedrock form aquifers of minor importance. The chief hydrologic significance of the till is in confining the artesian aquifer. Generally, the till is poorly permeable, although locally thin layers of sand may yield small quantities of water. Till that is present at or near the land surface in much of the area makes the acquisition of shallow groundwater difficult. The bedrock is poorly permeable. It yields water only from fractures, whose location and frequency cannot be easily predicted.

The chief aquifers are composed of outwash sand and gravel laid down by melt-water streams or in lakes. The outwash deposits are of two chief forms. The first consists of sheet-like deposits that lie just beneath the ground surface. These deposits range in thickness from a few feet to more than 100 feet. They typically rest on till or bedrock. The water in these deposits is unconfined. The other outwash deposits are buried beneath till. They are known to be as much as 50 to 60 feet thick, and probably are considerably thicker in some places. They commonly contain confined, or artesian, groundwater. Well logs and data from pumping tests suggest that outwash sand and gravel form a continuous or nearly continuous sheet in an area of more than 10 square miles north and west of Palmer (Jakola et al, 1991).

Recharge of the groundwater is chiefly from precipitation but it is likely that only a small proportion of the annual precipitation reaches the water body. During very dry seasons conspicuous declines in of water levels occur in many wells. Along the mountain fronts, groundwater seeps from fractures in bedrock into the sediments. At these higher elevations, rain and snowmelt also enter the sediments. Lastly, aquifers may be recharged by streams where surface water percolates into surrounding permeable sediments (losing reaches of streams). This is the case for the water-table aquifers in the terrace south of Palmer and in the Bodenburg Butte area, which receive underground flow from the Matanuska River. Groundwater flow in the confined aquifers is generally from the north and north-northwest. The direction of groundwater flow in the upper unconfined aquifer is more variable due to the influence from surficial topography as well as its close connection with surface water bodies (Trainer,1960).

TRINITY LUTHERAN CHURCH PUBLIC WATER SOURCE

Trinity Lutheran Church public water source is a Class B (transient/noncommunity) water source, which is privately owned and operated. The source consists of one well located 3 miles north of Palmer and west of the Glennallen highway at Mile 1 Farm Loop Road. The well is at an elevation of 550 feet above sea level. According to the well log, Trinity Lutheran Church appears to be grouted and functioning properly. The well penetrates gravel and silty sand to 250 feet below the surface. From 0 to 50 feet dry gravel is present. Till is present from 51 to 150. Silt and clay are present from 151 to 250 feet below the surface The well is screened for 6 feet and has a static water level of 160 feet below land surface at the time of drilling (5/18/85).

The water system at Trinity Lutheran Church consists of four hydropneumatic pressure tanks, jet pumps and four atmospheric storage tanks. This water source operates 220 days per year. The Trinity Lutheran Church drinking water source collectively serves approximately 59 residents and non-residents through four service connections.

ASSESSMENT AND PROTECTION AREA FOR TRINITY LUTHERAN CHURCH DRINKING WATER SOURCE

The Drinking Water Protection and Assessment Area that has been established for Trinity Lutheran Church 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. 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 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 Talkeetna Mountains and flows toward Cook Inlet. 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 well log and the recent Sanitary Survey. This analytical calculation was used as a guide in establishing the protection area for Trinity Lutheran Church. 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 (ADEC) 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 Areas for Trinity Lutheran Church contains four zones, Zone A, Zone B, Zone C and Zone D (Map 1, 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 down gradient from the well to take into account the area of the aquifer that is influenced by pumping of the well.

The Zone B protection area for Trinity Lutheran Church corresponds to a time-of-travel of less than two years and extends toward base of the Talkeetna Mountains. Zone C protection area corresponds to a time-of-travel of greater than 2 years and less than 5 years. Zone D corresponds to a time-of-travel of greater than 5 years and less than 10 years.

INVENTORY OF POTENTIAL AND EXISTING CONTAMINANT SOURCES

The Drinking Water Protection Program has completed an inventory of potential and existing sources of contamination within Trinity Lutheran Church 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
- Volatile organic chemicals.

Table 1 in Appendix C lists the Contaminant Source Inventory for Trinity Lutheran Church. Inventoried potential sources of contamination within Zone A were attributed to highways and roads, residential lawn & gardens and septic systems. Zones B contained residential lawn & gardens and septic systems. Zone C contained roads. Zone D contained only natural wilderness and was not considered in determining the vulnerability of this drinking water source to contamination. Below is a summary of the contaminant sources inventoried within the Trinity Lutheran Church protection area:

- Paved Highway
- Gravel Roads
- Residential Septic Systems
- Residential Lawn and Gardens.

These potential contaminant sources present risks for all three categories of drinking water contaminants for Trinity Lutheran Church 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 (Appendices B & C).

VULNERABILITY OF TRINITY LUTHERAN CHURCH 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 has been analyzed and an overall vulnerability score of 0 to 100 is 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)

Trinity Lutheran Church is completed in a confined aquifer setting. The well penetrates gravel and silty sand to 250 feet below the surface. From 0 to 50 feet dry gravel is present. Till is present from 51 to 150. Silt and clay are present from 151 to 250 feet below the surface, which may provide a protective barrier from the movement of contaminants in the subsurface. However, near the base of the Talkeetna Mountains, the clay and till layers tend to be discontinuous and thin toward the mountains. Therefore, contaminants that enter the subsurface near the base of the mountains may enter the confined aquifer uninhibited by any protective layer. This well appears to be properly grouted with surrounding concrete pad as indicated from ADEC records. Combining the susceptibilities of the wellhead and the aquifer to contamination leads to a score (0 – 50 points) and rating of overall Susceptibility (Appendix D). Table 1 shows the overall Susceptibility score and rating for Trinity Lutheran Church.

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

	Score	Rating
Susceptibility of the Wellhead	5	Low
Susceptibility of the Aquifer	15	High
Natural Susceptibility	20	Medium

Contaminant risks to a drinking water source depend on the type, number or density, and distribution of contaminant sources. One highway, three gravel roads, residential lawns and garden and septic systems contribute to the potential contamination of the Trinity Lutheran Church source of public drinking water.

A score (0 – 50 points) and rating of Contaminant Risks (Appendix D) is assigned based on the findings of the Contaminant Source Inventory (Appendix B - Table 1 – Table 7). This portion of the analysis examines any existing or historical contamination that has been detected at the drinking water source through routine sampling. It also reviews contamination that has or may have occurred but has not arrived or been detected at the 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	23	Medium
Nitrates and/or Nitrites	26	Medium
Volatile Organic Chemicals	13	Low

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

Table 3. Overall Vulnerability of Trinity Lutheran Church Public Drinking Water Source to Contamination by Category

Category	Score	Rating
Bacteria and Viruses	45	Medium
Nitrates and Nitrites	45	Medium
Volatile Organic Chemicals	35	Low

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.

The roads, lawns and gardens, and septic systems in Zone A--C are the factors determining contaminant risks for all categories of contaminants (See "Overall Rank after Analysis" in Table 2 – 4 of Appendix B).

Overall, contaminant risk for the bacteria and viruses category is medium. Bacteria and Viruses were not detected in the source waters of Trinity Lutheran Church. Taking the sampling history into account and combining the contaminate risk from bacteria and viruses with the susceptibility of the well yields an overall medium vulnerability to contamination from bacteria and viruses.

Sampling history of Trinity Lutheran Church source water indicates concentrations of nitrate (See Chart 6 – Contaminant Risks for Nitrates/Nitrites in Appendix D). Existing nitrate contamination is approximately 1% of the allowable limit (MCL) for this contaminant. Due to the high solubility and weak retention by soil, nitrates are very mobile in soil, moving at approximately the same rate as water. The current nitrate concentration in Trinity Lutheran Church remains at safe levels with respect to human health.

Overall, contaminant risk for the nitrate/nitrite category is medium due to the roads present up gradient from the well. Combining potential nitrate and/or nitrite contamination risk with the susceptibility of the well yields an overall medium vulnerability to contamination in this category.

Volatile Organic Chemicals were not detected in the source waters of Trinity Lutheran Church. Overall, a contaminant risk for the volatile organic chemicals category is low due to the roads, lawns and gardens and septic systems present up gradient from the well. Combining the contaminate risk with the susceptibility of the well yields an overall low vulnerability to contamination for Volatile Organic Chemicals.

