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2. Originator Information

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3. Title
Considerations in Ground Water Remediation at Superfund Sites

4. Summary of Directive (include brief statement of purpose)
The purpose of this memorandum is to transmit our findings from a recently completed study of several sites where ground water extration is being conducted to contain or reduce levels of contaminants in the ground water. In addition, this memorandum presents several recommendations for modifying the Superfund approach to ground water remediation.

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This Request Meets OSWER Directives System Format Standards.

9. Signature of Lead Office Directives Coordinator	Date
Betti VanEpps	11-22-89
10. Name and Title of Approving Official	**Date**
John Z. Cannon	11-18-89

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D C 20460

OCT 18 1989 Directive No. 9355.4-03

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

MEMORANDUM

SUBJECT: Considerations in Ground Water Remediation at Superfund Sites

FROM: Jonathan Z. Cannon
Acting Assistant Administrator

TO: Waste Management Division Directors
Regions I, IV, V, VI, VII, VIII
Emergency and Remedial Response Division Director
Region II
Hazardous Waste Management Division Directors
Region III, IX
Hazardous Waste Division Director
Region X

Purpose

The purpose of this memorandum is to transmit our findings from a recently completed study of several sites where ground water extraction is being conducted to contain or reduce levels of contaminants in the ground water. In addition, this memorandum presents several recommendations for modifying the Superfund approach to ground water remediation.

Background

The most common method for restoring contaminated ground water is extraction and treatment of contaminated ground water. Recent research has suggested that in many cases, it may be more difficult than is often estimated to achieve cleanup concentration goals in ground water. In response to these findings, the Office of Emergency and Remedial Response (OERR) initiated a project to assess the effectiveness of ground water extraction systems in achieving specified goals. Nineteen case studies were developed from among Superfund and State-lead sites, RCRA and Federal facilities. These sites were selected primarily on the basis that the ground water extraction systems had been operating for a period of time sufficiently long to allow for an evaluation of the system.

Objective

The objective of this memorandum is to describe the findings of this study and to recommend the consideration of certain factors and approaches in developing and implementing ground water response actions at Superfund sites.

Findings of Study

Several trends were identified from the case studies:

- The extraction systems are generally effective in containing contaminant plumes, thus preventing further migration of contaminants.
- Significant mass removal of contaminants (up to 130,000 pounds over three years) is being achieved.
- Concentrations of contaminants have generally decreased significantly after initiation of extraction but have tended to level off after a period of time. At the sites examined, this leveling off usually began to occur at concentrations above the cleanup goal concentrations expected to have been attained at that particular point in time.
- Data collection was usually not sufficient to fully assess contaminant movement and system response to extraction.

Several factors appear to be limiting the effectiveness of the extraction systems examined, including:

- Hydrogeological factors, such as the heterogeneity of the subsurface, the presence of low permeability layers, and the presence of fractures;
- Contaminant-related factors, such as sorption to the soil, and presence of non-aqueous phase liquids (dissolution from a separate non-aqueous phase or partitioning of contaminants from the residual non-aqueous phase);
- Continued leaching from source areas;
- System design parameters, such as pumping rate, screened interval, and location of extraction wells.

The report summarizing the study and findings, entitled Evaluation of Ground Water Extraction Remedies is attached. Additional copies of the report are available through the Public Information Center ((202) 382-2080) or the Center for

Environmental Research Information (FTS 684-7391 or (513) 569-7391).

Recommendations

The findings of the study substantiate previous research and confirm that ground water remediation is a very new, complex field. Based on this study, I am recommending consideration of certain factors and approaches in developing and implementing ground water response actions. The major recommendation is to orient our thinking so that we initiate early action on a small scale, while gathering more detailed data prior to committing to full-scale restoration. These recommendations are consistent with the Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites and do not alter Superfund's primary goal of returning ground water to its beneficial uses in a time frame that is reasonable given the particular site circumstances. The recommendations do, however, encourage the collection of data to allow for the design of an efficient cleanup approach that more accurately estimates the time frames required for remediation and the practicability of achieving cleanup goals.

