



Evaluating Karst Geology Using the Hazard Ranking System

Office of Emergency and Remedial Response
State, Tribal, and Site Identification Center (5204G)

Quick Reference Fact Sheet

Under karst conditions, contamination from a hazardous waste source can be expected to travel in ground water rapidly and erratically and with less dilution than in most other aquifer conditions. Because of this, sites overlying karst may pose a greater threat to human health and the environment. The Hazard Ranking System¹ (HRS) contains special considerations to account for the increased threat posed at sites where karst underlies any part of a source. This fact sheet will discuss the definition and identification of karst, the ways in which karst conditions at the location of a source affect the HRS scoring process, and commonly-asked questions and answers.

INTRODUCTION

What is karst? Consistent with the definition of karst in the HRS, *The Hazard Ranking System Guidance Manual*² defines karst as:

A kind of terrain with characteristics of relief and drainage arising from a high degree of rock solubility. The majority of karst conditions occur in limestone areas, but karst may also occur in areas of dolomite, gypsum, or salt deposits. Features associated with karst terrain may include irregular topography, abrupt ridges, sinkholes, caverns, abundant springs, disappearing streams, and the lack of a well-developed surface drainage system of tributaries and streams. Karst aquifers generally are associated with karst terrain on the surface. Karst aquifers at depth may not be associated with karst terrain.

Karst aquifers and karst terrain are formed by dissolution of certain types of rocks by ground water and rain. Where extensive dissolution has occurred (mature karst), ground water flow is dominated by conduits that act as tributaries to cave streams. Subterranean openings in karst range in

size from minute voids to large caverns. Ground water flow velocities are potentially very high, and contaminants

in karst can travel long distances with little dilution in comparison to contaminants in granular porous media aquifers.

In the United States, karst is most commonly found in the midwest, eastern, southern, and mountain states, but small pockets of karst can be found in almost every state in the Nation.³ The presence of a karst aquifer underneath a site must be based on site-specific information.

In the scoring of karst aquifers in the ground water pathway and the ground water to surface water component of the surface water pathway, the HRS accounts for differences in the fate and transport of hazardous substances by assigning higher factor values if karst aquifers are present under the site. Karst is evaluated differently for several HRS factors in these pathways.

IDENTIFYING KARST FOR SCORING PURPOSES

To score the ground water pathway or ground water to surface water component of the surface water pathway, the presence of karst conditions underlying any portion of the sources should generally be documented using site-specific information. *The Hazard Ranking System Guidance Manual* suggests that the site evaluator:

1. Use geologic maps and other readily available information to determine if karst features are expected within 4 miles of the site. If a karst formation is identified

within the target distance limit (TDL), continue with the following steps.

2. *Compile the available site-specific evidence that indicates the presence of karst.* Such information can be obtained from topographic maps, aerial photographs, maps of caves, and visual observations.

3. *Estimate the lateral extent of karst.* Based on the distribution of the karst features within the formation, use professional judgement to delineate laterally the areas containing karst features. Documentation of karst underlying a source may include, but is not limited to:

- A drilling or boring log from on-site wells that indicates voids beneath the source, illustrated by a lithologic log, loss of drill mud, or intermittent plunges of the drill bit into solution cavities.
- Surficial features of karst terrain, such as a sink hole, are evident on the site.
- Features of karst terrain are extensive surrounding the site, within the target distance limit, and indicate the karst formation extends beneath the site.

4. *Estimate the thickness of karst.* As an initial determination, the depth and thickness of the formation(s) containing the karst features should be evaluated. Indications of depth and thickness may be available from well log data, scientific literature, or other information compiled during the evaluation of aquifer boundaries.

5. *Define the aquifer boundaries for karst aquifers.* To identify karst aquifer boundaries, start with geologic maps and information compiled during the identification and definition of aquifers. Based on this information, compile a list of geologic materials and/or formations that are known to contain karst features.

6. *Identify wells that draw drinking water from a karst aquifer that underlies sources at the site.* These drinking water wells qualify for special consideration when scoring potential contamination.

The steps provided in *The Hazard Ranking System Guidance Manual* allow the use of professional judgement in identifying and evaluating karst aquifers. The rationale for evaluating a karst aquifer should be supported by site-specific and regional geologic references.

SPECIFIC CONSIDERATIONS OF KARST IN THE HRS

The factors that are potentially impacted when karst is present are listed in Exhibit 1. The following discussion summarizes how the affected factor values are adjusted when karst is present.

EXHIBIT 1 HRS GROUND WATER PATHWAY FACTORS EVALUATED DIFFERENTLY FOR KARST	
Ground Water Pathway	Evaluate d Differentl y
Likelihood of Release	
Observed Release	No
Potential to Release	YES
Containment	No
Net Precipitation	No
Depth to Aquifer	YES
Travel Time	YES
Waste Characteristics	
Toxicity	No
Mobility	YES
Hazardous Waste Quantity	No
Targets	
Nearest Well	YES
Population	YES
Resources	No
Wellhead Protection Area	No

Likelihood of Release

The adjustments in the likelihood of release to the potential to release factor value show that contaminants move rapidly through a karst aquifer.

