CHAPTER 5: SUSCEPTIBILITY ANALYSIS

5.1 INTRODUCTION

The susceptibility analysis for a public water system (PWS) consists of determining the level of threat that potential sources of contamination (PSOCs) within the delineated source water assessment area (SWAA) pose to the water supply. The analysis ranks the PSOCs as HIGH, MODERATE or LOW threats to the water source. The factors used in assigning the rankings have been developed by the Water Quality Control Division (Division) using differential analyses, which acknowledge different types of systems when considering the contributing factors. Examples of these factors include: the hazard posed by the contaminant(s) and its acute or chronic impact on human health; the likelihood of a release; the structural integrity of the intake or well; and the general proximity of the contaminant source to the PWS intake or well.

The susceptibility of a PWS will be determined by the possibility for a PWS to draw water that potentially could be contaminated at concentrations that may pose a concern to consumers of the water. This susceptibility analysis will determine the relative susceptibility of a PWS to different PSOCs and different classes of contaminants that may be present. The susceptibility analysis will use an iterative approach and will apply a non-numerical technique called matrix combination. While it is the intent of the State to evaluate community and non-transient, non-community water systems for all contaminants, prioritization will be given within the current time frame of the SWAP program to evaluating those contaminants that have established drinking water protection standards (i.e. contaminants of greatest concern). The analysis of transient, non-community systems will be limited to contaminants known to cause acute health care problems, as there is no reliable means of determining chronic exposure in transient populations. To ensure that the susceptibility ratings will be consistent across the State, given similar situations, the Division has recommended limiting the initial evaluations to contaminants of greatest concern for which there are data available on a statewide basis.

The iterative approach, which is acknowledged by the U.S. Environmental Protection Agency (EPA) as an efficient departure point, will be refined and expanded as additional information about the impacts and/or cumulative effects of various PSOCs becomes available. The State will make every effort to ensure that those PSOCs included in the initial analysis are of greatest concern to a PWS. The rating system will result in conservative analyses that will provide considerably more than adequate protection for the water source.

In recommending the iterative approach to susceptibility analysis, it is the intention of the State to attract broad public involvement in the analysis process. The simplicity of the non-numerical technique will result in conservative rankings that will be adequately protective of the water source.

5.2 DEFINITIONS

This chapter, more than any other in the SWAP document, demands that the definitions used be carefully developed, particularly given the similarity of terms such as hazard, threat and risk. To ensure consistency and clarity in the terms used in the susceptibility analyses, the following definitions have been selected.

Community water system: a public water system that: (A) serves at least 15 service connections used by year-round residents of the area served by the system; or (B) regularly serves at least 25 year-round residents. (Source: Colorado Primary Drinking Water Regulations).

Non-transient, non-community water system: a public water system that regularly serves at least 25 of the same people over six months per year (e.g., schools, workplaces, hospitals, etc.) (Source: Colorado Primary Drinking Water Regulations).

Transient, non-community water system: a public water system which does not serve 25 or more of the same people for 60 or more days per year, (e.g., restaurants, motels, campgrounds, etc.) (Source: Colorado Primary Drinking Water Regulations).

Acute contaminant: contaminants which cause acute health effects that occur shortly after exposure to a drinking water contaminant, usually a matter of hours or days. (Source: USEPA Susceptibility Guidance).

Chronic contaminant: a contaminant, which causes chronic health effects that, occurs over several or many years. (Source: USEPA Susceptibility Guidance).

Hazard: possible source of danger (Source: American Heritage Dictionary).

Threat: indication of impending danger or harm (Source: American Heritage Dictionary).

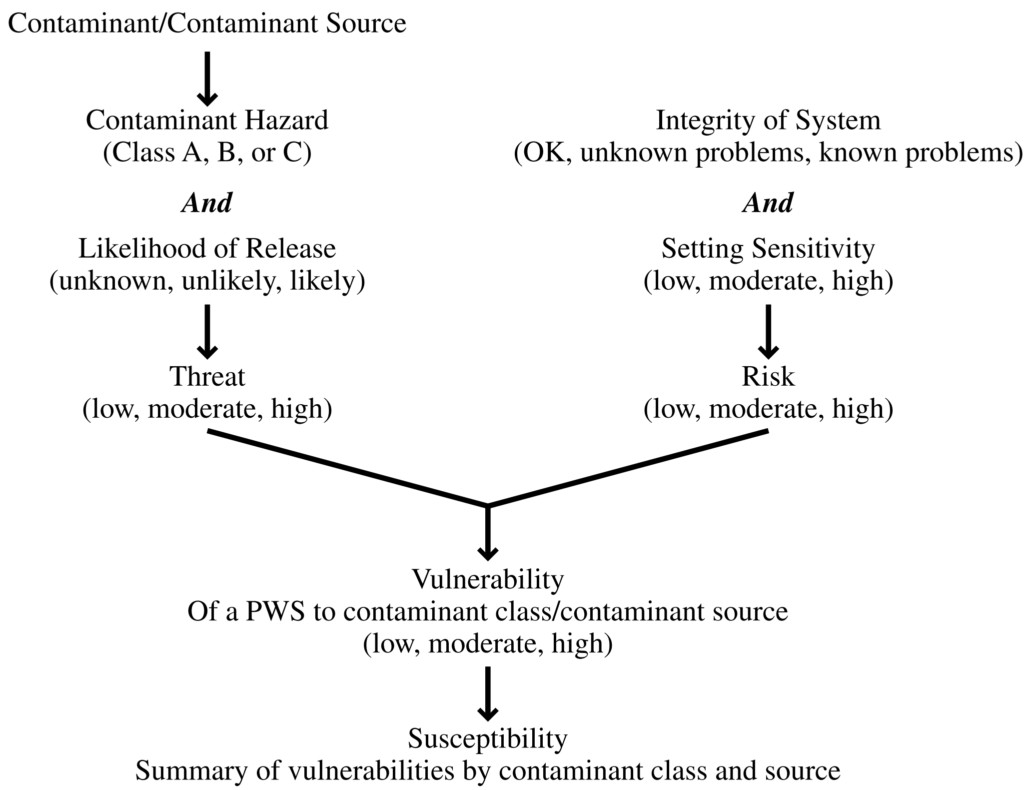
Risk: possibility of suffering harm or loss (Source: American Heritage Dictionary).

5.3 MATRIX COMBINATION FOR SUSCEPTIBILITY ANALYSIS

The susceptibility analysis for public water systems will be done using a non-numerical technique called matrix combination. In using this technique, categories like LOW, MODERATE or HIGH are assigned to factors important to the analysis. The factors and their categories are then combined in a series of matrix tables. While there is a relative relationship within the categories of a factor, there is no true numerical relationship. Although it is valid to rank this type of information, the magnitude of the differences among categories cannot be quantified by the assignment of numbers - the “worst“ of four ranked categories is not necessarily four times as bad as the “best” category.

Figure 5.1 is a diagram of the susceptibility analysis process, the factors involved, their categories, and how they will be combined to arrive at a susceptibility rating for a drinking water source exposed to possible contaminants located within its SWAA.

Figure 5.1. The Susceptibility Analysis Process



5.4 SUSCEPTIBILITY ANALYSIS FOR COMMUNITY AND NON-COMMUNITY SYSTEMS

During the initial iterative phase conducted by the State, the susceptibility analysis for community and non-community, non-transient water systems will include an analysis of sources known or suspected to use contaminants known to present acute and chronic human health concerns. These contaminants will include all contaminants listed as Class A and several contaminants listed as Class B. With a few exceptions, these are contaminants which have established Maximum Contaminant Levels (MCLs) or Maximum Contaminant Level Goals (MCLGs). These particular Class A and B contaminants should be of greatest concern to the PWS and to the consumer. In subsequent iterations, sources using remaining Class B and Class C contaminants will be analyzed. Examples of contaminants from these three classes appear as **Table 5.1**. A complete list can be found in Appendix E.

During the initial iterative phase, transient, non-community water systems will be evaluated for sources deemed to be Class A hazards only. The need to examine these systems for exposure to contaminants other than acute contaminants is influenced by the limited exposure of the consumer to the water from these PWSs.

Table 5.1 Examples of Contaminants Evaluated in the Susceptibility Analysis

Hazard Class		
A	**B**	**C**
Ammonia	Arsenic	Aluminum
Benzene	Creosote	Chloride
Cryptosporidium parvum	Methane	Fluoride
Dioxin	Phosphate	Iron
Giardia lamblia	Radionuclides	Manganese
Nitrate	Selenium	Silver
Trichloroethylene (TCE)	Sulfuric Acid	Sulfate
Viruses	Toluene	

5.5 FACTORS USED IN THE SUSCEPTIBILITY ANALYSIS

One of the stated objectives of the susceptibility analysis is to use a process that will result in consistent results statewide. To achieve this, the information used in the first iteration of the analysis must be available statewide. Many of the factors specifically noted in the EPA's draft "*Susceptibility Guidance*" do not meet this criterion and, therefore, are not included in this first iteration. The threat and risk factors that have been included are described below.

Threat Factors

Contaminant Hazard

The PSOCs identified during the contaminant inventory phase will be assigned an overall hazard class rating of A, B, or C. As a default position in this analysis, the State has elected to rank the various PSOCs identified in Appendix E (Table E.1) as either a Class A, B or C contaminant hazard. This decision was arrived at in recent consultation with the Design Team. It was realized that if information on the types of potential contaminants for a given PSOC was not available from searches of the state and federal databases or collected through community-based surveys, then a default position would be needed to classify the PSOC. Therefore, the State has provided a default contaminant hazard ranking for each PSOC listed in Table E.1 of Appendix E.