While standard procedures for the more refined data collection techniques suggested below are being developed, it will be beneficial at most sites to implement the ground water remedy in stages. This might consist of operating an extraction system on a small scale that can be supplemented incrementally as information on aquifer response is obtained.

These recommendations are described further below. The attached flow chart illustrates how the recommendations fit into the Superfund ground water response process.

Recommendation 1: Initiate Response Action Early.

The bias for action should be considered early in the site management process. Response measures may be implemented to prevent further migration of contaminants if they will prevent the situation from getting worse, initiate risk reduction, and/or the operation of such a system would provide information useful to the design of the final remedy. Because the data needed to design a ground water containment system are often more limited than that needed to implement full remediation, it will in a number of cases be possible and valuable to prevent the contaminant plume from spreading while the investigation to select the remediation system progresses. The determination of whether to implement a containment system should be based on existing information, data defining the approximate plume boundaries, hydrologic data, contaminants present, and approximate concentrations, and best professional judgment. Examples of situations where this type of action will probably be warranted include sites where ground water plumes are migrating

rapidly (e.g., highly permeable aquifers, mobile contaminants, potential migration thorough fractures) and sites near drinking water wells that are potentially affected by the plume.

A Record of Decision (ROD) for an interim remedy may be prepared with a limited evaluation of alternatives that compares the advantages of taking an early action to the possible ramifications of waiting until the investigation has been completed. The evaluation of this action should be included as part of the scoping phase for the site and if determined to be appropriate, implemented while the overall RI/FS is underway. The RI/FS for the final action at the site should continue and incorporate information gained from this early action. If a containment action is implemented, the ground water flow should be monitored frequently, immediately before, during, and immediately after initiation of the action to obtain information on system response.

It is also advisable to implement ground water remediation systems in a staged process at sites where data collected during the remedial investigation did not clearly define the parameters necessary to optimize system design. This might consist of installing an extraction system in a highly contaminated area and observing the response of the aquifer and contaminant plume during implementation of the remedy. Based on the data gathered during this initial operation, the system could be modified and expanded as part of the remedial action phase to address the entire plume in the most efficient manner.

Recommendation 2: Provide Flexibility in the Selected Remedy to Modify the System Based on Information Gained During Its Operation.

In many cases it may not be possible to determine the ultimate concentration reductions achievable in the ground water until the ground water extraction system has been implemented and monitored for some period of time. Records of Decision should indicate the uncertainty associated with achieving cleanup goals in the ground water.

In general, RODs should indicate that the goal of the action is to return the ground water to its beneficial uses; i.e., health-based levels should be achieved for ground water that is potentially drinkable. In some cases, the uncertainty in the ability of the remedy to achieve this goal will be low enough that the final remedy can be specified without a contingency. However, in many cases, it may not be practicable to attain that goal, and thus it may be appropriate to provide in the ROD for a contingent remedy, or for the possibility that this may only be an interim ROD. Specifically, the ROD should discuss the possibility that information gained during the implementation of

the remedy may reveal that it is technically impracticable to achieve health-based concentrations throughout the area of attainment, and that another remedy or a contingent remedy may be needed.

Where sufficient information is available to specify an alternative or contingent remedy at the time of remedy selection, the ROD should discuss the contingency in equal detail to the primary remedial option, and should provide substantive criteria by which the Agency will decide whether or not to implement the contingency. See Interim Final Guidance on Preparing Superfund Decision Documents, OSWER Directive 9355.3-02 (May 1989), at page 9-17.[1] The ROD may also discuss the possibility that an ARARs waiver will be invoked when MCLs or other Federal or State standards cannot practicably be attained in the ground water; a written waiver finding should be issued at the time the contingency is invoked, or in limited circumstances, in the ROD itself.[2]

The public should be informed of the decision to invoke the contingency (and, perhaps, the waiver) through issuance of an Explanation of Significant Differences (ESD) which involves a public notice. A formal public comment period is not required when a decision is made to invoke a contingency specified in the ROD; however, the Region may decide to hold additional public comment periods pursuant to NCP section 300.825(b) (proposed) (Dec. 21, 1988, 53FR at 51516). In any event, the public may submit comments after ROD signature on any significant new information which "substantially support[s] the need to significantly alter the response action" NCP Section 300.825(c) (proposed).

