

Capture Zone Analysis For Pump and Treat Systems

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Objectives of This Presentation

- Provide a preview of forthcoming EPA document on capture zone evaluations for pump and treat systems
- Provide a brief overview of issues associated with capture zone evaluations
 - Specifically capture zone analysis for porous media or aquifers that behave as a porous media

Acknowledgements

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Presentation Outline

- Status of forthcoming EPA document - *A Systematic Approach for the Evaluation of Capture Zones at Pump & Treat Systems*
 - Companion to *Methods for Monitoring Pump-and-Treat Performance*
- Definition of “capture zone” and importance of evaluating capture zones
- How is capture zone analysis integrated with other components of effective P&T management?
- Steps associated with a systematic approach for performing capture zone analysis
 - “iterative process”
 - “converging lines of evidence”

Status of Forthcoming EPA Document

- Working Title - *A Systematic Approach for the Evaluation of Capture Zones at Pump & Treat Systems*
- Intended for:
 - technical professionals who perform capture zone analyses
 - project managers who review those analyses and/or make decisions based on those analyses
- Presents basic (and sometimes complex) concepts using text and schematics, and then illustrates those concepts with three examples
- EPA hopes to have finalized for distribution by end of FY04
 - Currently working on 2nd major revision
- Companion technical training is planned for early FY05 (Regions 3 and 9)

What is a "Capture Zone"?

- "Capture Zone" refers to the three-dimensional region that contributes the groundwater extracted by one or more wells or drains
- For pump-and-treat (P&T) systems, there are two components that should be the focus of a project manager
 - actual capture zone
 - target capture zone
- "Capture zone analysis" is the process of interpreting the actual capture zone, and comparing it to the target capture zone to determine if sufficient capture is achieved

Actual Capture Zone

Target Capture Zone

Actual and Target Capture Zones

Capture Zone Analysis Is Important

- Containment (or “capture”) is one of the objectives at almost every site with a P&T system
- Interpreting actual capture and comparing it to a “target capture zone” allows success or failure to be evaluated
- Recommendation to perform an improved capture zone analysis was made at 17 of the first 20 Fund-lead sites where a Remediation System Evaluation (RSE) was performed

Common Capture Zone Issues Observed During RSEs

- No target capture zone defined, or no comparison of target capture zone to interpreted capture zone (capture not really evaluated in any way at about half of the sites)
- Ignored issues associated with water levels at pumping wells when interpreting potentiometric surfaces
- Neglected potential for vertical transport
- Numerical model used for design but never verified or updated based on actual pumping responses
- Confused drawdown response with capture
- Not monitoring water levels at all measuring points, or not converting depth to water to water level elevation

Drawdown vs. Capture

Actual System May Differ From Designed System

- It is not enough to assume capture is sufficient because the design indicated it would be...the actual capture zone must be evaluated because it may be different than assumed or estimated during the design of the remedy
 - Design may not have accounted for system down time (i.e., when wells are not pumping)
 - Design may not have accounted for time-varying influences such as seasons, tides, irrigation, or transient off-site pumping
 - Design may not have accounted for declining well yields due to fouling or lower-than-expected well yield, or may not have provided for proper well maintenance
 - Design may not have adequately addressed geologic heterogeneities

therefore the actual capture zone must be interpreted!!!

Potential Negative Impacts From Poor Capture Zone Analysis

- May compromise protectiveness with respect to receptors

Failed Capture

- May allow plume to grow
 - May require expansion of extraction and/or monitoring network
 - May increase cleanup time
- Potentially wastes time and money

Capture Zone Analysis As a Component of P&T Management

- Are remedy objectives clearly established?
 - Is containment one of the objectives, and if so, why?
 - Is there a “target capture zone” that can be illustrated?
 - If containment and cleanup are both objectives, is the relative priority of containment clearly stated?

- Is capture being routinely evaluated and reported?
 - What “lines of evidence” are being evaluated?
 - Is the frequency of capture zone analysis appropriate for the site?

- Is it uncertain whether or not capture is sufficient?
 - Iterative process (evaluate capture, identify key data gaps, fill the data gaps, re-evaluate capture)

- Is there a viable “exit strategy”?
 - How will it be determined that containment is no longer required?
 - Might the Target Capture Zone change over time (e.g., shrinking plume) and how will that be addressed?