The default rating was based, in general, on the prevalence of the different classes of contaminants (A, B, or C) with respect to each other. Based on the total number of potential contaminants listed for a given PSOC in Table E.1, if Class contaminants comprised 25% or more of the total, the PSOC was ranked as a Class A contaminant hazard. If Class B contaminants comprised more than 25% of the total, and Class A and C contaminants comprised less than 25% of the total, respectively, the PSOC was ranked as a Class B contaminant hazard. Similarly, if Class C contaminants comprised more than 25% of the total, while Class A and B contaminants comprised less than 25% of the total, respectively, the PSOC was ranked as a Class C contaminant hazard. Based on this default classification scheme, approximately 30% of the PSOCs in Table E.1 were determined to Class A hazards, while about 70% of the PSOCs were determined to be Class B hazards. None of the PSOCs were determined to be Class C contaminant hazards by default.

In the event that information on the potential contaminants for a given PSOC is available from searches of the state and federal databases or collected through community-based surveys, classification of the PSOC would proceed in a similar manner as described above. With site-specific information of the number and type of potential contaminants that are present at a PSOC, it is possible that the default ranking for a Class A PSOC might be changed to a Class B or Class C contaminant ranking. Similarly, it is also possible that the default ranking for a Class B or C PSOC might be changed based on site-specific information. As a result, this may provide incentive for the operator of the PSOC and/or the PWS to confirm locally if site-specific information on the types of potential contaminants can be obtained.

The contaminant hazard ratings are based on existing categories used by regulatory agencies. Class A contaminants include those that pose the most serious immediate (i.e. acute) health threats or are classified as carcinogens. With a few exceptions, Class A will include all contaminants with an MCLG of zero. Examples are benzene, trichloroethene (TCE), pathogenic microbial organisms, fecal coliforms, *Giardia lamblia,* and *Cryptosporidium parvum*. Class B includes the remainder of the primary drinking water standard contaminants, such as organic and inorganic chemicals, metals, radioactive materials, and unregulated contaminants not included in Class A. Many of these contaminants have established MCLs and/or MCLGs greater than zero. Class C contains the secondary drinking water standard contaminants such as sulfate or iron, which do not have serious health impacts, but cause aesthetic problems such as odor, taste, and appearance problems. Refer to Appendix E (Table E.2) for a complete listing of potential contaminants and their hazard classes.

In recent consultation with the Design Team, there was concern that some PSOCs may have more than one potential source present (and therefore, more than one contaminant hazard) and how that should be treated. In the event that more than one type of source may be present at a given PSOC location, the State will try to identify which of the sources presents the greatest contaminant hazard threat for purposes of conducting the susceptibility analysis. Information about the other sources identified at a facility would be retained as metadata (i.e., backup or supporting data) for purposes of increasing citizen and PWS awareness of these additional potential sources and would be referenced in the assessment report if the PWS so chooses.

Likelihood of Release

Likelihood of release is meant to evaluate the probability of a release of contaminants from a PSOC, and examines such factors as the compliance history (if applicable and/or available), and/or protective⁄preventative measures or best management practices (BMPs) in place that could affect whether contaminants might be released. The State expects that general information on compliance history, and protective/preventative measures or BMPs may reside in some of the state and federal regulatory databases for some types of PSOCs.

The Design Team suggested in the initial iteration conducted by the State for regulated PSOCs, the likelihood of release should be based on available compliance history information contained in the regulated state and federal databases. Where information on protective/preventative measures or BMPs can be obtained from the databases, it will be utilized in determining the likelihood of release rating in the initial iteration.

In the second iteration, where the PWS potentially supplies additional information obtained at the local level, the Design Team suggested incorporating information on protective/preventative measures or BMPs, where this information can be obtained by searching local databases or conducting site surveys of the PSOCs. Criteria checklists will be developed by the State and included in the state guidance document to aid the PWS and/or citizen volunteer groups in collecting this information. In developing these checklists, many of these measures and/or BMPs will be referenced by the State from available information sources. Sources of information might include BMP manuals, such as storm water runoff management, and Spill Prevention Control and Countermeasure (SPCC) plans. SPCC plans are usually provided to Local Emergency Planning Committees (LEPCs) as a requirement of the Community Right-to-Know Act. LEPCs also may be a good resource for PWSs or citizen volunteer groups to use in identifying local PSOCs that may not appear in the state or federal regulatory databases.

Again, the State realized that if information on compliance history, and protective/preventative measures or BMPs for a given PSOC could not be determined by searches of the state and federal databases or through community-based surveys, then a default rating system would be needed to classify the PSOC. If information on the compliance history and/or protective/preventative measures or BMPs is available and indicates that a release has occurred or is possible, a likelihood of release rating of KNOWN RELEASE / LIKELY will given to the PSOC. If this information indicates that a release has not occurred and that a release is not imminently indicated, a rating of UNLIKELY will be given to the PSOC. If information cannot be obtained to make a determination, a default rating of UNKNOWN will be given to the PSOC. In this case, until information can be obtained to make a determination, the State has elected to be conservative and assume the "worst case scenario," and treat the PSOC as if a release has occurred or is likely. As a result, this may provide incentive for the operator of the PSOC and/or the PWS to demonstrate whether site-specific information on compliance history and/or protective/preventative measures or BMPs is available that might change this default rating. It is possible that such information might demonstrate that the likelihood of release is UNLIKELY, which could ultimately affect vulnerability rating for the PSOC.

Likelihood of release evaluations will be made for both point and non-point sources of pollution. Examples of non-point sources that might appear in the evaluation include highways that allow the transport of hazardous materials through the SWAA, agricultural activities that occur upstream of a drinking water intake or upgradient of a well, and urban development that results in significant increases in oil, grease, and sediment loading to streams.

Risk Factors

Integrity of the System

According to the EPA guidance, the integrity of the system refers to the structural soundness and maintenance of the intake or well and the connections between the intake/well and the distribution system up to the first form of treatment, if any. A structurally sound intake or well should help to reduce the likelihood of contaminants entering the system.

The structural integrity of ground water wells is determined by an evaluation of factors such as the age, design, and construction of the well; surface protection surrounding the well (impervious pads and drainage away from the well hole); and maintenance records. Since PWSs are the best source for this kind of information, they will be strongly encouraged to participate in the susceptibility analysis. Given the number of PWSs involved (> 2,200) and the short timeframe involved, the State and its contractor(s) will not be able to conduct field visits to all of the PWSs to observe and document the structural integrity of their systems. As a result, the PWS will be encouraged to photographically document the integrity of their structures and submit the documentation to the contractor(s) to aid in the analysis. The State may verify the documentation of up to 5% of the PWSs as a quality control measure by conducting field visits on a limited basis.

Evaluation of surface water systems will consider the age and integrity of the intake structure, as well as exposure to the environment between a point of diversion and the treatment plant. An example of the latter is the use of ditches or natural open channels to convey water or storage in reservoirs vs. closed pipelines and/or tunnels. Where pipelines and/or tunnels are used, the State will assume that the water will be adequately protected from open exposure to the environment. For open conveyances, the length also will be taken into account. The State assumes those longer open conveyances present a greater threat of accidental exposure to contaminants.

In both cases, the State will be developing a criteria checklist to be included in the state guidance document and considered by the State's contractor(s) and PWS in evaluating this factor.

Setting Sensitivity

Setting sensitivity attempts to assess, in very general terms, the risk factor posed by the contaminant transport differences within a SWAA. The risk will be assessed by determining the relative proximity of a PSOC to the PWS intake or well by defining sensitivity zones around the intake or well. For ground water systems, the setting sensitivity analysis also will attempt to take into account the hydrogeologic characteristics of the SWAA that might effect the movement of a contaminant from a PSOC toward a PWS well(s).

Determining the setting sensitivity of a PWS to a PSOC will involve a second phase of delineation to define sensitivity zones around an intake or well. For surface water and ground water systems, the size of the sensitivity zones has been developed based on guidance from the Design Team.

Surface Water Systems

Factors for evaluating setting sensitivity for surface water systems include the distance to the surface drainage network and the distance between the intake and the PSOC. If any stream or segment of a stream in the SWAA has been identified on the 303(d) list in the 305(b) report, or has had a Total Maximum Daily Load (TMDL) developed for it, the setting sensitivity rating will be increased by one level.

Buffer zones will be used to categorize the distance from a PSOC to the drainage network and to the intake. The drainage network must include all perennial and intermittent streams tributary to the drainage segment on which the intake and/or diversion structure are located. These tributaries must appear on the U.S. Geological Survey (USGS) topographic quadrangles at the 1:24,000 scale. With respect to categorizing the distance of a PSOC from the drainage network, Zone 1 will be defined as either a 1,000-foot wide band on each either side of the stream, lake or shallow alluvial aquifer (for cases where ground water is under the influence of surface water) or the 100 year flood plain. Since Zone 1 is the closest zone to the drainage network and is of greatest concern, the PWS will be advised to use the method that provides the widest and most protective zone. Zone 2 will extend 1/4 mile beyond each side of the boundary of Zone 1. Zone 3 will encompass the remainder of the SWAA up to be watershed boundary or to the State border. With respect to categorizing the distance of the PSOC from the PWS intake, a radial distance of greater than 15 valley miles between the PSOC and the surface water intake will be considered as the “Far” zone, while a radial distance less than 15 valley miles will be considered as the “Near” zone.