There may also be situations where the Region finds that it is impracticable to achieve the levels set out in the ROD, but no contingency had been previously specified in the ROD. In such cases, a ROD amendment would be necessary to document fundamental changes that are made in the remedy based on the information gained during implementation; an ESD would be necessary to

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[1] For instance, the ROD may provide that a contingent remedy will be implemented if there is a levelling-off of contaminant concentrations despite continued ground water extraction over a stated period of time.

[2] It may be possible to invoke a waiver at the time of ROD signature (a "contingent waiver") where, for example, the ROD is detailed and establishes an objective level or situation at which the waiver would be triggered. However, the use of contingent waivers should only be considered on a case-by-case basis after discussion with OERR\OWPE.

document significant but non-fundamental changes in the remedy based on the additional information.

For sites where there is substantial uncertainty regarding the ability of the remedy to return the ground water to its beneficial uses (e.g., dense non-aqueous phase liquids in fractured bedrock) it is appropriate to indicate that the initial action is interim with an ultimate remedy to be determined at some specified future date. The action should be designed to achieve the basic goal and carefully monitored over time to determine the feasibility of achieving this goal. In many of these cases, this can only be determined after several years of operation. The five year review may be the most appropriate time to make this evaluation. When sufficient data have been collected to specify the ultimate goal achievable at the site (e.g., first or second five year review), a final ROD for ground water would be prepared specifying the ultimate goal, including anticipated time frame, of the remedial action.

Although overall system parameters must be specified in the ROD, it is usually appropriate to design and implement the ground water response action as a phased process. An iterative process of system operation, evaluation, and modification during the construction phase can result in the optimum system design. Extraction wells might be installed incrementally and observed for one to three months to determine their effectiveness. This will help to identify appropriate locations for additional wells and can assure proper sizing of the treatment systems as the range of contaminant concentrations in extracted ground water is confirmed.

If it is determined that some portion of the ground water within the area of attainment cannot be returned to its beneficial uses, an evaluation of an alternate goal for the ground water should be made. Experience to date on this phase of ground water remediation is extremely limited and more definitive guidance on when to terminate ground water extraction will be provided later. When the point at which contaminant concentrations in ground water level off, however, this should be viewed as a signal that some re-evaluation of the remedy is warranted. In many cases, operation of the extraction system on an intermittent basis will provide the most efficient mass removal. This allows contaminants to desorb from the soil in the saturated zone before ground water is extracted providing for maximum removal of contaminant mass per volume of ground water removed.

Ground water monitoring should continue for two to three years after active remediation measures have been completed to ensure that contaminant levels do not recover. For cases where contaminants remain above health-based levels, reviews to ensure

that protection is being maintained at the site will take place at least every five years.

Recommendation 3: Collect Data to Better Assess Contaminant Movement and Likely Response of Ground Water to Extraction.

In addition to the traditional plume characterization data normally collected, the following data is of particular importance to the design and evaluation of ground water remedies and should be considered in scoping ground water RI/FSs. Assessments of contaminant movement and extraction effectiveness can be greatly enhanced by collecting more detailed information on vertical variations in stratigraphy and correlating this to contaminant concentrations in the soil during the remedial investigation. More frequent coring during construction of monitoring wells and the use of field techniques to assess relative contaminant concentrations in the cores are methods that may be used to gain this information. More detailed analysis of contaminant sorption to soil in the saturated zone can also provide the basis for estimating the time frame for reducing contaminant concentrations to established levels and identifying the presence of non-aqueous phase liquids. Cores taken from depths where relatively high concentrations of contaminants were identified might be analyzed to assess contaminant partitioning between the solid and aqueous phases. This might involve measuring the organic carbon content and/or the concentration of the contaminants themselves.