“Elements of Effective Management For Pump and Treat Systems” provides an overview of these types of management issues for pump-and-treat systems (EPA 542-R-02-009, December 2002)

A Systematic Approach for Capture Zone Analysis

- Step 1: Review site data, site conceptual model, and remedy objectives
- Step 2: Define site-specific target capture zone(s)
- Step 3: Interpret water levels
 - Potentiometric surface maps
 - Water level pairs (gradient control points)
- Step 4: Perform calculations (as appropriate based on site complexity)
 - Flow budget calculation
 - capture zone width calculation (can include drawdown calculation)
 - Modeling (analytical and/or numerical) to simulate heads, in conjunction with particle tracking and/or transport modeling
- Step 5: Evaluate concentration trends (and potentially tracer tests)
- Step 6: Interpret actual capture based on steps 1 to 5, compare to target capture zone(s), assess uncertainties and data gaps

converging lines of evidence increases confidence in the conclusions

Key Concepts for Technical Analysis

- Target capture zone should be clearly stated and relate to the remedy objectives
- Interpreting capture is extremely difficult, and usually no one line of evidence is sufficient
 - Capture effectiveness is primarily evaluated based on field-obtained data
 - Using “converging lines of evidence” adds confidence in the conclusions of the capture zone evaluation
- Use of simple calculations (such as analytical calculation of capture zone width) are often not appropriate without other lines of evidence, because some of the assumptions are typically violated

Key Concepts For Technical Analysis

- Interpretations of capture from potentiometric surfaces are highly dependent on the availability of representative water levels at or near pumping wells
 - Best data are provided when piezometers are located in immediate vicinity of extraction wells
 - Using water levels measured in pumping wells that are subject to well losses may lead to an over-estimate of capture!
 - Not using any water levels near pumping wells may lead to an under-estimate of capture!

Key Concepts For Technical Analysis

- Concentration trends at monitoring wells can provide evidence of capture (or lack thereof), but must be located properly to provide useful evidence of capture
 - Downgradient performance monitoring wells are located downgradient of the capture zone and are currently impacted
 - Sentinel wells are located downgradient of the capture zone and are not currently impacted
 - Locations of monitoring wells for evaluating capture based on concentration trends must be carefully scrutinized, and adding additional monitoring points may be appropriate
- Even if monitoring points are located properly (beyond the actual capture zone), usually takes a long time (typically years) to indicate successful capture

Monitoring Well Concentration Schematic

Key Concepts For a Project Manager

- Remedy objective with respect to plume containment should be clear goals
- A "Target Capture Zone" that considers potential for both horizontal and vertical transport should be established

"Converging lines of evidence" for capture zone analysis (i.e., use of multiple techniques to evaluate capture) should be employed, and should primarily rely on field-collected data that indicate capture and/or validate model predictions that indicate capture
- Need for additional field data to reduce uncertainties in the capture zone analysis should be routinely evaluated, and any such data gaps should be addressed
- Frequency of capture zone evaluation is site-specific, factors include time to reach quasi-steady-state, temporal nature of stresses (on-site, off-site), travel-time to potential receptors, etc.
- Many aspects of capture zone analysis require hydrogeologic expertise...project managers should use the assistance of support personnel and/or contractors if they lack that expertise

Pertinent EPA Guidance References

Available at http://www.epa.gov/superfund/resources/gwdocs/pum_tre.htm:

- "Elements for Effective Management of Operating Pump and Treat Systems," November 2002. OSWER 9355.4-27FS-A.
- "Methods for Monitoring Pump-and-Treat Performance," June 1994. ORD Publication EPA/600/R-94/123, NTIS Order Number PB95-125456.
- "Design Guidelines for Conventional Pump-and-Treat Systems, September 1997. ORD and OSWER joint Publication EPA/540/S-97/504, EPA-68-C4-0031, NTIS Order Number PB98-115389INZ, 44p.
- "Pump-and-Treat Ground-Water Remediation: A Guide for Decision Makers and Practitioners", July 1996. ORD Publication EPA/625/R-95/005, NTIS Order Number PB97-154009, 74p. Available on-line from ORD

Other forthcoming documents:

- "O&M Report Template for Ground Water Remedies (With Emphasis on Pump-and-Treat Systems)," Draft 2004. OSWER 9283.1-22FS. EPA 542-R-04-006.
- "Effective Contracting Approaches for Operating Pump and Treat Systems," Draft 2004. OSWER 9283.1-21FS. EPA 542-R-04-005.
- "Cost-Effective Design of Pump and Treat Systems," Draft 2004. OSWER 9283.1-20FS. EPA 542-R-04-007.