The following three diagrams illustrate the application of the zone approach to surface water systems. **Figure 5.2** is a general diagram of a surface water intake on a stream with Zones 1, 2, and 3, and the “Near” and “Far” zones depicted.

Figure 5.3 illustrates the zone approach with a lake upstream from the surface water intake. Zone 1 includes a 1,000-foot wide buffer around the edge of the lake at a minimum, as contaminants entering the lake at any point may impact the PWS. The “Near” and “Far” zone determinations are the same as those in depicted in Figure 5.2.

Figure 5.2 Zone Approach for Surface Water Intakes

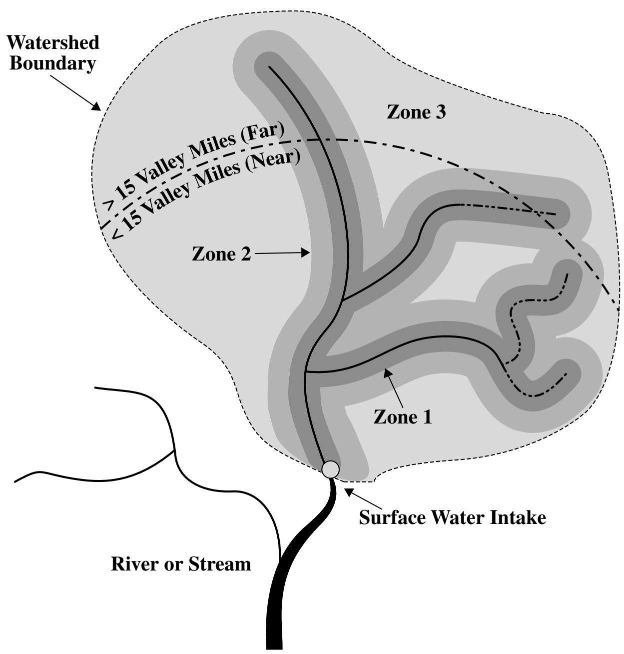


Figure 5.3 Zone Approach Illustrating Intake Downstream from A Lake

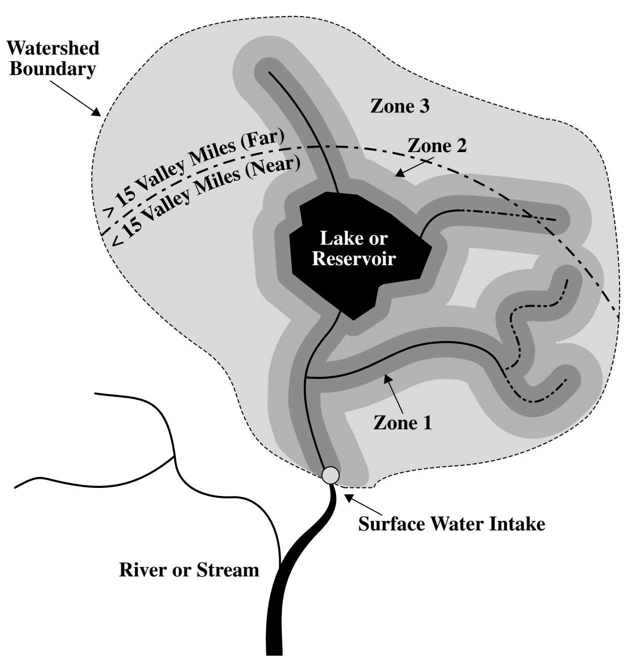
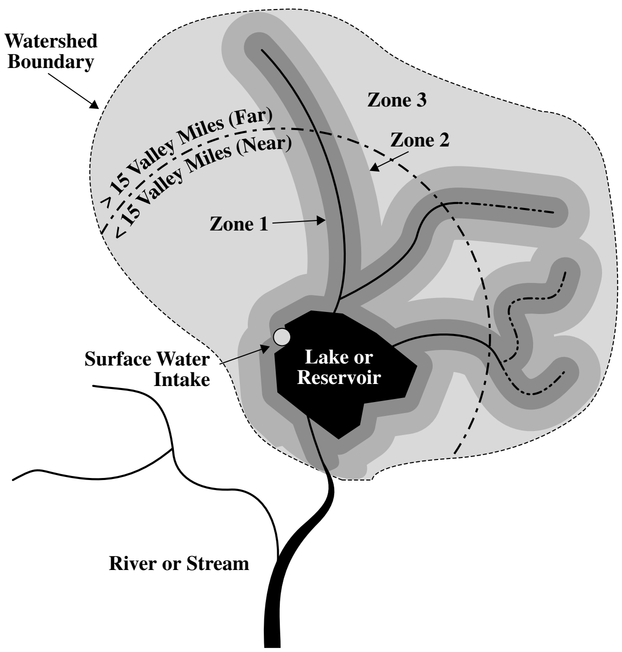


Figure 5.4 illustrates a surface water intake on a lake or reservoir. Once again, the "Near" and "Far" zones are determined in the same manner as those for the previous two examples. Zone 1 includes a 1,000-foot wide buffer around the perimeter of the lake or reservoir. In taking this approach, the sensitivity of the area surrounding the entire lake through which contaminants could move is taken into account. Therefore, a contaminant entering the lake on the opposite side or some distance from the intake will still be addressed in the susceptibility analysis.

Figure 5.4 Zone Approach for Intake on A Lake or Reservoir



Ground Water Systems

The zone approach has also been developed for determining setting sensitivity for ground water systems. Once again, three zones, at increasing distances from the wellhead have been identified. **Table 5.2** indicates the graduated distances of the three zones.

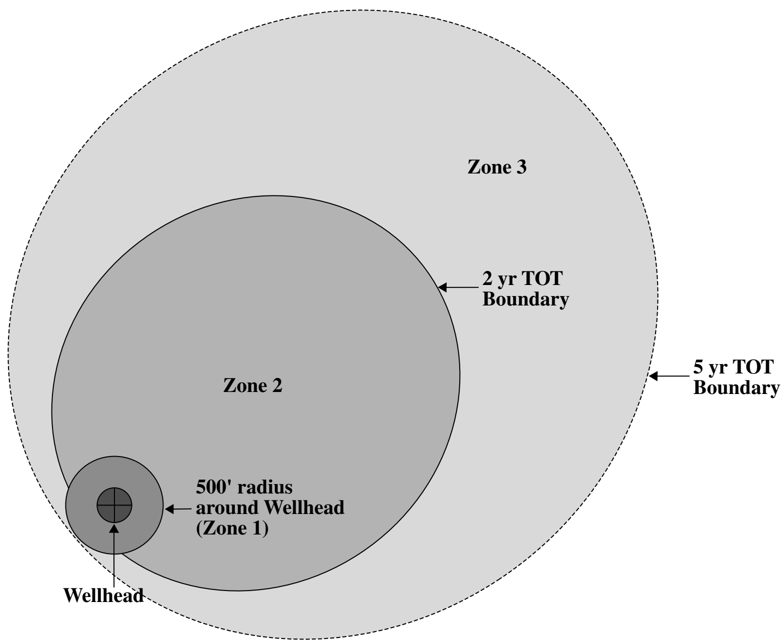
Table 5.2 Definition of Sensitivity Zones Around a PWS Well

Zone 1	500' radius from the wellhead
Zone 2	outer boundary of Zone 1 to the 2-year time of travel (TOT)
Zone 3	outer boundary of Zone 2 to the 5-year TOT

Zone 1, being the closest to the well is of greatest concern. PSOCs located this close to the well are definitely a potential risk, and will generally receive a high rating due to the short travel distance to the well. Zone 2 extends farther out and PSOCs located within this zone are of slightly lesser concern. Zone 3 extends the farthest distance and, generally, is of the lowest concern, depending on what PSOCs are identified within this zone.

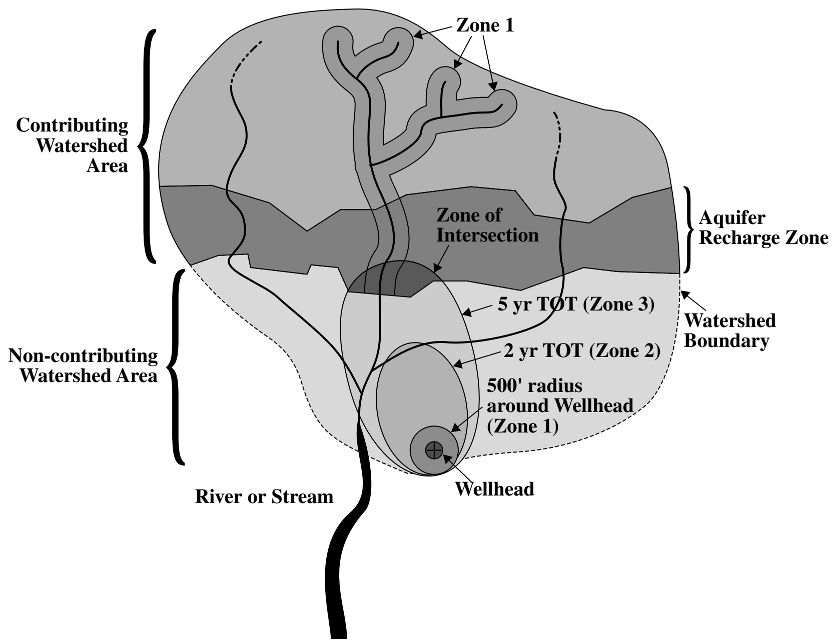
Figure 5.5 illustrates the three zones used in evaluating the setting sensitivity of wells in unconfined aquifers.