SUMMARY

A *Source Water Assessment* has been completed for the Trinity Lutheran Church source of public drinking water. The overall vulnerability of this source to contamination is **Medium** for bacteria and viruses, nitrates and/or nitrites, and **Low** volatile organic chemicals. This assessment of contaminant risks can be used as a foundation for local voluntary protection efforts as well as a basis for the continuous efforts on the part of the Trinity Lutheran Church 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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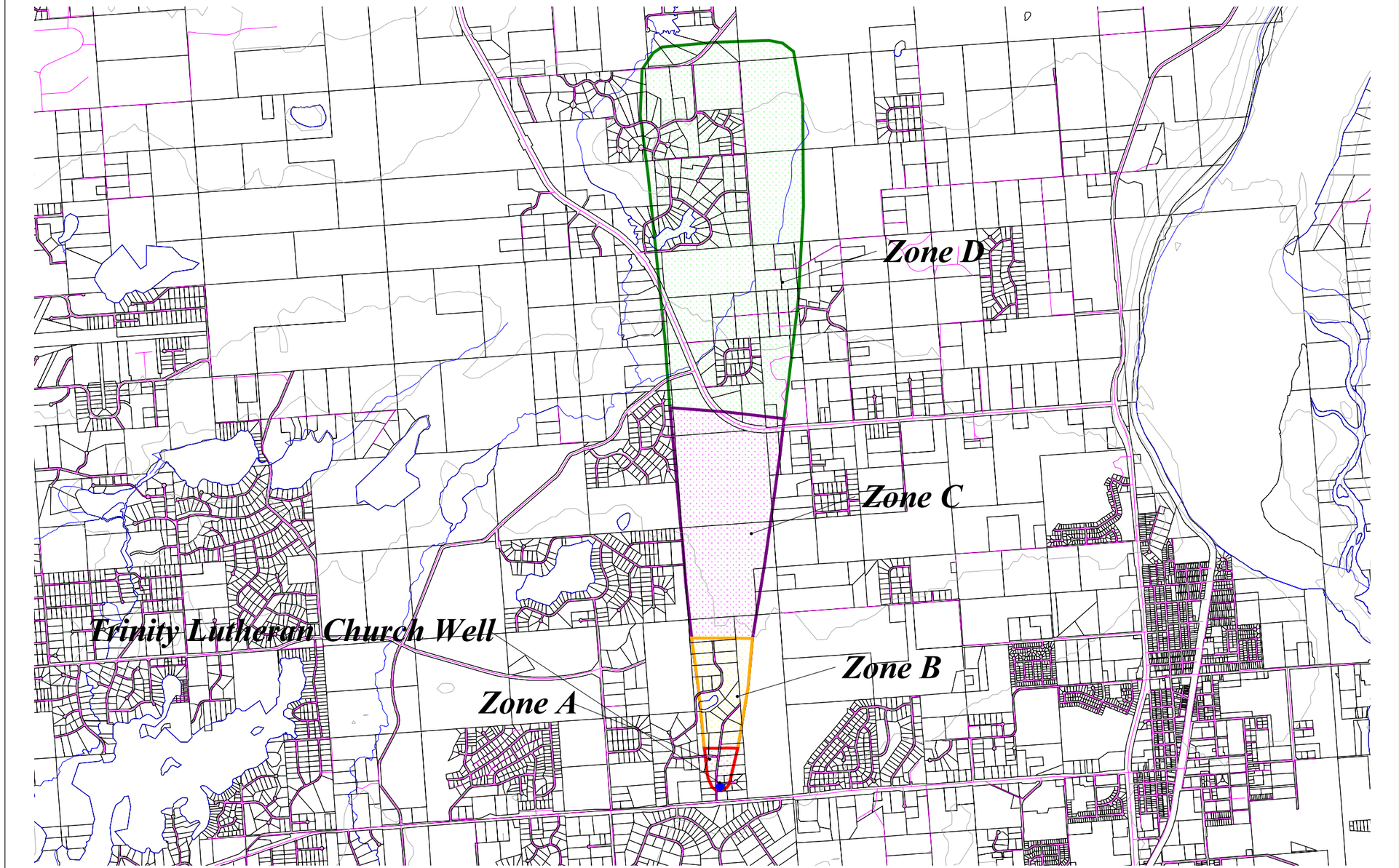
APPENDIX A

Trinity Lutheran Church
Drinking Water Protection Area

Trinity Lutheran Church (PWSID 224345)
Drinking Water Protection Areas



7000 0 7000 14000 Feet

N

- Public Water System Wells
- Lakes and Rivers
- Zone A Protection Area Several Months to 2 Years Travel Time
- Zone B Protection Area Less Than 2 Years Travel Time
- Zone C Protection Area 2 to 5 Years Travel Time
- Zone D Protection Area 5 to 10 Years Travel Time
- Roads
- Mat-Su Borough Parcel Boundaries
- Elevation Contours

Map 1

Prepared by: B.E.S.T. Resource

APPENDIX B

Contaminant Source Inventory and Risk Ranking for Trinity Lutheran Church

Table 1

Contaminant Source Inventory for Trinity Lutheran Church

PWSID 224345.001

Contaminate Source Category	Contaminant Source ID	CS ID Tag	Zone	Location	Map	Comments
Lawns and gardens	R1	R1-1	A,B	Located north of the well	2	Zone A 19 contains acres and Zone B contains 80 acres
Septic systems (serves one or more single-family homes)	R2	R2-24	A	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-18	A	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-19	A	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-17	A	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-16	A	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-23	A	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-22	A	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-21	A	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-14	B	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-13	B	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-12	B	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-20	B	Arabian	2	

Contaminant Source Inventory for Trinity Lutheran Church

Contaminate Source Category	Contaminant Source ID	CS ID Tag	Zone	Location	Map	Comments
Septic systems (serves one or more single-family homes)	R2	R2-11	B	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-10	B	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-9	B	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-8	B	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-7	B	Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-6	B	Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-5	B	Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-4	B	Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-3	B	Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-2	B	Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-1	B	Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-25	B	Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-26	B	Hassen Bey	2	

Table 1

Contaminant Source Inventory for Trinity Lutheran Church

PWSID 224345.001

Contaminate Source Category	Contaminant Source ID	CS ID Tag	Zone	Location	Map	Comments
Highways and roads, dirt/gravel	X20	X20-1	A,B	Arabian	2	
Highways and roads, dirt/gravel	X20	X20-2	A	Cody Road	2	
Highways and roads, dirt/gravel	X20	X20-3	A	Wietz II	2	
Highways and roads, dirt/gravel	X20	X20-4	A	Hassen Bey	2	

Table 2

Potential and Existing Sources of Contamination for Trinity Lutheran Church Bacterias and Viruses

PWSID 224345.001

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank for Analysis	Location	Map	Comments
Lawns and gardens	R1	R1-1	A,B	Low	1	Located north of the well	2	Zone A 19 contains acres and Zone B contains 80 acres
Septic systems (serves one or more single-family homes)	R2	R2-24	A	Very Low	2	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-18	A	Very Low	3	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-19	A	Very Low	4	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-17	A	Very Low	5	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-16	A	Very Low	6	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-23	A	Very Low	7	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-22	A	Very Low	8	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-21	A	Very Low	9	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-14	B	Very Low	10	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-13	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-12	B	Very Low		Arabian	2	

Potential and Existing Sources of Contamination for Trinity Lutheran Church Bacterias and Viruses

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank for Analysis	Location	Map	Comments
Septic systems (serves one or more single-family homes)	R2	R2-20	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-11	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-10	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-9	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-8	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-7	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-6	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-5	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-4	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-3	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-2	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-1	B	Very Low		Hassen Bey	2	

Potential and Existing Sources of Contamination for Trinity Lutheran Church Bacterias and Viruses

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank for Analysis	Location	Map	Comments
Septic systems (serves one or more single-family homes)	R2	R2-25	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-26	B	Very Low		Hassen Bey	2	
Highways and roads, dirt/gravel	X20	X20-1	A,B	Very Low		Arabian	2	
Highways and roads, dirt/gravel	X20	X20-2	A	Very Low		Cody Road	2	
Highways and roads, dirt/gravel	X20	X20-3	A	Very Low		Wietz II	2	
Highways and roads, dirt/gravel	X20	X20-4	A	Very Low		Hassen Bey	2	

Potential and Existing Sources of Contamination for Trinity Lutheran Church Nitrates and Nitrites

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank for Analysis	Location	Map	Comments
Lawns and gardens	R1	R1-1	A,B	Low	1	Located north of the well	2	Zone A 19 contains acres and Zone B contains 80 acres
Septic systems (serves one or more single-family homes)	R2	R2-24	A	Very Low	2	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-18	A	Very Low	3	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-19	A	Very Low	4	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-17	A	Very Low	5	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-16	A	Very Low	6	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-23	A	Very Low	7	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-22	A	Very Low	8	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-21	A	Very Low	9	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-14	B	Very Low	10	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-13	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-12	B	Very Low		Arabian	2	

Potential and Existing Sources of Contamination for Trinity Lutheran Church Nitrates and Nitrites

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank for Analysis	Location	Map	Comments
Septic systems (serves one or more single-family homes)	R2	R2-20	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-11	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-10	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-9	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-8	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-7	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-6	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-5	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-4	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-3	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-2	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-1	B	Very Low		Hassen Bey	2	

Potential and Existing Sources of Contamination for Trinity Lutheran Church Nitrates and Nitrites