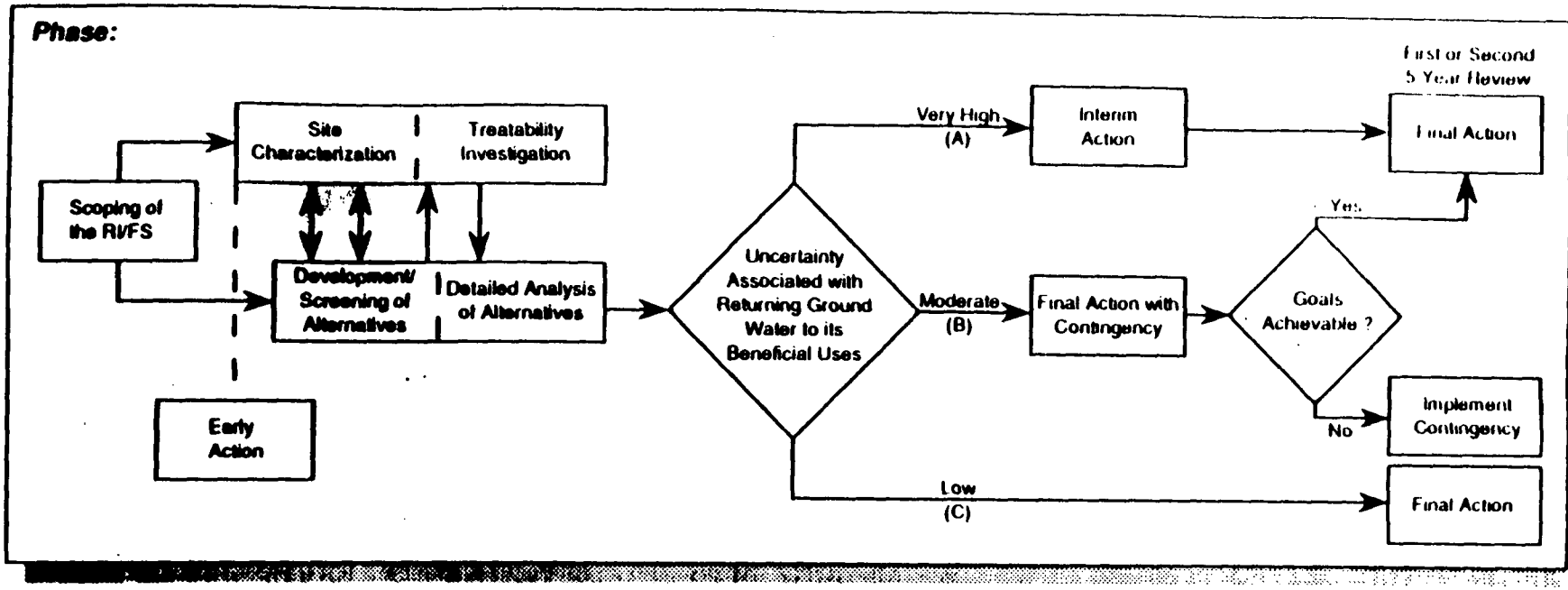
The long-term goal is to collect this information during the RI so that more definitive decisions can be made at the ROD stage. Standardized sampling and analytical methods to support these analyses are currently being evaluated.

For further information, please consult the appropriate Regional Ground Water Forum member, Jennifer Haley at FTS 475-6705 or Caroline Roe at FTS 475-9754 in OERR's Hazardous Site Control Division, or Dick Scalf at the Robert S. Kerr Environmental Research Laboratory (FTS 743-2308)

Attachment: Flow Chart
Summary Report

cc: Superfund Branch Chiefs, Regions I - X
Superfund Section Chiefs, Regions I - X wo/summary report

GROUND WATER REMEDIATION PROCESS



Actions:

- Identify data collection needs
- Identify possible containment action
- Install gradient control wells in phased process
- Monitor aquifer response
- Design and implement ground water extraction system in phased process
- Monitor aquifer response
- Evaluate data from system operation
- Determine practicable goals
- Identify any areas where long term institutional controls will be necessary

Administrative Considerations:

ROD (Early Action)

A). ROD (Interim Remedy)
B). ROD (Contingency)
C). ROD (Final)

A). ROD (Final)
B) ESD or ROD amendment

Enforcement Considerations:

Negotiate RI/FS Scope:

- Data collection
- Early action

Negotiate Consent Decree

A). Negotiate Consent Decree
B) Possible stipulation or amendment to Consent Decree