Figure 5.5 Zone Approach for Unconfined Aquifers



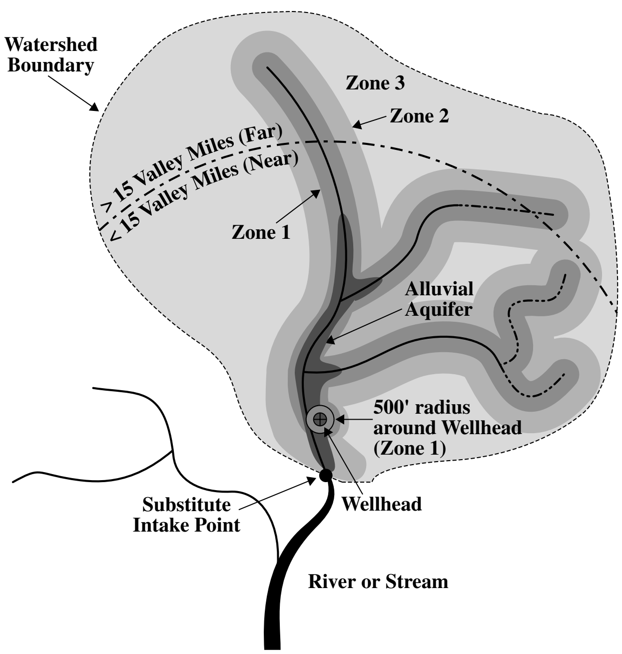
Applying the zone approach to a well in a confined aquifer may result in a somewhat different assessment, as is illustrated in **Figure 5.6**. Identification of the three zones around the well will be the same as before. However, if the location of the recharge area is known and is intersected by one of the zones established around the well, the PWS needs to be concerned about the nearest portion of the watershed that is upgradient of the well and potentially contributing water to this zone of intersection. Where this is the case, the zones for the contributing drainage area will be determined in a similar manner as those for surface water. The zones established around the contributing surface water drainage area would depend on which well zone (1, 2 or 3) intersects the recharge area. If Zone 3 of the well intersects the recharge area, Zone 1 will be established around the contributing drainage, including that portion contained within the recharge zone. This example is illustrated in Figure 5.6. If Zone 2 of the well intersects the recharge area, Zones 1 and 2 will be established around the contributing drainage. In the event that Zone 1 of the well intersects or the well itself is in the recharge area, all three zones will be established around the contributing drainage. In this case, the concept of "Near" and "Far" zones will not apply. In some instances, the recharge area can be a significant distance from the wellhead and might not intersect with the zones established around the well, causing the time of travel to the well to be considerably longer than five years. In this situation, the contributing watershed would be of less concern. As a precautionary measure, however, the PWS will have the option to consider inventorying the contributing watershed even if the TOT is greater than five years.

Figure 5.6 Zone Approach for Deep, Confined Aquifer with Recharge Area Illustrated



High-risk ground water systems are those found in unconfined alluvial, fracture-flow, and karst aquifers. The geology in these situations makes them very vulnerable to contamination from surface activities. For this reason, an assumption is made that they are highly sensitive. **Figure 5.7** illustrates a well in an alluvial aquifer with a likely hydrologic connection to the stream (i.e., ground water under the influence of surface water). For this special case, the analysis will be treated like the surface water systems illustrated earlier in establishing the buffer zones. Zone 1 will include the 500-foot radius around the wellhead and the 1,000-foot wide zone extending from the edge of the alluvial aquifer or from all perennial and intermittent streams in the watershed. Zone 2 covers 1/4 mile on either side of Zone 1. Zone 3 is the remainder of the SWAA up to the watershed boundary. PSOCs in the "Near" zone will be closer than 15 valley miles from the well, and PSOCs in the "Far" zone will be farther away than 15 valley miles upstream. A more detailed discussion of the delineation method for this example and an example for a fracture-flow or karst aquifer situation is provided in Section 5.6.

Figure 5.7 Zone Approach for High Risk Aquifers



Examples of other factors that could be considered in determining the setting sensitivity for ground water systems are well depth and geologic features such as impervious layers that would prevent contaminants from reaching the well. Well depth is generally recorded on the well permit that many PWSs may have on file. Identifying the presence of natural barriers will be more difficult to determine as comprehensive geologic maps and sensitivity determinations have not been completed for all ground water formations in the State. Where this information is available, it will be used in determining setting sensitivity. The well drillers' log, which is often attached to the well permit, should indicate the soil layers above the well. Depending on how well the log is completed, it may be helpful in assessing setting sensitivity. A list of the most significant factors that could effect contaminant transport will be included in the State's guidance document for conducting a SWAP assessment.

5.6 STEPS IN DETERMINING SUSCEPTIBILITY

As was previously illustrated in Figure 5.1, the susceptibility of a PWS is determined by summarizing the potential vulnerability of the PWS to various PSOCs within the SWAA. The vulnerability of a PWS to a PSOC is determined by knowing both the threat and risk posed. Threat is determined by defining the contaminant hazard present and the likelihood of release posed by the PSOC. Risk is determined by assessing the structural integrity of the PWS and defining the setting sensitivity of the SWAA. The steps involved to evaluate the threat, risk, vulnerability, and susceptibility are discussed below.

Threat Identification - Steps 1,2 and 3

Step 1. Identify the Contaminant Hazard

As mentioned above, the contaminants identified during the contaminant inventory for a particular PSOC will be separated into three hazard classes, A, B, and C, based on their known or suspected impacts to human health. Classes A and B contain the most serious contaminants, those on the National Primary Drinking Water Standards list or the Drinking Water Contaminant Candidate list. Class A, with few exceptions, includes all contaminants with an MCLG of zero and that have established acute health care concerns (e.g., are carcinogenic). Class B includes all other primary drinking water standards contaminants and drinking water contaminant candidate list contaminants that may or may not have established chronic health care concerns. Class C includes the National Secondary Drinking Water Standard contaminants. Unregulated contaminants of concern to Colorado also appear on the list. Appendix E (Table E.2) lists which classes each contaminant falls into.

The first part of this process is to identify the contaminant(s) from the inventory, if possible, and assign the class(es) into which they fall. While it is the intent of the State to analyze community and non-transient, non-community water systems for all three classes of contaminants, prioritization will be given within the current time frame of the SWAP program to analyzing Class A and Class B contaminants that have established drinking water protection standards. The analysis of transient, non-community systems will be limited to Class A contaminants, which are known to cause acute health care problems, as there is no reliable means of determining chronic exposure in transient populations.

The second part of the process involves assigning an overall hazard classification to the PSOC. This designation will be determined based, in general, on the prevalence of Class A, B or C contaminants, with respect to each other. Based on the total number of potential contaminants identified from the database searches or community-bases surveys, if Class contaminants comprise 25% or more of the total, the PSOC will be ranked as a Class A contaminant hazard. If Class B contaminants comprise more than 25% of the total, and Class A and C contaminants comprise less than 25% of the total, respectively, the PSOC will be ranked as a Class B contaminant hazard. Similarly, if Class C contaminants comprise more than 25% of the total, while Class A and B contaminants comprise less than 25% of the total, respectively, the PSOC will be ranked as a Class C contaminant hazard.

If information on the types of potential contaminants for a given PSOC is not available from searches of the state and federal databases or is not collected through community-based surveys, then a default position will be needed to classify the PSOC. Therefore, the State has provided a default contaminant hazard ranking for each PSOC listed in Table E.1 of Appendix E. The default rating was based, in general, on the prevalence of the different classes of contaminants (A, B, or C) with respect to each other, as defined above.

In the event that more than one type of source may be present at a given PSOC location, the State will try to identify which of the sources presents the greatest contaminant hazard threat for purposes of conducting the susceptibility analysis. Information about the other sources identified at a facility would be retained as metadata (i.e., backup or supporting data) for purposes of increasing citizen and PWS awareness of these additional potential sources and would be referenced in the assessment report if the PWS so chooses.

Step 2. Determine the Likelihood of Release

The likelihood of release will be determined by an evaluation of the compliance history (if applicable and/or available), and/or protective/preventative measures or best management practices (BMPs) that could affect whether contaminants might be released. In the initial iteration conducted by the State for regulated PSOCs, the likelihood of release will be based primarily on available compliance history information contained in the regulated state and federal databases. Where information on protective/preventative measures or BMPs can be obtained from the databases, it will be utilized in helping to determine the likelihood of release rating in the initial iteration.

In the second iteration, where the PWS potentially supplies additional information obtained at the local level, information on protective/preventative measures or BMPs will be incorporated into the analysis, where this information can be obtained by searching local databases or conducting site surveys of the PSOCs. Criteria checklists will be developed by the State and included in the State's guidance document to aid the PWS and/or citizen volunteer groups in collecting this information. In developing these checklists, many of these measures and/or BMPs will be referenced by the State from available information sources.