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank for Analysis	Location	Map	Comments
Septic systems (serves one or more single-family homes)	R2	R2-25	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-26	B	Very Low		Hassen Bey	2	
Highways and roads, dirt/gravel	X20	X20-1	A,B	Very Low		Arabian	2	
Highways and roads, dirt/gravel	X20	X20-2	A	Very Low		Cody Road	2	
Highways and roads, dirt/gravel	X20	X20-3	A	Very Low		Wietz II	2	
Highways and roads, dirt/gravel	X20	X20-4	A	Very Low		Hassen Bey	2	

Potential and Existing Sources of Contamination for Trinity Lutheran Church Volatile Organic Chemicals (VOCs)

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank for Analysis	Location	Map	Comments
Lawns and gardens	R1	R1-1	A,B	Low	1	Located north of the well	2	Zone A 19 contains acres and Zone B contains 80 acres
Septic systems (serves one or more single-family homes)	R2	R2-24	A	Very Low	2	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-18	A	Very Low	3	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-19	A	Very Low	4	Cody Road	2	
Septic systems (serves one or more single-family homes)	R2	R2-17	A	Very Low	5	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-16	A	Very Low	6	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-23	A	Very Low	7	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-22	A	Very Low	8	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-21	A	Very Low	9	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-14	B	Very Low	10	Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-13	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-12	B	Very Low		Arabian	2	

Potential and Existing Sources of Contamination for Trinity Lutheran Church Volatile Organic Chemicals (VOCs)

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank for Analysis	Location	Map	Comments
Septic systems (serves one or more single-family homes)	R2	R2-20	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-11	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-10	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-9	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-8	B	Very Low		Arabian	2	
Septic systems (serves one or more single-family homes)	R2	R2-7	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-6	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-5	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-4	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-3	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-2	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-1	B	Very Low		Hassen Bey	2	

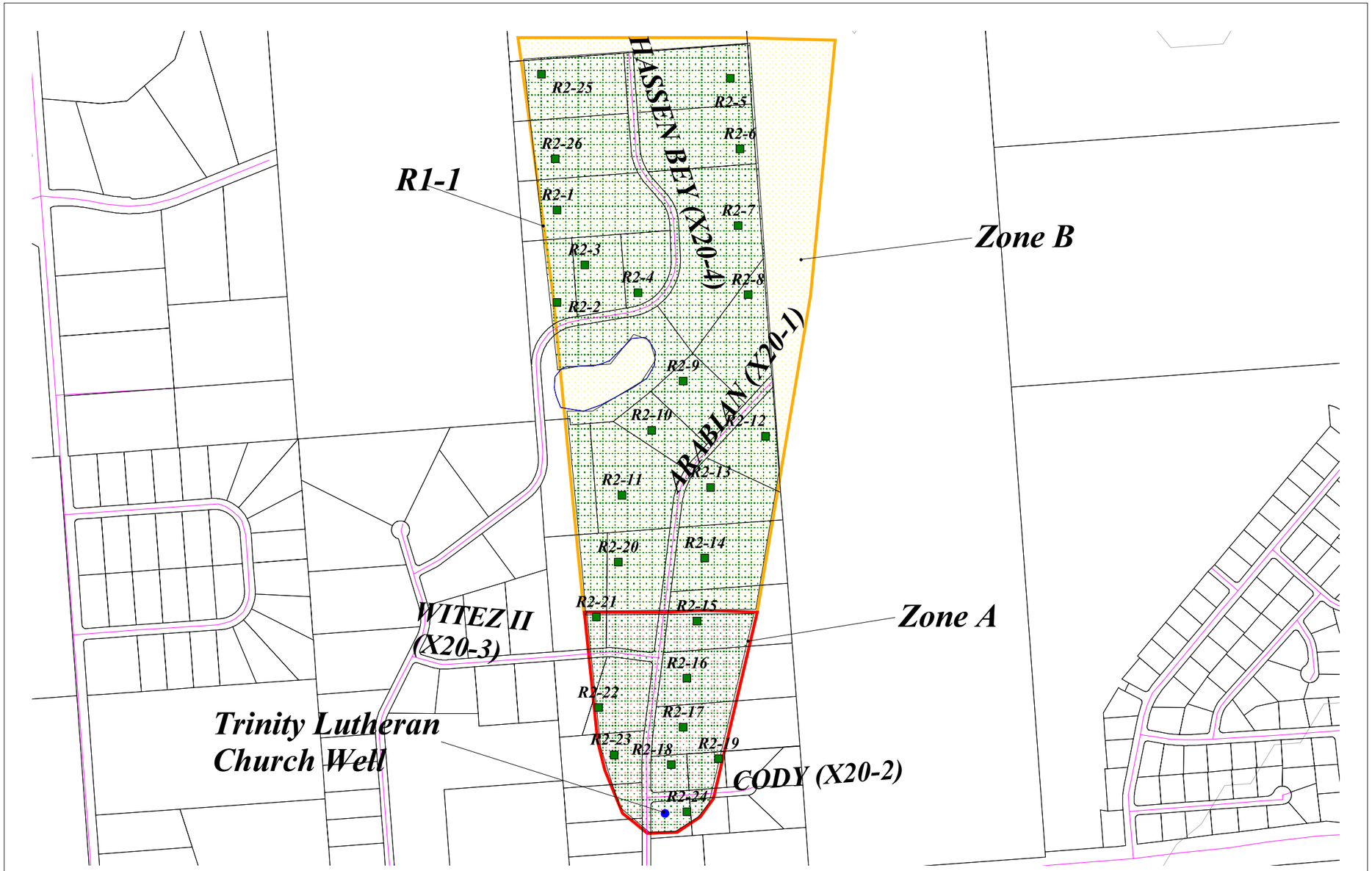
Potential and Existing Sources of Contamination for Trinity Lutheran Church Volatile Organic Chemicals (VOCs)

Contaminant Source Category	Contaminant Source ID	CS ID Tag	Zone	Risk Ranking for Analysis	Overall Rank for Analysis	Location	Map	Comments
Septic systems (serves one or more single-family homes)	R2	R2-25	B	Very Low		Hassen Bey	2	
Septic systems (serves one or more single-family homes)	R2	R2-26	B	Very Low		Hassen Bey	2	
Highways and roads, dirt/gravel	X20	X20-1	A,B	Very Low		Arabian	2	
Highways and roads, dirt/gravel	X20	X20-2	A	Very Low		Cody Road	2	
Highways and roads, dirt/gravel	X20	X20-3	A	Very Low		Wietz II	2	
Highways and roads, dirt/gravel	X20	X20-4	A	Very Low		Hassen Bey	2	

APPENDIX C

Trinity Lutheran Church
Drinking Water Protection Area
and Potential & Existing Contaminant Sources

Drinking Water Protection Areas Potential & Existing Sources of Contamination for Trinity Lutheran Church



1000 0 1000 2000 Feet

PWSID 224345.001

N

Lakes and Rivers

Public Water System Wells

Zone A Protection Area
Several Months to 2 Years
Travel Time

Zone B Protection Area
Less Than 2 Years
Travel Time

Roads (Paved X20)

Mat-Su Borough Parcel Boundaries

Elevation Contours

Residential Septic System (R2)

Lawn & Garden (R1)

