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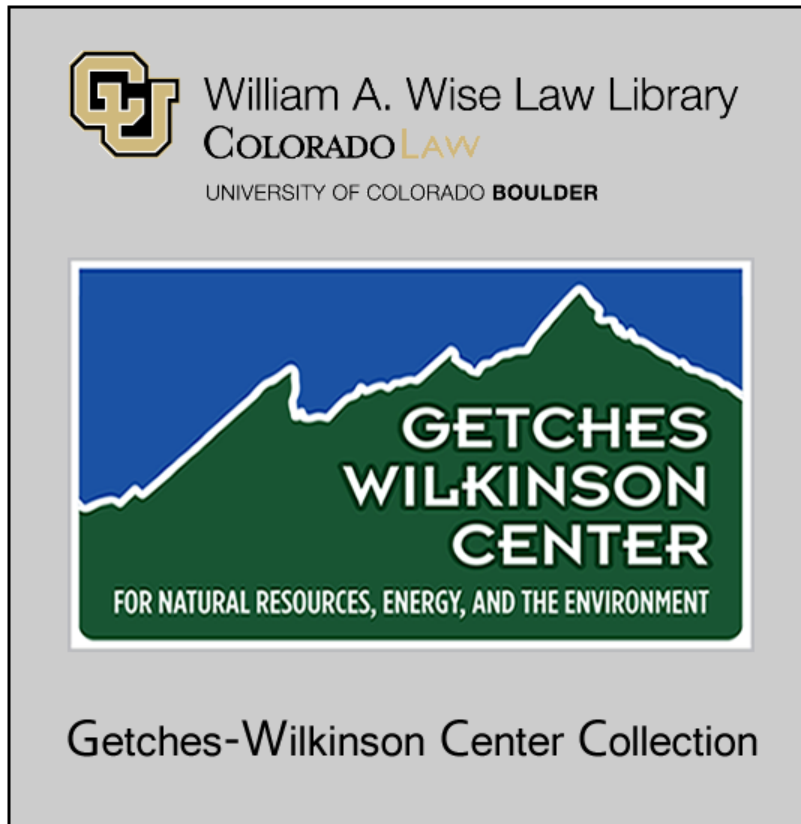


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**GROUNDWATER CLEANUP:
IS IT WORTH IT?**

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**Uncovering the Hidden Resource:
Groundwater Law, Hydrology and Policy in the 1990s**

**University of Colorado at Boulder
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GROUNDWATER CLEANUP: IS IT WORTH IT?

I. INTRODUCTION

A. Summary

During the past decade, many decisions have been made to restore aquifers to drinking water standards using the pump-and-treat approach. However, until recently, little data have been available with which to evaluate the effectiveness of this remedial approach. Recent theoretical studies and field experience have indicated that aquifer restoration using the pump and treat approach is not as feasible as was originally predicted. Evidence suggests that groundwater pumping is ineffective for permanently reducing levels of aquifer contamination to meet health-based goals for groundwater. The primary contributors to the ineffectiveness of pumping are factors associated with the physical and chemical processes that affect the behavior of contaminants in the subsurface environment. This discussion focuses on the limitations and costs associated with aquifer restoration, and outlines considerations for selecting approaches for managing contaminated aquifers.

B. General References

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II. INDICATORS OF PUMP AND TREAT EFFECTIVENESS

- A. The primary indicators of effectiveness of a pump and treat system in restoring an aquifer to a specified cleanup level are permanent reduction of aquifer concentrations over time and reduction of the contaminant mass in the aquifer.
- B. The ideal scenario would be a steady decrease in contaminant concentrations until the target level is attained.

III. PUMP AND TREAT PERFORMANCE RECORDS

- A. Although concentrations may drop initially, this decline is followed by a leveling of concentrations with little or no further decrease in concentrations.
- B. At sites where the plume appears to be well-contained, concentrations have leveled after average VOC concentration reductions of approximately 60% to 90% in onsite wells, with large masses of contamination (at least 50%) remaining in the aquifer.
- C. At all sites where contaminant concentrations have leveled, the concentrations remain well above the target levels, even at sites where cleanup goals were established above drinking water standards.
- D. When pumps are turned off, the concentrations rise again, often to levels greater than the initial concentrations.

IV. PRIMARY FACTORS INFLUENCING EFFECTIVENESS

- A. If not fully remediated, contaminated soils serve as the primary source of contamination.
- B. Even if soils are remediated, immobilized contaminants in the vadose zone and subsurface continue to serve as secondary sources of contamination.
 - 1. Contaminants sorbed into the aquifer material matrix. The mass of contaminant sorbed to the aquifer material is generally significantly greater than the mass in solution.
 - 2. Immobile contaminants in the non-aqueous phase. The mass of contamination in the non-aqueous phase may be considerably greater than in the dissolved phase.
 - 3. Contaminants trapped in zones of low permeability or fractured bedrock. Even highly soluble contaminants may be trapped in the finer pore structure.

V. FEASIBILITY OF AQUIFER RESTORATION

- A. Pumping is generally effective for plume containment.**
- B. Evidence to date suggests that eliminating secondary sources of contamination within a reasonable time frame is technically infeasible, and this factor will continue to be the primary contributor to the ineffectiveness of pump and treat systems, even after soil remediation is complete.**
 - 1. Little success has been achieved in locating dense NAPLs (DNAPLs).**
 - 2. Mobilizing DNAPLs is currently not feasible.**
 - 3. Contaminant desorption rates are extremely slow, and contaminants appear to irreversibly sorbed in some cases.**

VI. COSTS AND REMEDIAL TIME FRAMES

- A. Inadequate consideration of the presence of continuous secondary sources of contamination has resulted in underestimation of remedial time frames.**
 - 1. Recent modeling studies estimate pump and treat time frames of 100 to 1,000 years for VOC-contaminated sites.**
 - 2. Remedial time frames for aquifer restoration are underestimated by at least a factor of three.**
 - 3. Estimates of contaminant retardation are essential for determining remedial time frames.**
 - 4. Site-specific retardation factors cannot be obtained because the mechanisms that control contaminant desorption are not fully understood.**
- B. Underestimation of remedial time frames has resulted in the gross underestimation of costs of remediation.**
- C. The ineffectiveness of pumping to achieve aquifer restoration results from fundamental chemical and physical processes. Therefore, spending more money on site characterization, completing source remedial actions, and modifying pump and treat system designs will not ensure successful remediation.**