If information on the compliance history and/or protective/preventative measures or BMPs is available and indicates that a release has occurred or is possible, a likelihood of release rating of KNOWN RELEASE / LIKELY will given to the PSOC. If this information indicates that a release has not occurred and that a release is not imminently indicated, a rating of UNLIKELY will be given to the PSOC. If information on compliance history, and protective/preventative measures or BMPs for a given PSOC cannot be determined by searches of the state and federal databases or through community-based surveys, then a default rating of UNKNOWN will be utilized to classify the PSOC. In this case, until information can be obtained to make a determination, the State has elected to be conservative and assume the "worst case scenario," and treat the PSOC as if a release has occurred or is likely. As a result, this may provide incentive for the operator of the PSOC and/or the PWS to demonstrate whether site-specific information on compliance history and/or protective/preventative measures or BMPs is available that might change this default rating. It is possible that such information might demonstrate that the likelihood of release rating is UNLIKELY, which could ultimately affect the vulnerability rating for the PSOC.

For the different classes of PSOCs that were identified earlier in Table 4.1, the likelihood of release may be affected by several different protective/preventative measures or best management practices. For each PSOC class (e.g., agricultural, industrial, etc.), the State will attempt to develop criteria checklists for the most significant protective/preventative measures and best management practices that might be applicable to that PSOC class. In general, these measures and practices may or may not be unique to the PSOC in question.

Examples of protective/preventative measures or best management practices that might be assessed for agricultural PSOCs might include the preventative measures in place to restrict livestock access to streams supplying drinking water or waste containment measures in place at a confined animal feeding operation. Similarly, examples of protective/preventative measures for industrial PSOCs might include spill prevention measures in place. Since there may be several different types of PSOCs within a given classification, the most significant protective/preventative measures and best management practices for that class may not be applicable to all of the PSOCs.

Step 3. Derive the Threat

Threat is determined by comparing the overall contaminant hazard rating with the overall likelihood of release rating for the PSOC and assigning the corresponding threat rating proposed by the State in **Table 5.3.** Examples of interpreting the ratings presented in Table 5.3 are given below.

Table 5.3 Threat as a Combination of Hazard and Likelihood of Release

LIKELIHOOD OF RELEASE	CONTAMINANT HAZARD RATING		
	A	***B***	***C***
Unlikely	Moderate	Low	Low
Unknown / Known Release or Likely	High	High	Moderate

If it has been determined that the PSOC has a contaminant hazard rating of A, the threat to the PWS will be deemed to be MODERATE if the likelihood of release rating was UNLIKELY and HIGH if the likelihood of release rating was UNKNOWN or KNOWN RELEASE/LIKELY. If the PSOC has been given a contaminant hazard rating of B, then the threat will be deemed to be LOW or HIGH if the release rating has been designated as UNLIKELY, or UNKNOWN or KNOWN RELEASE/LIKELY, respectively. The process for interpreting a PSOC with a contaminant hazard rating of C is similar.

Risk Identification - Steps 4, 5 and 6

Step 4. Determine Structural Integrity of Water System

The integrity of the water system refers to the assessment of the structural soundness and maintenance of the surface water intake, diversion and conveyance system or the soundness of the ground water well(s). The theory is that a structurally sound and properly maintained surface water intake, diversion and conveyance system or ground water well is less vulnerable to exposing the water supply to potential contamination. Factors common to the structural soundness evaluation of surface water systems and ground water systems include age, construction, and maintenance history. Normally, these can be obtained from the well permit or the construction records. When kept, maintenance records and reports provide information on operations and any chronic problems.

<u>Ground Water Systems</u>
A physical inspection of the well will indicate whether or not it is properly sealed. A site inspection will also reveal if the area around the well is graded so that runoff water drains away rather than collects around the wellhead. A review of maintenance records will indicate if the recommended measures are being employed on a scheduled basis.

Properly drilled, sealed and maintained wells will receive a rating of OK in this analysis. Wells with documented structural and/or maintenance problems will receive a rating of KNOWN PROBLEMS. If these factors cannot be assessed due to a lack of records, and/or the inability to make a site visit, a default rating of UNKNOWN PROBLEMS will be assigned. In this case, until information can be obtained to make a determination, the State has elected to be conservative and assume the "worst case scenario," and treat the situation as if there are potential problems with the structural integrity. As a result, this should provide incentive for the PWS to demonstrate whether structural integrity problems exist or not. It is possible that such information might demonstrate that the structural integrity of the water system is OK, which could ultimately affect the vulnerability rating for a given PSOC.

The State will provide a checklist of these evaluation factors in the guidance document to aid the contractor(s) and PWS in assessing the structural integrity of the ground water supply well(s).

<u>Surface Water Systems</u>

Although the same theory applies to surface water intake, diversion and conveyance structures, (i.e., that properly constructed and maintained intake, diversion and conveyance structures reduce the likelihood of contaminants entering the system), the approach is slightly different. The evaluation of the construction of intakes and diversion structures covers items like the present condition of the concrete (is it solid or crumbling); are the screens in place, and are they in reasonably good condition (not rusted and corroded); are excessive sand and gravel deposits blocking the flow of water; and is the intake or diversion structure clear of debris.

In addition, surface water systems will be evaluated for problems associated with the possible exposure of the water to the outside environment during open-channel conveyance and storage between the point of diversion from the watershed and the treatment plant. The earlier example presented in Section 5.5 cited the potential problems associated with the use of open conveyance and storage structures like ditches, reservoirs, or natural channels to convey or store water vs. using an enclosed pipeline or tunnel. Where pipelines and/or tunnels are used, the State will assume that the water will be adequately protected from open exposure to the environment. Where open-channel conveyance and storage structures are used, the age, condition, length and maintenance of the structures will be evaluated.

Based on the evaluation results, an overall rating of OK, KNOWN PROBLEM or UNKNOWN PROBLEM will be assigned to the PWS. A rating of OK is given when the structures are determined to be sound and properly maintained. Problems noted in the evaluation of the structures will result in a rating of KNOWN PROBLEMS. If the age or structural condition of the intake, diversion or conveyance structure cannot be assessed from available information or from not conducting a site evaluation, a rating of UNKNOWN PROBLEMS will be given. Until information can be obtained to make a determination, the State has elected to be conservative and assume the "worst case scenario," and treat the situation as if there are potential problems with the structural integrity. Again, this should provide incentive for the PWS to demonstrate whether structural integrity problems exist or not. It is possible that such information might demonstrate that the structural integrity rating of the water system is OK, which could ultimately affect the vulnerability rating for a given PSOC.

The State will provide a checklist of these evaluation factors in the guidance document to aid the contractor(s) and PWS in assessing the structural integrity of the surface water intake(s) and diversion structure(s).

Step 5. Determine Setting Sensitivity

Setting sensitivity attempts to assess, in very general terms, the risk factor posed by the contaminant transport differences within the SWAA. The theory is that if the potential movement of contaminants within the watershed or aquifer is rapid, potential impacts and disruptions to the PWS could be realized quickly if the PSOC is located in close proximity to the PWS. The impact and/or disruption might be significant, depending on the types of contaminant involved. In general, the risk will be assessed by determining the relative proximity of a PSOC to the PWS intake or well by defining sensitivity zones around the intake or well. Depending on which zone the PSOC is located in, a sensitivity rating of LOW, MODERATE or HIGH will be assigned to the PSOC indicating the general risk posed

Determining the setting sensitivity of a PWS to a PSOC will involve a second phase of delineation. This second phase of delineation involves using the original delineation method (i.e., watershed delineation, fixed radius method, WHPA analytical modeling, or hydrogeologic mapping) and refining the delineation of the SWAA to include sensitivity zones around a surface water intake or ground water well. For surface water and ground water systems, the size of the sensitivity zones has been developed based on guidance from the Design Team.

Ground Water Supply Systems

With respect to ground water supply systems, the setting sensitivity analysis also will attempt to take into account the hydrogeologic characteristics of the SWAA, where feasible, that might effect the movement of a contaminant from a source toward a PWS well(s). Depending on the aquifer setting, delineation of the SWAA for a well(s) will be accomplished using one or more of following methods: (1) the calculated fixed radius method, (2) the analytical modeling method, or (3) the hydrogeologic mapping method. The first two methods utilize analytical equations that require some general knowledge of the hydraulic characteristics of the aquifer, and will be used where the aquifer is porous in nature. The third method may be used where fractured or karst aquifer conditions exist, where porous unconsolidated deposits are limited in areal extent or where widely varying types of these deposits are present, where hydraulic boundaries exist, and/or where springs are used by PWSs. It is also possible that hydrogeologic mapping can be used in conjunction with the two analytical methods to more accurately delineate the SWAA.

Determination of the sensitivity setting will involve: (1) refining the SWAA to include sensitivity zones around the PWS well(s), (2) identifying the PSOCs within each of the zones and assigning a preliminary sensitivity rating to the PSOCs which will represent the general risk posed to the PWS well(s), and (3) adjusting this rating based on additional factors that could effect the movement of contaminants within the aquifer.

The first step will be accomplished by conducting additional delineation of the SWAA using the delineation method originally used to define the SWAA. In the case of the first two methods, this refinement will utilize the same analytical equations and general knowledge of aquifer flow properties to define the sensitivity zones. Three zones of increasing distances from the wellhead will be defined based on either a pre-set radial distance or various time of travel scenarios (500-foot radius, 2 year TOT, 5 year TOT) that have been developed by the State. Where one of these two delineation methods is used in conjunction with the third method, the three sensitivity zones will be defined in the same manner.