Map 2

Prepared by: B.E.S.T. Resource

APPENDIX D

Vulnerability Analysis for Trinity Lutheran Church Public Drinking Water Source

Chart 1. Susceptibility of the wellhead – Trinity Lutheran Church

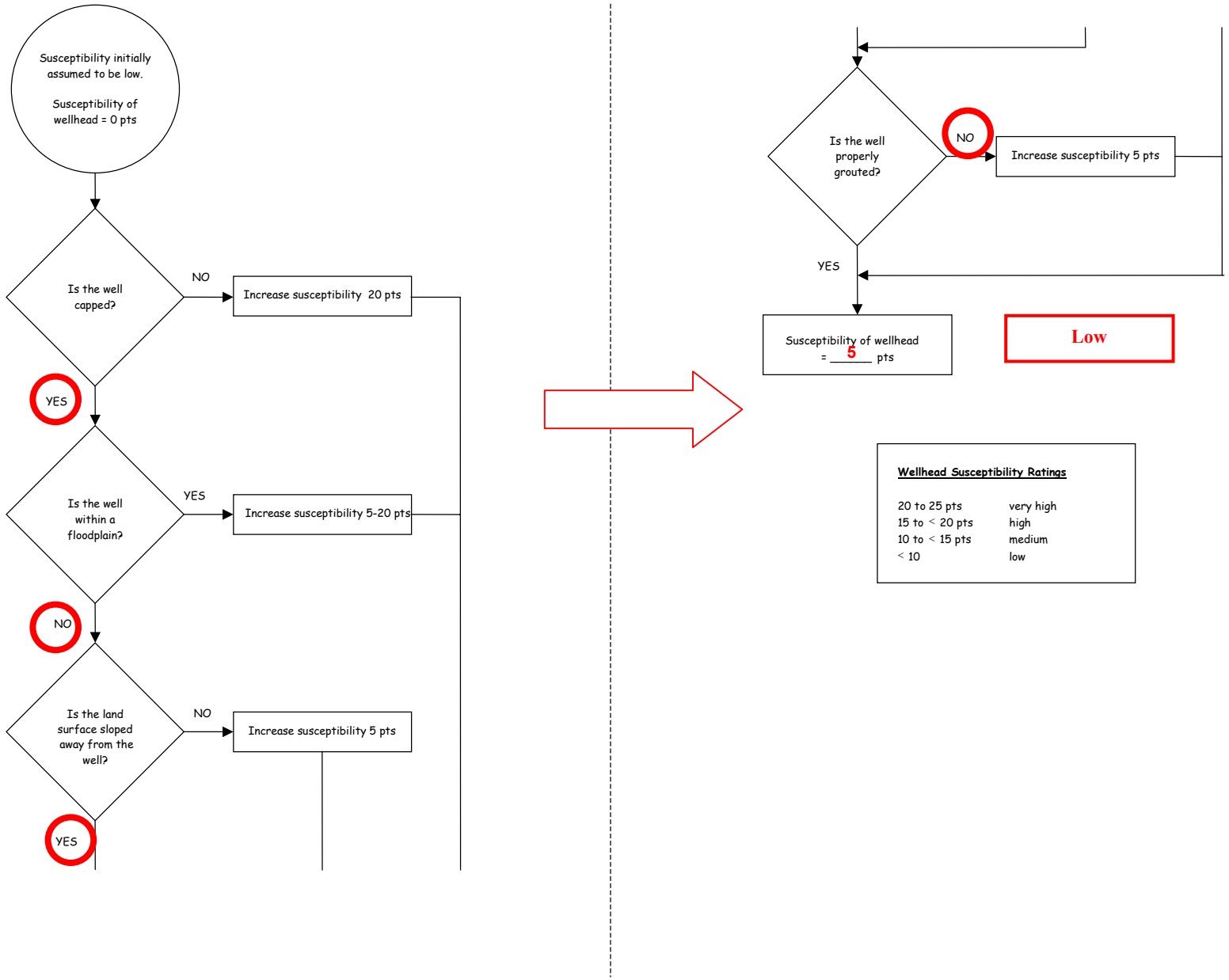
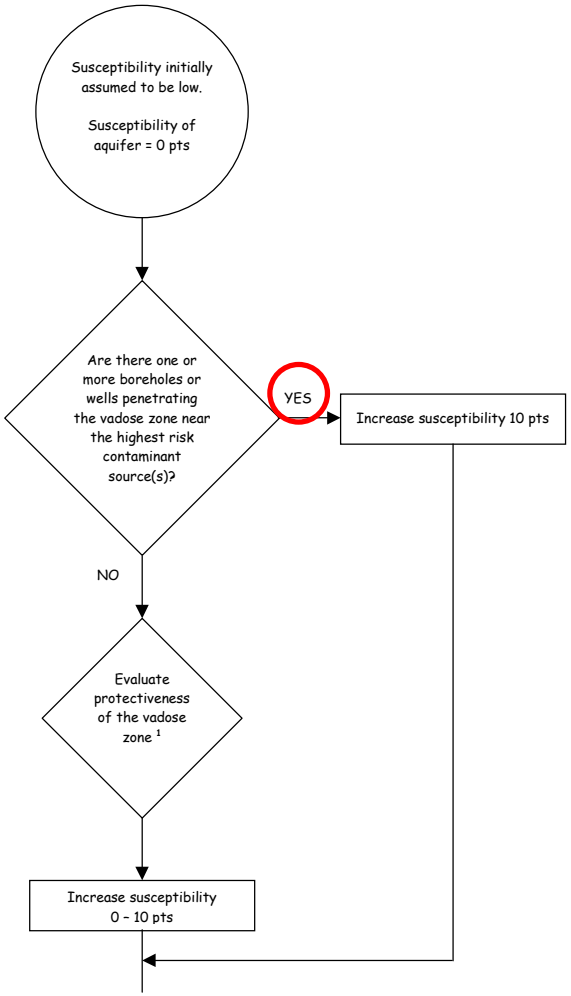
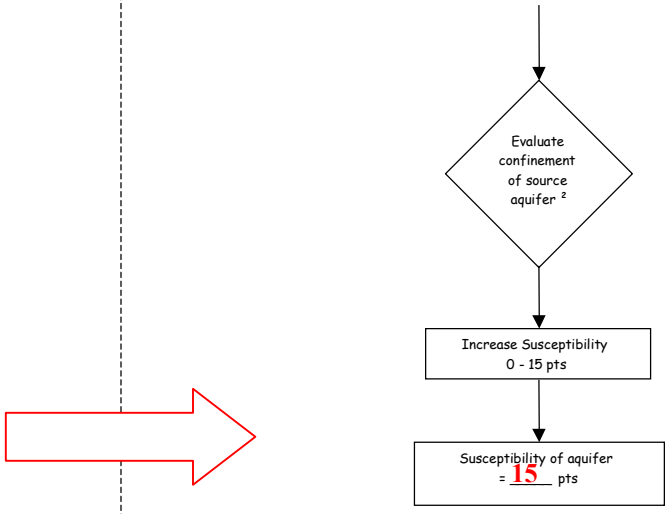


Chart 2. Susceptibility of the aquifer – Trinity Lutheran Church



Recharge (16-20 inches per year, base of Talkeetna Mountains, and silty gravelly sand)
6/10 = 3 Points
Depth to bottom of confining unit (100 feet) 0/10 = 0 Points

Protectiveness of the Vadose Zone Total = **3/10 Points**



Confinement (100 feet of till) 0/15 = 0 Points
Density of boreholes/wells (high density in Zone A) 15/15 = 5 Points

Degree of Confinement Total = **5 Points**

15 Points

High

Aquifer Susceptibility Ratings

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

1. **Protectiveness of the Vadose Zone**
   - net recharge (function of precipitation, slope of land surface, & permeability of soils) [0-10 pts: 50%]
   - 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 $\leq 10^{-6}$ cm/s, minimum thickness of at least one layer = 20 ft, interpolate linearly 100' - 20', 0 - 10 pts; unconfined = 15 pts; 65%]
   - 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]

Chart 3. Contaminant risks for Trinity Lutheran Church – Bacteria & Viruses

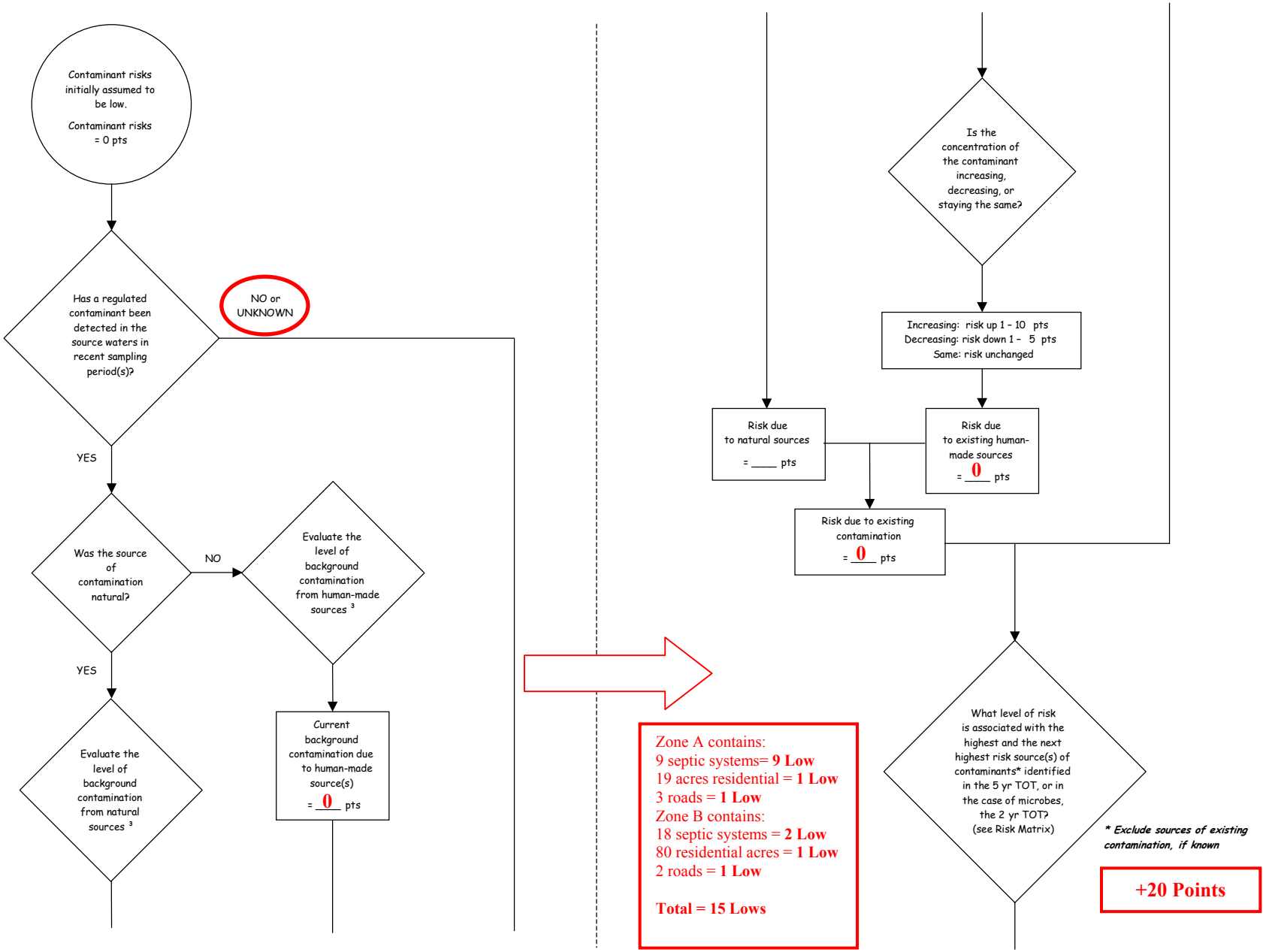


Chart 3. Contaminant risks for Trinity Lutheran Church – Bacteria & Viruses (Continued)