Depth to Aquifer

In evaluating the depth to aquifer factor value for a site located in karst terrain, assign a thickness of 0 feet to a karst aquifer that underlies any portion of the sources at the site.

Travel Time

The HRS gives special consideration in the travel time factor value by stating that “[if], for the interval being evaluated, all layers that underlie a portion of the sources at the site are karst assign a value of 35.”¹ If the entire interval

is not karst, continue the evaluation for the "Other Than Karst" layers. Assign a thickness of 0 feet to a karst layer that underlies any portion of the sources at the site.

Waste Characteristics

The adjustment to the waste characteristics mobility factor value shows that contaminants may move more rapidly in solution channels, or other karst features, than through a non-karst aquifer.

Mobility

The Superfund Chemical Data Matrix⁴ (SCDM) gives mobility values for chemicals in karst and non-karst settings. Use the value given in the "karst" column if the entire interval from a source at the site to the aquifer being evaluated is karst. If karst is present in the interval, but the entire interval is not karst, use "non-karst" values given in SCDM.

When using HRS Table 3-8 to assign a mobility factor, use the distribution coefficient category "karst" if the entire interval from a source at the site to the aquifer being evaluated is karst. If karst is present in the interval, but the entire interval is not karst, use "non-karst" values given in the table.

Targets

Adjustments in the evaluation of targets show that the individuals drinking water from a karst aquifer can be exposed to higher concentrations of contaminants than they would be if they were drinking from other aquifer types.

Nearest Well

If none of the target drinking water wells is subject to level I or level II concentrations for the aquifer and if one of the target aquifer is a karst aquifer that underlies any portion of the sources at the site and if any well draws drinking water from this karst aquifer within the TDL, assign a value of 20 for the nearest well factor for the aquifer.

Population

For potentially contaminated drinking water populations, use the "Karst" portion of HRS Table 3-12 to assign values only for that portion of the target population served by points of withdrawal of drinking water from a karst aquifer that underlies any portion of the sources at the site. Continue the evaluation with use of "Other Than Karst" values from HRS Table 3-12, applied to the remainder of the target drinking water population.

QUESTIONS AND ANSWERS

Q: Are surficial features of karst, such as sinkholes, springs, and disappearing streams, necessary to establish the presence of an underlying karst aquifer?

A: *No. A karst aquifer may exist at such a depth that surface features do not exist. Consideration of an aquifer as karst does not require surface features.*

Q: Are surficial features of karst sufficient to document the existence of a karst aquifer if found at or very near a source?

A: *Usually. Although these features may be absent in the case of karst existing at depth, the presence of sinkholes and other surficial features is indicative of karst. However, in the western United States, lava tubes, fissures, open sinkholes, and caves have been formed by extrusion of the still-liquid portion of cooling lava. These surface features may bear a resemblance to karst. "Sinkholes" in lava generally lack the symmetry of those developed in solution terrain.*

Q: Can a non-karst area riddled with mining shafts or lava tubes be evaluated as karst?

A: *No. These features may, however, be adequate to document aquifer interconnection, which may lead to a higher site score.*

Q: Does the presence of a limestone aquifer necessarily mean that the aquifer is karst?

A: *No. The area must either show surficial karst expression or the aquifer must have karst features.*

Q: Can the existence of a karst formation lying between two non-karst formations be used to document interconnection between the aquifers above and below the karst layer?

A: *Not necessarily. It still should be shown that the hydraulic conductivities are less than two orders of magnitude between each formation. For example, karst features can actually channel water horizontally and stop vertical migration.*

Q: When some of the individuals within the TDL are obtaining water from a surficial karst portion of an aquifer, but others are obtaining water from a non-karst portion, how are the targets evaluated?

A: *The two sets of targets are evaluated separately and then added together. Use the karst portion of HRS Table 3-12 to assign values for the population that obtains water from an eligible karst aquifer. The remaining non-karst water-drawing population is assigned a value from the "other than karst" portion of HRS Table 3-12. These values are then assigned to the potential contamination formula in HRS section 3.3.2.2.*

Q: *A karst aquifer found 2.1 miles away from a source is proven to be interconnected with an aquifer underlying the source. Can the aquifer beneath the site be evaluated as karst? What if the interconnected karst aquifer is found 1.5 miles from a source?*

A: *At greater than 2 miles, interconnection is not used in scoring a site, so distant karst formations are not relevant to site evaluation. At less than 2 miles, an interconnected karst aquifer that is used for drinking water is evaluated as karst only if that karst aquifer underlies a source on the site.*

REFERENCES

1. 40 C.F.R., Appendix A (1997). *Hazard Ranking System; Final Rule*. 55 FR 51582.
2. U.S. Environmental Protection Agency, November, 1992. *The Hazard Ranking System Guidance Manual*. Interim Final. Office of Solid Waste and Emergency Response. Directive 9345.1-07, pp. 137 to 146.
3. U.S. Department of the Interior, U.S. Geological Survey, 1986. *National Atlas of the United States of America*, "Engineering Aspects of Karst," Map with Narrative.
4. U.S. Environmental Protection Agency, June, 1994. *The Superfund Chemical Data Matrix (SCDM)*. Office of Solid Waste and Emergency Response. Directive 9360.4-18.