For cases involving high-risk ground water systems, delineation of the sensitivity zones will be different from the cases described above. For the case described earlier and illustrated by Figure 5.7 where ground water might be under the influence of surface water, the situation will be treated like a surface water system in most respects. In this case, Zone 1 would include a 500-foot radius around the well and a 1,000-foot wide zone surrounding the drainage network and/or the boundary of the alluvial aquifer, if it were known. Zone 2 would extend a distance of 1/4 mile from the edge of Zone 1, and Zone 3 would extend from the edge of Zone 2 up to the watershed boundary, respectively.

In the case of fracture-flow or karst aquifers where hydrogeologic mapping might be used and the SWAA was defined to be the boundary of the watershed, three sensitivity zones will be employed that were developed by the State to conservatively assess the potential risk to the PWS from a PSOC. Zone 1 will extend outward from the wellhead for a distance of 1/4 mile. Zone 2 will extend from the boundary of Zone 1 outward to a radial distance of one mile from the wellhead. Zone 3 will extend from the boundary of Zone 2 outward to the boundary of the watershed or the aquifer.

Once these zones have been defined, the next step will be to identify the PSOCs located within each of the sensitivity zones and assign a preliminary sensitivity rating to them. If the PSOC is located in Zone 1, 2 or 3 it will be given a preliminary setting sensitivity rating of HIGH, MODERATE and LOW, respectively.
The final step in determining the sensitivity rating for a PSOC will be to adjust this rating, if necessary, based on the presence of additional hydrogeologic factors that could greatly enhance or slow the transport of contaminants toward the PWS well(s). The rating will be adjusted up or down one level depending on whether there are more factors present that could enhance or slow transport, respectively. **Table 5.4** presents an example of determining the setting sensitivity rating for a PSOC while taking into account factors that may effect the transport of contaminants between the source and the PWS well(s).

A list of the most significant factors that could effect contaminant transport will be included in the State's guidance document for conducting a SWAP assessment. Examples of factors that could enhance the transport of contaminants might include the presence of improperly constructed or abandoned wells in the near vicinity of the PSOC, or the presence of faults or fractures, which could act as direct pathways for introducing contamination into the aquifer. Examples of factors that could slow the transport of contaminants might include the depth of the well, the presence of low permeability, subsurface, silt or clay layers (aquitards), or ground water remediation systems that use wells for hydraulic control of subsurface contamination of the aquifer. Identifying the presence of natural barriers will be more difficult to determine as comprehensive geologic maps and sensitivity determinations have not been completed for all ground water formations in the State. Where this information is available, it will be referenced for use in determining setting sensitivity.

Table 5.4 Setting Sensitivity Determination for Ground Water Systems

	PROXIMITY TO WELL		
RATING & ADJUSTMENT FACTORS	***ZONE 1***	***ZONE 2***	***ZONE 3***
Preliminary Sensitivity Rating:	**High**	**Moderate**	**Low**
Other Factors Present Enhancing Transport	High	High	Moderate
Other Factors Present Slowing Transport	Moderate	Low	Low

<u>Surface Water Supply Systems</u>

The setting sensitivity analysis for surface water systems will evaluate the proximity of a PSOC to both the intake and the drainage network. The drainage network includes all of the streams and water bodies in the watershed that drain to the intake within the SWAA. The theory behind this analysis is that the closer the PSOC is to the drainage network and the PWS intake, the quicker a potential contaminant can reach the stream and the intake, and cause impacts and disruptions to the PWS. Again, the impact and/or disruption might be significant, depending on the types of contaminant involved.

With respect to evaluating the proximity of the PSOC to the drainage network, three sensitivity zones will be defined around the drainage network above the intake or point of diversion. Descriptions of these three zones and example illustrations of how these zones would be delineated were provided previously in Section 5.7.

The proximity of the PSOC to the intake or point of diversion will be indicated as NEAR or FAR. NEAR will mean that the PSOC is located within a radial distance of 15 valley miles upstream from the intake. Valley miles are used rather than stream miles to ensure the most conservative coverage and the greatest distance from the intake. FAR will mean that the PSOC is located upstream of the intake a distance of more than 15 valley miles. Note that for smaller watersheds, there may not be any area of the watershed that falls in the "Far" zone.

A setting sensitivity rating of LOW, MODERATE or HIGH will be assigned to each PSOC in the PWS's area of interest based on the relative proximity of the PSOC to the drainage network and the PWS intake. **Table 5.5** presents the ratings developed by the State based on the possible combinations. For example, if a PSOC were located in the closest zone to the drainage network (Zone 1) and within a radial distance of 15 valley miles from the intake (Near zone), a setting sensitivity rating of HIGH would be assigned. Similarly, if a PSOC were located in the farthest zone from the drainage network (Zone 3) and at a radial distance greater than 15 valley miles from the intake (Far zone), a setting sensitivity rating of LOW would be assigned.

An additional factor will be considered in the analysis that could adjust the rating. The rating for the setting sensitivity may be increased by one level if any portion of the stream system is on the 303(d) list or if a TMDL has been established for any drinking water contaminant. For example, an outcome from **Table 5.5** could be increased from LOW to MODERATE or from MODERATE to HIGH. However, a rating of HIGH would remain unchanged.

Table 5.5 Setting Sensitivity Determination for Surface Water Systems

DISTANCE FROM INTAKE	**DISTANCE TO DRAINAGE NETWORK**		
	ZONE 1	***ZONE 2***	***ZONE 3***
Near (< 15 valley miles)	High	Moderate	Low
Far (> 15 valley miles)	Moderate	Low	Low

Step 6. Derive the Risk

Ground Water Supply Systems

Risk is determined by comparing the setting sensitivity rating with the structural integrity rating of the PWS and assigning a risk rating of LOW, MODERATE, or HIGH. The process is slightly different for ground water systems and surface water systems. **Table 5.6** presents the risk ratings for ground water systems. The table has been expanded to show the ratings for each possible scenario. As with the setting sensitivity ratings for ground water systems (Table 5.4), the risk ratings have been adjusted up or down one level depending on whether there are factors present that could either enhance or slow the transport of contaminants, respectively.

The risk ratings from Table 5.6 would be interpreted as follows. If a given PSOC was located in Zone 1 and had a corresponding setting sensitivity rating of MODERATE, and the system integrity was determined to be OK, the corresponding preliminary risk that the PSOC poses to contaminating the PWS will be considered MODERATE. Whether the system integrity rating is KNOWN or UNKNOWN PROBLEMS, the impact on the risk rating will be the same. For instance, in the example above, if known problems exist with the system integrity, and a given PSOC was located in Zone 1 and had a corresponding setting sensitivity rating of MODERATE, the preliminary risk of a PSOC to the PWS now would be considered HIGH. The outcome would be the same if problems with the system integrity could not be assessed accurately (i.e. UNKNOWN PROBLEMS). The State has decided to be conservative in this case, until further evidence becomes available to determine whether the system integrity rating is OK or whether the rating should be designated as KNOWN PROBLEMS.

As noted earlier, the preliminary risk ratings will be adjusted up or down one level depending on whether there are factors present that could either enhance or slow the transport of contaminants, respectively. For the example where the PSOC was located in Zone 1 and the system integrity was determined to be OK, if it was determined that geologic factors were present that could enhance the transport of contaminants, the preliminary risk rating of MODERATE would be adjusted up to HIGH. Similarly, if it was determined that geologic factors were present that could slow the transport of contaminants, the preliminary risk rating of MODERATE would be adjusted down to LOW. In the example where the PSOC was located in Zone 1 and there are known or unknown problems with the system integrity, similar adjustments would be made to the preliminary risk rating of HIGH, depending on whether the factors enhance or slow the transport of contaminants.

Surface Water Supply Systems

Table 5.7 presents the risk ratings for surface water systems. Again, the table has been expanded to show the ratings for each possible scenario. The risk ratings from Table 5.7 would be interpreted as follows.

Table 5.6 Risk as a Combination of Setting Sensitivity and System Integrity - Ground Water Supply Systems

SYSTEM INTEGRITY	SETTING SENSITIVITY Rating (Setting)	RISK RATING
Known/Unk. Problems	High [1] (Zone 1 & Enhancement)	HIGH [1]
OK	High [1] (Zone 1 & Enhancement)	HIGH [1]
Known/Unk. Problems	**High (Zone 1)**	**HIGH**
OK	**High (Zone 1)**	**MODERATE**
Known/Unk. Problems	Mod. [2] (Zone 1 & Slowing)	MODERATE [2]
OK	Mod. [2] (Zone 1 & Slowing)	LOW [2]
Known/Unk. Problems	High [1] (Zone 2 & Enhancement)	HIGH [1]
OK	High [1] (Zone 2 & Enhancement)	HIGH [1]
Known/Unk. Problems	**Mod. (Zone 2)**	**MODERATE**
OK	**Mod. (Zone 2)**	**MODERATE**
Known/Unk. Problems	Low [2] (Zone 2 & Slowing)	LOW [2]
OK	Low [2] (Zone 2 & Slowing)	LOW [2]
Known/Unk. Problems	Mod.[1] (Zone 3 & Enhancement)	HIGH [1]
OK	Mod.[1] (Zone 3 & Enhancement)	MODERATE [1]
Known/Unk. Problems	**Low (Zone 3)**	**MODERATE**
OK	**Low (Zone 3)**	**LOW**
Known/Unk. Problems	Low [2] (Zone 3 & Slowing)	LOW [2]
OK	Low [2] (Zone 3 & Slowing)	LOW [2]

[1] Corresponding preliminary rating (in bold) was increased one level due to presence of factors that could enhance the transport of contaminants.