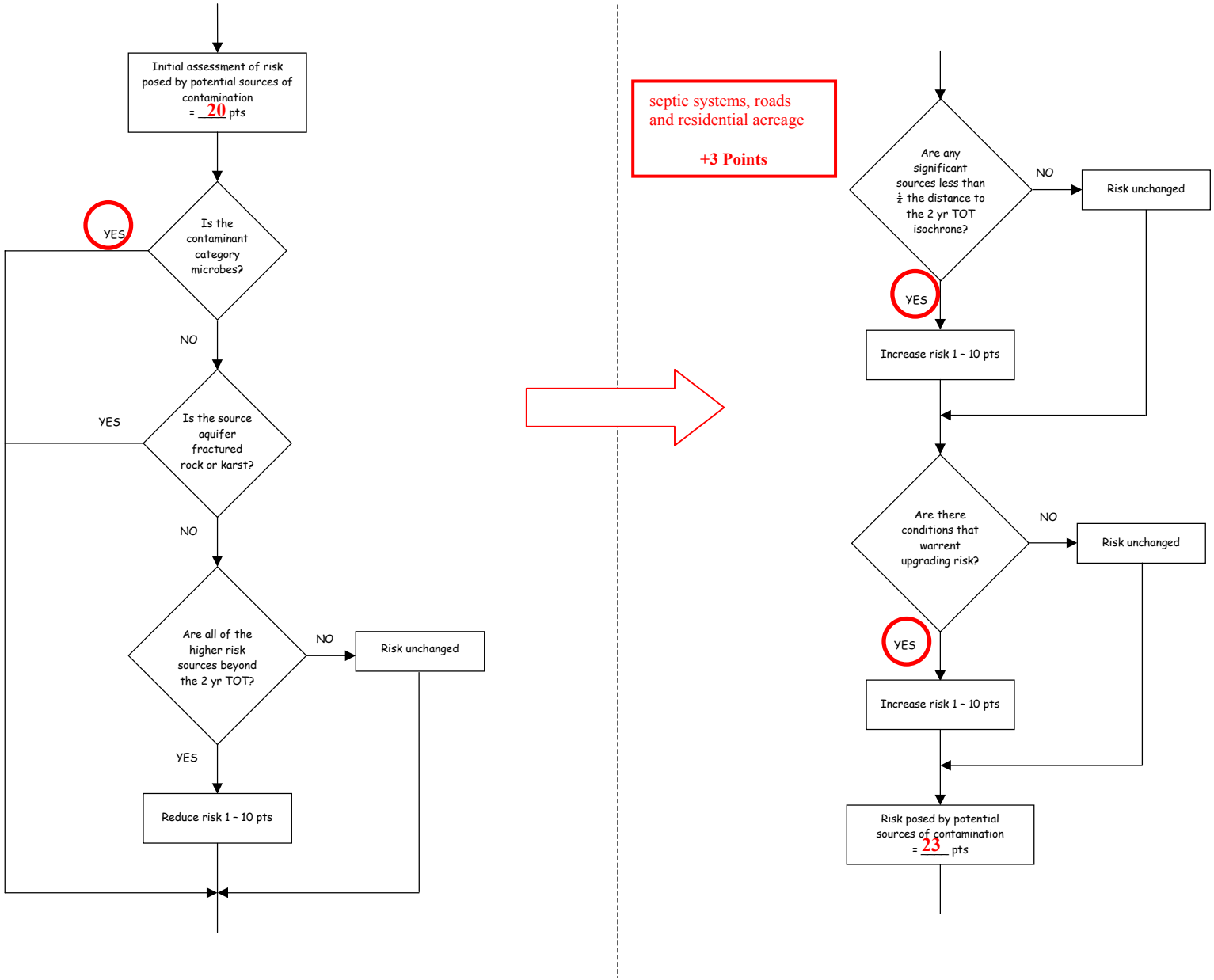
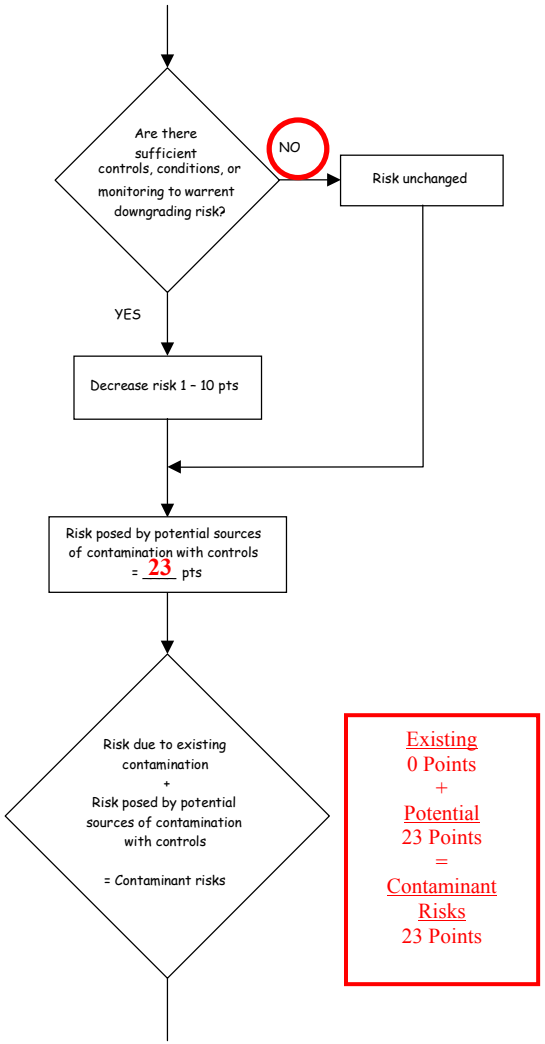


Chart 3. Contaminant risks for Trinity Lutheran Church – Bacteria & Viruses (Continued)



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

** Truncate risk at 50 pts*

Contaminant risks*
= 23 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 Trinity Lutheran Church – Bacteria & Viruses

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)

27 residential septic systems, 5 roads, and 99 acres of residential area = 15 Lows	**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 Trinity Lutheran Church – Bacteria & Viruses