[2] Corresponding preliminary rating (in bold) was decreased one level due to presence of factors that could slow the transport of contaminants.

Table 5.7 Risk as a Combination of Setting Sensitivity and System Integrity - Surface Water Supply Systems

SYSTEM INTEGRITY	SETTING SENSITIVITY Rating (Setting)	RISK RATING
Known/Unk. Problems	High (Zone 1 & Near)	HIGH
OK	High (Zone 1 & Near)	HIGH
Known/Unk. Problems	Mod. (Zone 2 & Near)	HIGH
OK	Mod. (Zone 2 & Near)	MODERATE
Known/Unk. Problems	Mod. (Zone 1 & Far)	MODERATE
OK	Mod. (Zone 1 & Far)	MODERATE
Known/Unk. Problems	Low (Zone 3 & Near)	MODERATE
OK	Low (Zone 3 & Near)	LOW
Known/Unk. Problems	Low (Zone 2 & Far)	MODERATE
OK	Low (Zone 2 & Far)	LOW
Known/Unk. Problems	Low (Zone 3 & Far)	LOW
OK	Low (Zone 3 & Far)	LOW

If a given PSOC was located in Zone 2 and less than 15 valley miles from the intake (i.e., Near), had a corresponding setting sensitivity rating of MODERATE, and the system integrity was determined to be OK, the corresponding risk that the PSOC poses to contaminating the PWS will be considered MODERATE. Whether KNOWN or UNKNOWN PROBLEMS exist with the system integrity, the impact on the risk rating will be the same. For instance, in the example above, if KNOWN PROBLEMS exist with the system integrity, and a given PSOC was located in Zone 1 and the "Near Zone", and had a corresponding setting sensitivity rating of MODERATE, the risk of a PSOC to the PWS would now be considered HIGH. The outcome would be the same if problems with the system integrity could not be assessed accurately (i.e. UNKNOWN PROBLEMS). The State has decided to be conservative in this case, until further evidence becomes available to determine whether the system integrity is OK or whether there are KNOWN PROBLEMS with the system integrity.

Step 7. Determine Vulnerability

The vulnerability of a surface or ground water system to a PSOC is determined by combining the threat and risk ratings (Steps 3 and 6) to derive the vulnerability rating. In coordination with the Design Team, the State has developed vulnerability ratings for ground water and surface water systems, based on the possible combinations of threat and risk scenarios. Again, the process is slightly different for ground water systems and surface water systems.

<u>Ground Water Supply Systems</u>

Table 5.8 presents the possible vulnerability ratings for ground water systems, based on the possible combinations of threat and risk ratings. The risk ratings from Table 5.8 would be interpreted as follows.

If a given PSOC had a contaminant hazard rating of CLASS A and a likelihood of release rating of UNLIKELY, the corresponding threat rating would be MODERATE. Conversely, if the system integrity rating of the PWS was determined to be KNOWN PROBLEMS (or UNKNOWN PROBLEMS) and the PSOC was located in Zone 2 (i.e. setting sensitivity rating of MODERATE), the corresponding risk rating would be MODERATE. Coupling the MODERATE threat rating with the MODERATE risk rating results in a corresponding vulnerability rating of MODERATE.

As noted earlier in Steps 5 and 6, the preliminary risk ratings could be adjusted up or down one level depending on whether there are factors present that could either enhance or slow the transport of contaminants, respectively. For the example above where the PSOC was located in Zone 2 and the system integrity rating was determined to be KNOWN PROBLEMS (or UNKNOWN PROBLEMS), if it was determined that geologic factors were present that could enhance the transport of contaminants, the preliminary setting sensitivity rating of MODERATE would be adjusted up to HIGH, respectively. This results in the preliminary risk rating being adjusted from MODERATE to HIGH. Coupling the previous threat rating of MODERATE with the adjusted risk rating of HIGH, results in a vulnerability rating of HIGH. Similarly, if it was determined that geologic factors were present that could slow the transport of contaminants, the preliminary setting sensitivity rating and risk ratings of MODERATE would be adjusted down to LOW, respectively. Coupling the previous threat rating of MODERATE with the adjusted risk rating of LOW results in a vulnerability rating of LOW. The process of interpretation is similar for the other combinations.

<u>Surface Water Systems</u>

Table 5.9 presents the possible vulnerability ratings for surface water systems, based on the possible combinations of threat and risk ratings. The risk ratings from Table 5.9 would be interpreted as follows.

Table 5.8 Vulnerability as a Combination of Threat and Risk – Ground Water Supply Systems

		CONTAMINANT HAZARD:	Class A	Class A	Class B	Class B	Class C	Class C
		LIKELIHOOD OF RELEASE:	Unlikely	Unk/Known or Likely	Unlikely	Unk/Known or Likely	Unlikely	Unk/Known or Likely
		THREAT RATING:	MODERATE	HIGH	LOW	HIGH	LOW	MODERATE
SYSTEM INTEGRITY	**SETTING SENSITIVITY Rating (Setting)**	**RISK RATING**						
Known/Unk. Problems	High[1] (Zone 1/Enhance.)	HIGH[1]	**HIGH**	**HIGH**	**HIGH**	**HIGH**	**HIGH**	**HIGH**
OK	High[1] (Zone 1/Enhance.)	HIGH[1]	**HIGH**	**HIGH**	**HIGH**	**HIGH**	MODERATE	**HIGH**
Known/Unk. Problems	High (Zone 1)	HIGH	**HIGH**	**HIGH**	MODERATE	**HIGH**	MODERATE	**HIGH**
OK	High (Zone 1)	MODERATE	MODERATE	**HIGH**	MODERATE	**HIGH**	LOW	MODERATE
Known/Unk. Problems	Mod.[2] (Zone 1/Slow.)	MODERATE[2]	MODERATE	MODERATE	LOW	MODERATE	LOW	MODERATE
OK	Mod.[2] (Zone 1/Slow.)	LOW[2]	LOW	MODERATE	LOW	MODERATE	LOW	LOW
Known/Unk. Problems	High[1] (Zone 2/Enhance.)	HIGH[1]	**HIGH**	**HIGH**	**HIGH**	**HIGH**	**HIGH**	**HIGH**
OK	High[1] (Zone 2/Enhance.)	HIGH[1]	**HIGH**	**HIGH**	MODERATE	**HIGH**	MODERATE	**HIGH**
Known/Unk. Problems	Mod. (Zone 2)	MODERATE	MODERATE	**HIGH**	MODERATE	MODERATE	MODERATE	MODERATE
OK	Mod. (Zone 2)	MODERATE	MODERATE	MODERATE	LOW	MODERATE	LOW	MODERATE
Known/Unk. Problems	Low[2] (Zone 2/Slow.)	LOW[2]	LOW	MODERATE	LOW	LOW	LOW	LOW
OK	Low[2] (Zone 2/Slow.)	LOW[2]	LOW	LOW	LOW	LOW	LOW	LOW
Known/Unk. Problems	Mod.[1] (Zone 3/Enhance.)	HIGH[1]	**HIGH**	**HIGH**	MODERATE	**HIGH**	MODERATE	**HIGH**
OK	Mod.[1] (Zone 3/Enhance.)	MODERATE[1]	MODERATE	**HIGH**	MODERATE	**HIGH**	MODERATE	MODERATE
Known/Unk. Problems	Low (Zone 3)	MODERATE	MODERATE	MODERATE	LOW	MODERATE	LOW	MODERATE
OK	Low (Zone 3)	LOW	LOW	MODERATE	LOW	MODERATE	LOW	LOW
Known/Unk. Problems	Low[2] (Zone 3/Slow.)	LOW[2]	LOW	LOW	LOW	LOW	LOW	LOW
OK	Low[2] (Zone 3/Slow.)	LOW[2]	LOW	LOW	LOW	LOW	LOW	LOW

[1] Corresponding preliminary rating (shaded) was increased one level due to the presence of factors that could enhance contaminant transport.

[2] Corresponding preliminary rating (shaded) was decreased one level due to the presence of factors that could slow contaminant transport.

Table 5.9 Vulnerability as a Combination of Threat and Risk – Surface Water Supply Systems

		CONTAMINANT HAZARD:	Class A	Class A	Class B	Class B	Class C	Class C
		LIKELIHOOD OF RELEASE:	Unlikely	Unk/Known or Likely	Unlikely	Unk/Known or Likely	Unlikely	Unk/Known or Likely
		THREAT RATING:	MODERATE	HIGH	LOW	HIGH	LOW	MODERATE
SYSTEM INTEGRITY	**SETTING SENSITIVITY Rating (Setting)**	**RISK RATING**						
Known/Unk. Problems	High (Zone 1 & Near)	HIGH	**HIGH**	**HIGH**	MODERATE	**HIGH**	MODERATE	**HIGH**
OK	High (Zone 1 & Near)	HIGH	MODERATE	**HIGH**	MODERATE	**HIGH**	MODERATE	MODERATE
Known/Unk. Problems	Mod. (Zone 2 & Near)	HIGH	MODERATE	**HIGH**	MODERATE	**HIGH**	MODERATE	**HIGH**
OK	Mod. (Zone 2 & Near)	MODERATE	MODERATE	**HIGH**	MODERATE	MODERATE	LOW	MODERATE
Known/Unk. Problems	Mod. (Zone 1 & Far)	MODERATE	MODERATE	**HIGH**	MODERATE	**HIGH**	LOW	MODERATE
OK	Mod. (Zone 1 & Far)	MODERATE	MODERATE	MODERATE	LOW	MODERATE	LOW	MODERATE
Known/Unk. Problems	Low (Zone 3 & Near)	MODERATE	MODERATE	**HIGH**	LOW	MODERATE	LOW	MODERATE
OK	Low (Zone 3 & Near)	LOW	LOW	MODERATE	LOW	MODERATE	LOW	LOW
Known/Unk. Problems	Low (Zone 2 & Far)	MODERATE	MODERATE	MODERATE	LOW	MODERATE	LOW	MODERATE
OK	Low (Zone 2 & Far)	LOW	LOW	MODERATE	LOW	MODERATE	LOW	LOW
Known/Unk. Problems	Low (Zone 3 & Far)	LOW	LOW	MODERATE	LOW	MODERATE	LOW	LOW
OK	Low (Zone 3 & Far)	LOW	LOW	MODERATE	LOW	LOW	LOW	LOW

If a given PSOC had a contaminant hazard rating of CLASS B and a likelihood of release rating of LIKELY, the corresponding threat rating would be HIGH. Similarly, if the likelihood of release rating were UNKNOWN or KNOWN, the corresponding threat rating would remain unchanged. If the system integrity rating of the PWS was determined to be OK and the PSOC was located in Zone 3 and NEAR (i.e. setting sensitivity rating of LOW), the corresponding risk rating would be LOW. Coupling the HIGH threat rating with the LOW risk rating results in a corresponding vulnerability rating of MODERATE.

For the example above, if the PSOC had a contaminant hazard rating of CLASS B but a likelihood of release rating of UNLIKELY, the corresponding threat rating would be LOW. If the system integrity rating of the PWS was determined to be OK and the PSOC was located in Zone 3 and NEAR (i.e. setting sensitivity rating of LOW), the corresponding risk rating would be LOW. Coupling the LOW threat rating with the LOW risk rating results in a corresponding vulnerability rating of LOW. The process of interpretation is similar for the other combinations.

Step 8. Determine Susceptibility

The relative susceptibility of a system to different classes of PSOCs and, therefore, to different classes of contaminants is determined by the outcome of the vulnerability assessment. As a result, the outcome will be summarized in two ways. First the outcome will be summarized by tabulating the number of vulnerability ratings for each contaminant hazard rating given to a PSOC, such as the example given in **Table 5.10**. This table will summarize the number of LOW, MODERATE, and HIGH vulnerability ratings that Class A, B, and C PSOCs in the SWAA received during the susceptibility analysis. The State will also tabulate the number of vulnerability ratings by general PSOC classification (e.g., agricultural, industrial, etc.), such as the example given in **Table 5.11**. This table will summarize the number of LOW, MODERATE, and HIGH vulnerability ratings received by the different classes of PSOCs (e.g. agricultural, industrial, etc.).

Once this is completed, the susceptibility analysis will be narratively summarized in a general and concise manner. The narrative report will include brief discussions on the factors that impacted the analysis (i.e., contaminant hazards, likelihood of release, structural integrity of the PWS, and setting sensitivity) and the outcome of the susceptibility analysis. The State envisions presenting summary maps showing the distribution of PSOCs within the SWAA that received a HIGH or MODERATE vulnerability rating in the susceptibility analysis. Presumably, these would include the PSOCs of greatest concern (i.e., Class A and B). With respect to surface water systems, the map would include PSOCs located within the PWS's area of responsibility and area of interest. For the area of responsibility, only PSOCs receiving a HIGH or MODERATE vulnerability rating will be shown. For the area of interest, only PSOCs receiving a HIGH vulnerability rating will be shown. Based on the summary tables and maps for the narrative report, it is hoped that general statements can be made about system susceptibility to categories or classes of contaminants and contaminant sources, as well as identification of possible cumulative effects.

Table 5.10 Summary of Vulnerabilities by Contaminant Class (Example)

CONTAMINANT CLASS	NUMBER OF VULNERABILITY RATINGS			
	Low	Moderate	High	TOTAL
CLASS A	1	5	3	**9**
CLASS B				
With MCLs/MCLGs	3	3	1	**7**
Without MCLs/MCLGs	0	4	2	**6**
With & Without MCLs/MCLGs	2	2	1	**5**
CLASS C	0	0	0	**0**
TOTAL	**6**	**14**	**7**	**27**

Table 5.11 Summary of Vulnerabilities by Contaminant Source Class (Example)

CONTAMINANT CATEGORY/ Source	NUMBER OF VULNERABILITY RATINGS			
	Low	Moderate	High	TOTAL
COMMERCIAL/INDUSTRIAL:				
Chem./Petro. Processing Sites	0	0	1	**1**
Gas Stations	2	4	3	**9**
Mining/Milling Sites	1	2	0	**3**
Storage Tank Sites	1	5	2	**8**
TOTAL	**4**	**11**	**6**	**21**
RESIDENTIAL/MUNICIPAL:				
Landfills/Dumps	0	2	1	**3**
Septic Systems	2	4	1	**7**
Wastewater Treatment Plants	0	1	1	**2**
TOTAL	**2**	**7**	**3**	**12**
ARGICULTURAL/RURAL:				
Campgrounds/Rest Areas	2	3	2	**7**
Irrigated Crop Areas	4	3	2	**9**
Pesticide/Fertilizer Storage Sites	0	1	1	**2**
TOTAL	**6**	**7**	**5**	**18**

To understand the susceptibility analysis procedure better, a brief case study is provided in **Appendix F**. This case study presents a hypothetical situation for two different PWSs, in which various PSOCs and factors are evaluated and rated. Included is a brief outline on the ancillary information that might be considered and included in the narrative report.

5.7 RESPONSIBLE PARTIES

As with the contaminant inventory element, the task of conducting the susceptibility analysis will be spearheaded by the State and its contractor(s) in cooperation with the PWS or a consortium of stakeholders including the PWS, and by citizens in the community. The involvement of local citizens in the susceptibility analysis will be strongly encouraged. Additionally, owners of large numbers of PWSs, particularly the transient, non-community PWSs, such as the U.S. Forest Service, National Park Service, and Colorado Department of Transportation will be encouraged to work in cooperation with the State and its contractor(s) to complete the analyses on the systems for which they are responsible. Following completion of the susceptibility analysis, the results will be made available to the public.

During the initial phase of the susceptibility analysis effort, the State and its contractor(s) will perform a preliminary susceptibility analysis in which all PSOCs identified during the contaminant inventory will be analyzed. At a minimum, the PSOCs evaluated in the preliminary analysis will include those of greatest concern (i.e., those containing potential contaminants for which MCLs and MCLGs have been established) that were identified during the first phase of the contaminant inventory (i.e., those identified in the state and federal data bases). Once the preliminary analysis has been completed, it will be given to the PWS and/or stakeholders to review.

During the next phase of the susceptibility analysis, the PWS will be encouraged to take the lead on reviewing the preliminary results and provide comments and/or recommendations on changes to the rankings developed by the State. During the review process, the PWS will be encouraged to solicit input from citizens and other PWSs and stakeholders located within the same SWAA. The PWS will inform the State of any desired changes in the susceptibility analysis results. The State will review and incorporate these changes, as appropriate, into the analysis if the PWS can provide persuasive evidence to do so.

Depending on whether involvement by the PWS or citizens occurs during the contaminant inventory and the susceptibility analysis, the inclusion and analysis of local information may have to occur in a later iteration.

5.8 SUSCEPTIBILITY DETERMINATIONS

The State plans to use a tiered or phased approach with the susceptibility analyses, starting with the most serious PSOCs that can be identified from existing state and federal data bases and determining the vulnerabilities of the PWS. All known information about the identified PSOCs will be assembled and evaluated in an effort to make an accurate determination of the susceptibility of the PWS. The susceptibility analysis will be furnished to the PWS and/or stakeholders to review and make possible revisions.

The PWS will be encouraged to take the lead on reviewing the preliminary susceptibility analysis results and recommending revisions to the rankings developed by the State. The PWSs will be advised of the benefits of public involvement in this element, and will be encouraged to solicit participation and feedback from interested citizens and other stakeholders within the SWAA. As stated before, the State will review and incorporate these changes into the analysis if the PWS can provide persuasive evidence to do so.

The PWS will be considered susceptible to all PSOCs that are given a HIGH or MODERATE vulnerability rating in the susceptibility analysis. In addition, any activity that is a known source of contamination that has impacted the drinking water supply should be included in this list.

For subsequent iterations, as additional information can be collected, the susceptibility analyses will become more refined and comprehensive. At a minimum however, the State will focus on assembling all available information about the most serious PSOCs that are identified from the existing state and federal databases and making a realistic determination of the vulnerability to the water supply.

5.9 USE OF THE SUSCEPTIBILITY ANALYSES

It is anticipated that the results of the contaminant inventory and the susceptibility analysis will be used in the protection phase of SWAP to identify appropriate management approaches to protect the water supply. Identification of the potential sources of contamination and the potential impacts that they present to the water supply will give the PWS a good indication of the most serious potential problems. The PWS will be encouraged to use this information to discuss and institute appropriate means of ensuring the long-term safety of its water source. This information will also provide an opportunity for the PWS to determine the costs associated with needed improvements, and permit the PWS to decide how to meet them. The State will encourage all PWSs to develop a SWAP protection plan with the information provided by the SWAP assessment.