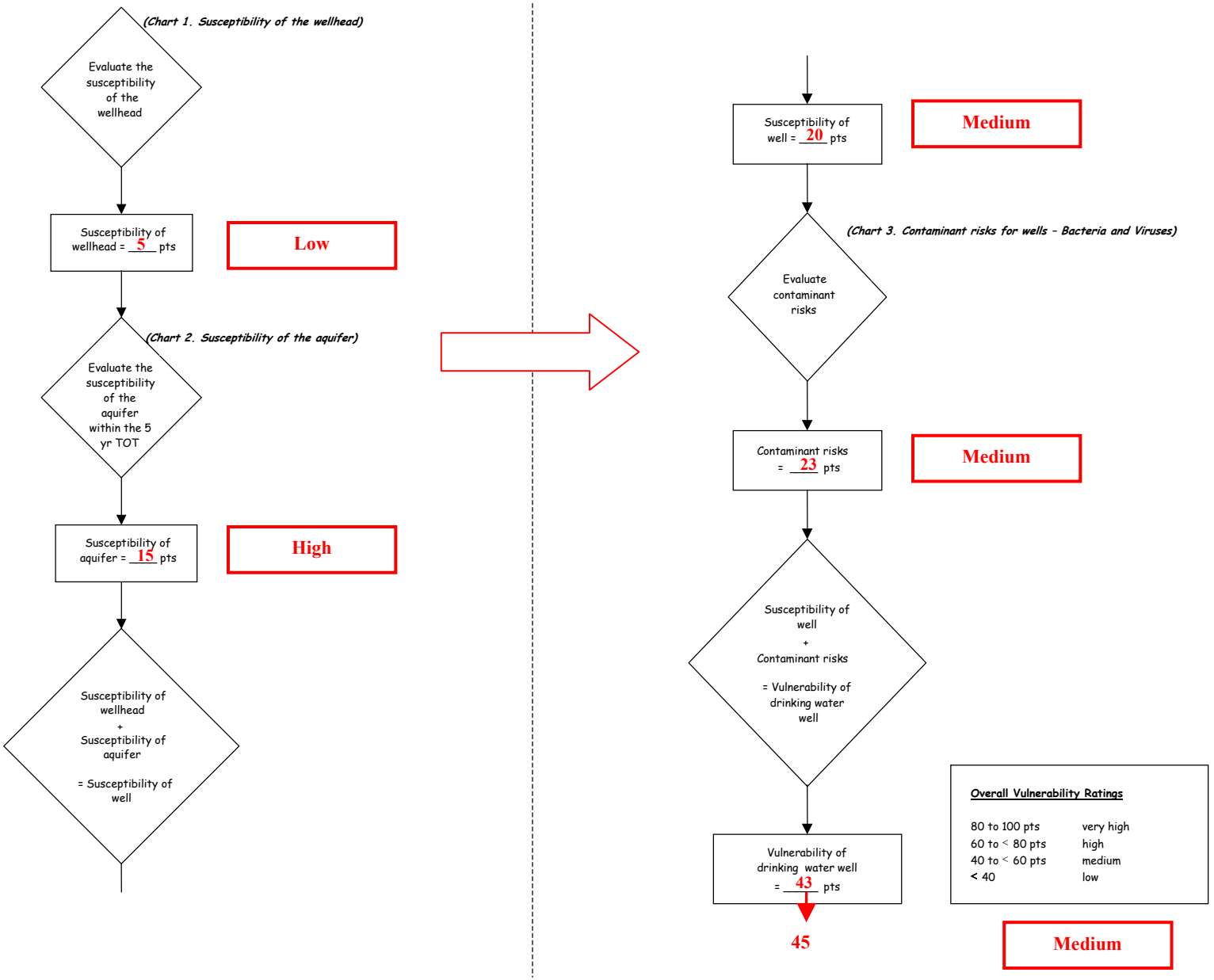


Chart 5. Contaminant risks for Trinity Lutheran Church– Nitrates and Nitrites

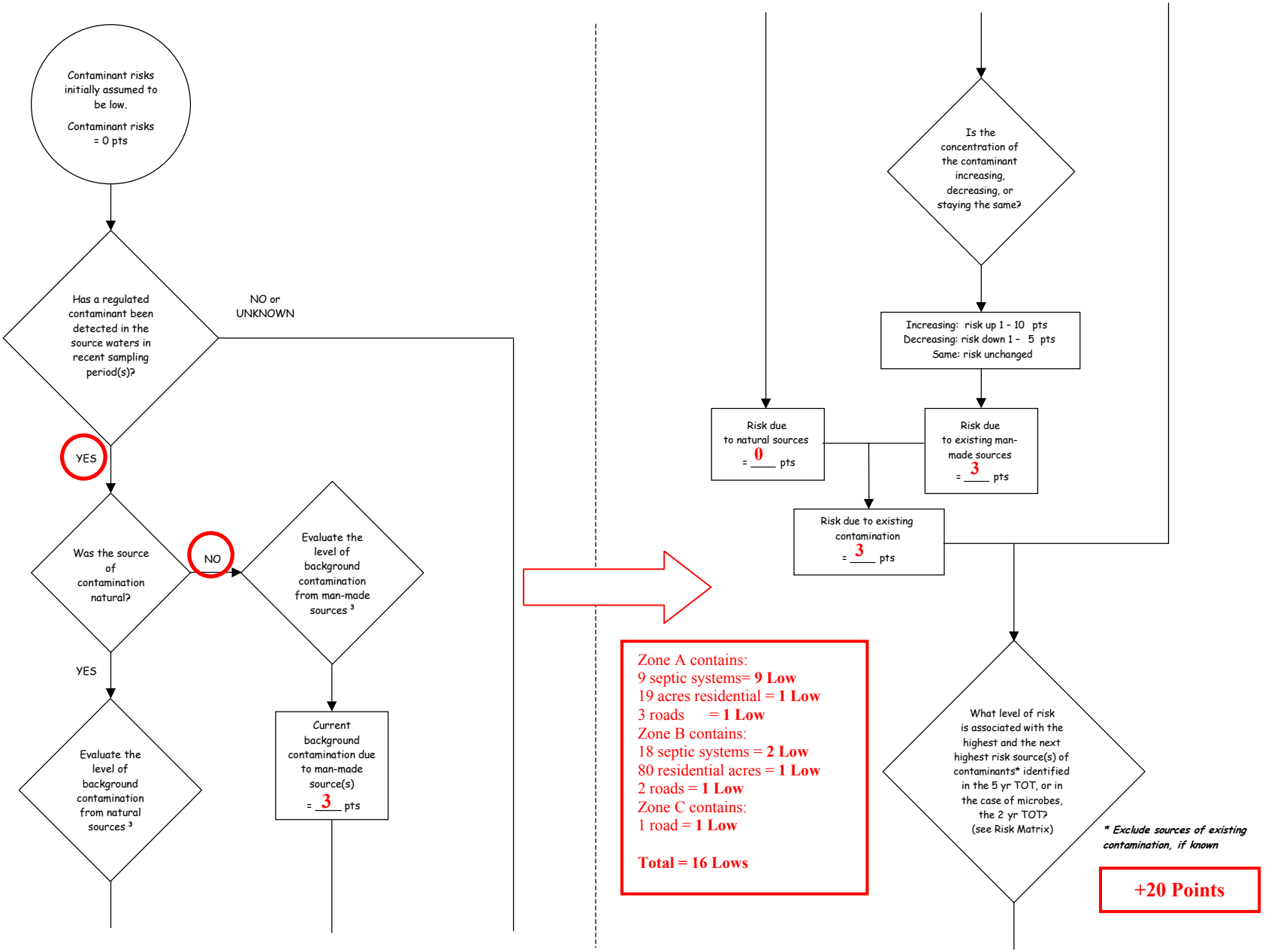


Chart 5. Contaminant risks for (Water Source Name)– Nitrates and Nitrites (Continued)

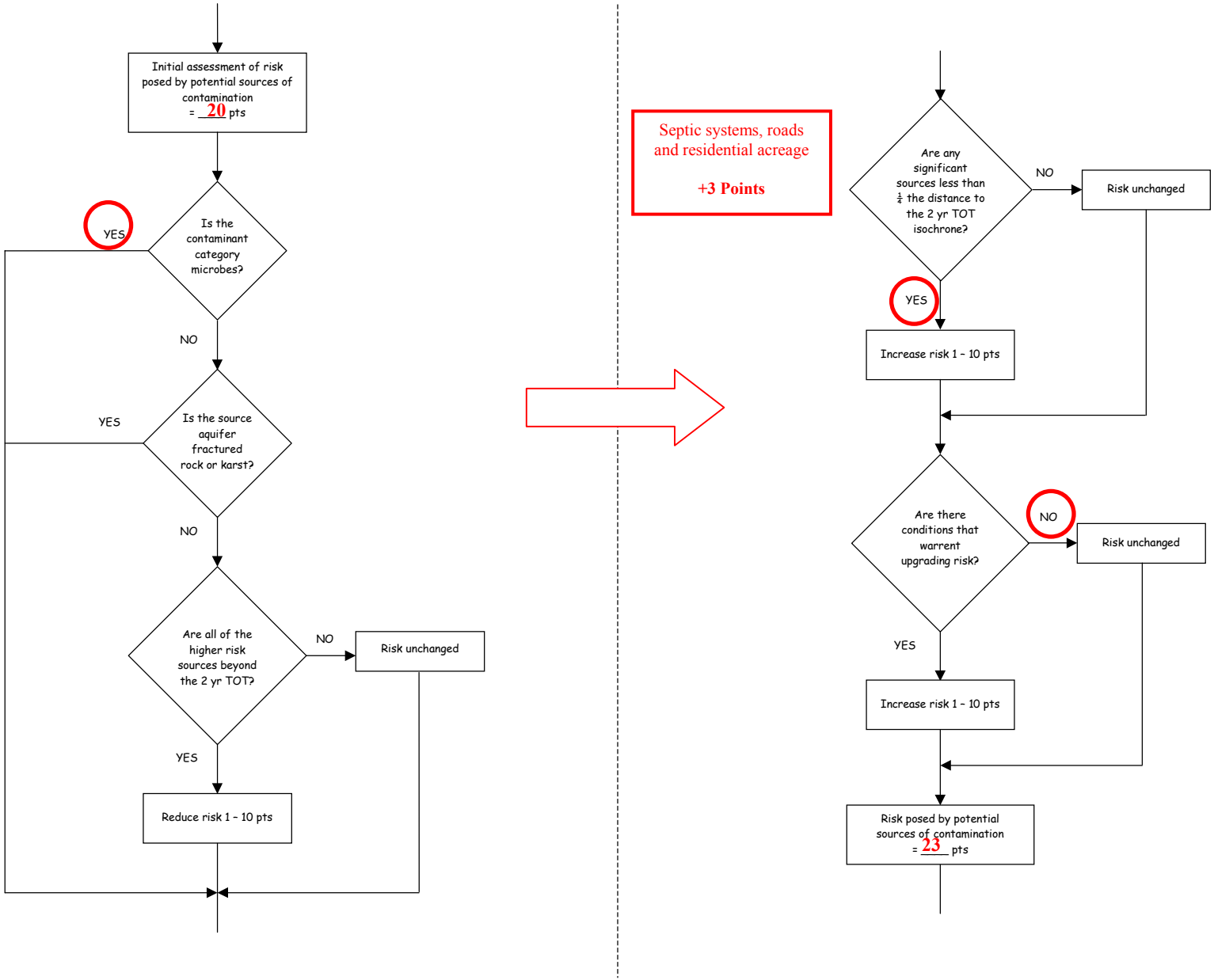
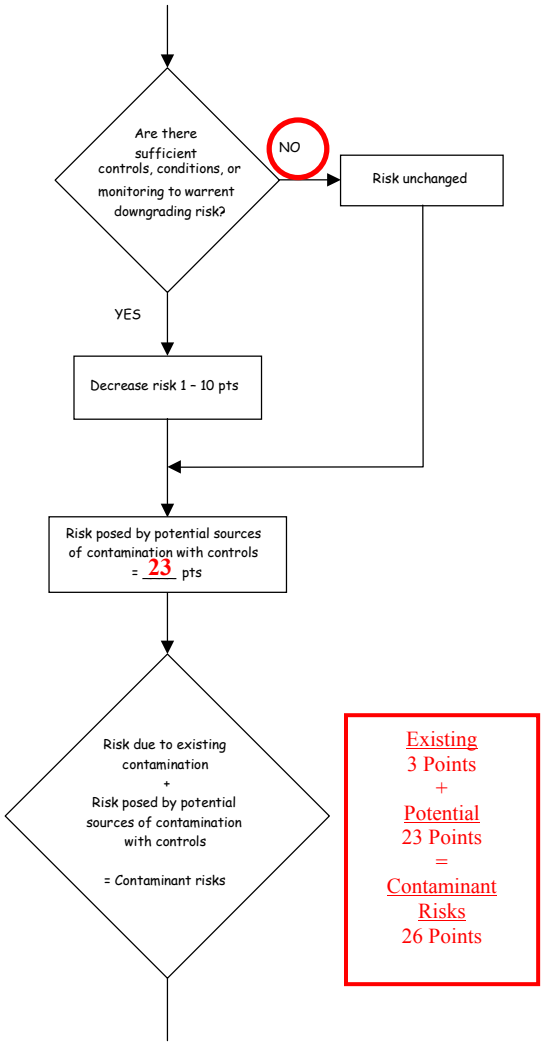


Chart 5. Contaminant risks for (Water Source Name)– Nitrates and Nitrites (Continued)



Existing
3 Points
+
Potential
23 Points
=
Contaminant Risks
26 Points

* *Truncate risk at 50 pts*

Contaminant risks*
= 26 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
1.29 mg/L on 7/20/99
1.27 mg/L on 9/23/98
1.71 mg/L on 9/10/97
1.49 mg/L on 5/7/96
1.32 mg/L 11/8/95
0.076 on 12/14/94

Maximum Contaminant Level (MCL)
= 10mg/L
1.29/10
= 0.129 or 12.9% of MCL

+3 Points

Table 2. Risk Matrix for Contaminant Sources for Trinity Lutheran Church– Nitrates and Nitrites

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	27 residential septic systems, 5 roads, and 99 acres of residential area = 16 Lows	**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 Trinity Lutheran Church– Nitrates and Nitrites

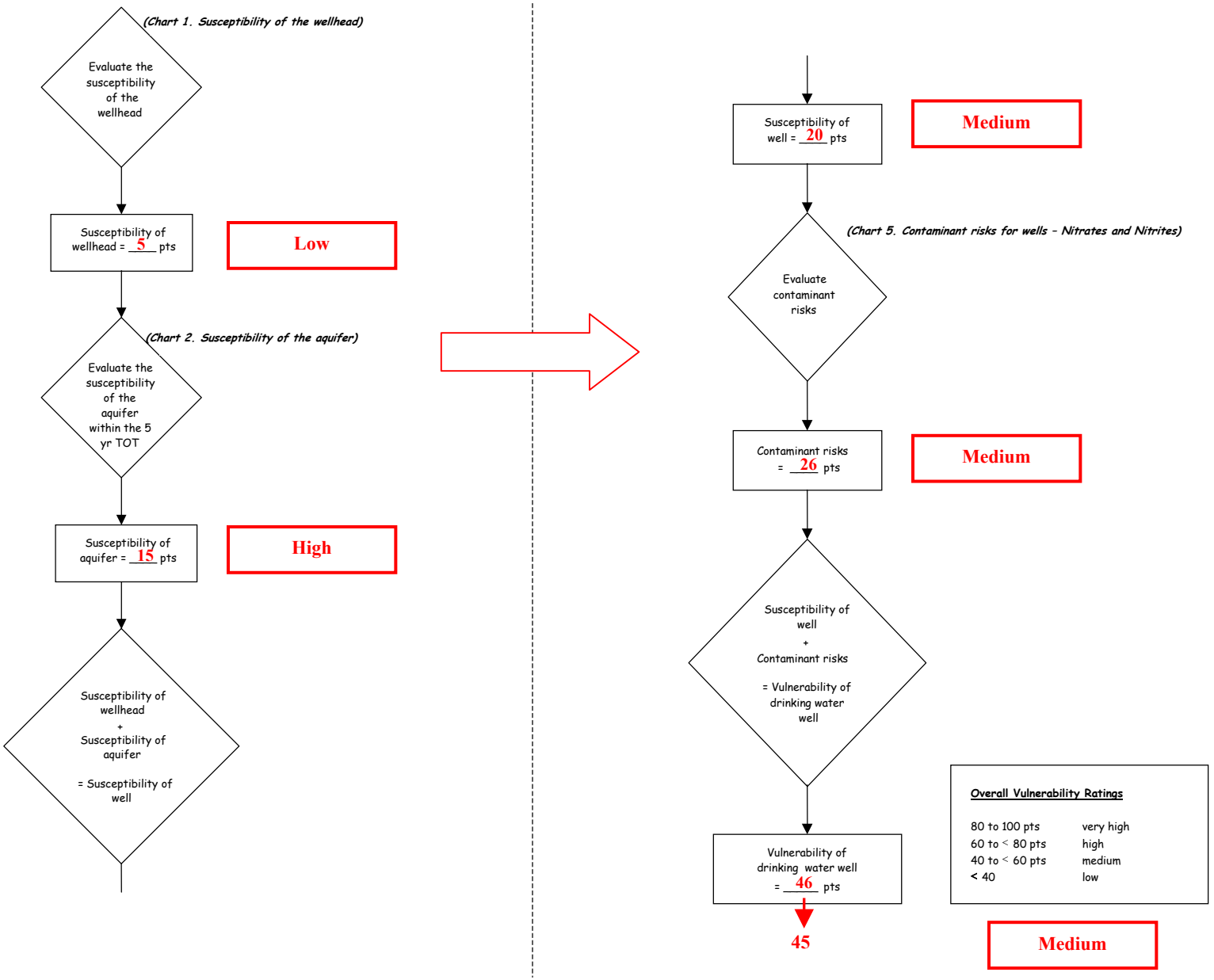


Chart 7. Contaminant risks for Trinity Lutheran Church – Volatile Organic Chemicals

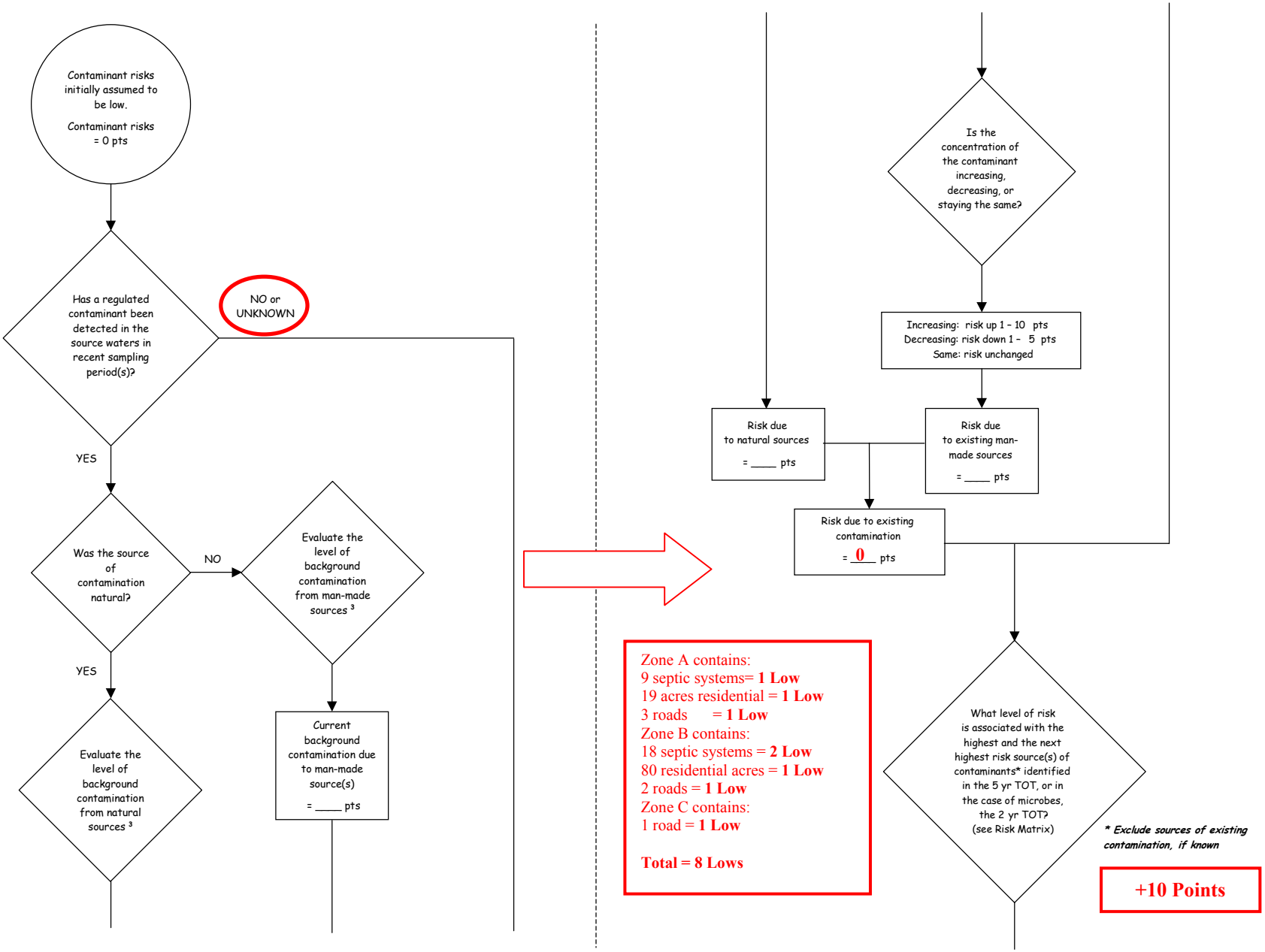


Chart 7. Contaminant risks for Trinity Lutheran Church – Volatile Organic Chemicals (Continued)

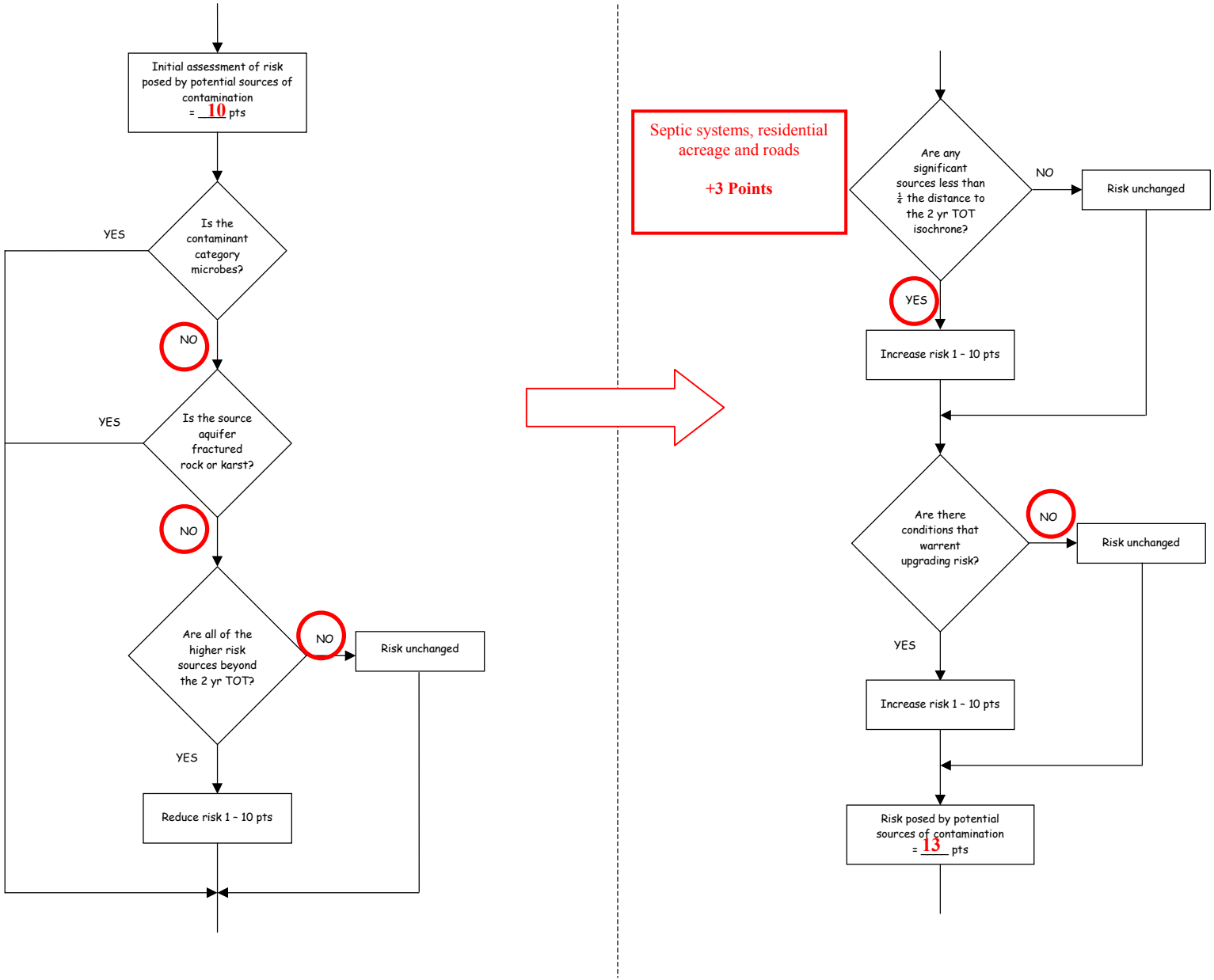
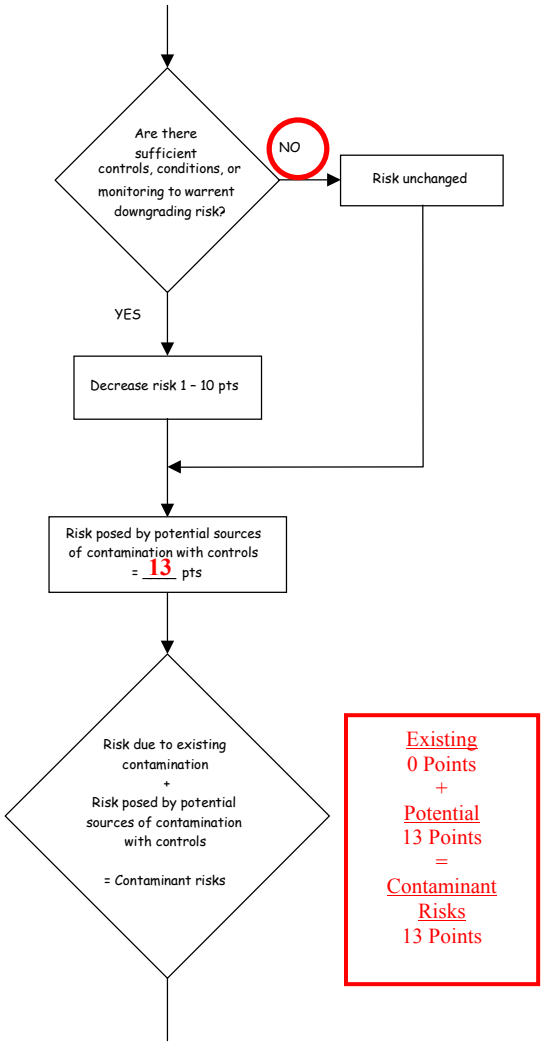
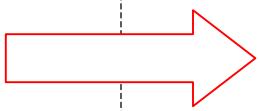
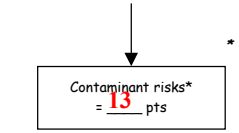


Chart 7. Contaminant risks for Trinity Lutheran Church – Volatile Organic Chemicals (Continued)



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





** Truncate risk at 50 pts*

Low

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 Trinity Lutheran Church – Volatile Organic Chemicals

Level of Risk Associated with the Highest Risk Sources

Next Highest Risk Sources(s)	27 residential septic systems, 5 roads, and 99 acres of residential area = 8 Lows	**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 Trinity Lutheran Church– Volatile Organic Chemicals