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Cincinnati, OH 45268

Center for Environmental
Research Information
Cincinnati, OH 45268

Technology Transfer

CERI-90-16 April 1990

EPA

Physical/Chemical Treatment of Hazardous Wastes

Speaker Slide Copies and Supporting Information

CERI-90-16
April 1990

PHYSICAL/CHEMICAL TREATMENT OF HAZARDOUS WASTE SITES

Speaker Slide Copies and Supporting Information

April 1990

Prepared by

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for

Center For Environmental Information
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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PROCESS-BASED TREATMENT DECISION MAKING

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PROCESS-BASED TREATMENT DECISION MAKING

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Physical and chemical technologies are generally not stand-alone treatment techniques. In most cases, Physical/Chemical technology must be used in combination with other techniques to form a treatment train. The main function of the physical treatment technologies and most chemical treatment technologies is to separate the hazardous constituents from the media in which they are found. This is beneficial as Physical/Chemical technologies can provide methods for meeting the goals of the "Hierachy of Waste Management."

The hierachy establishes the order of preferred waste management activities:

1st Waste minimization/reduction
2nd Recovery, reuse, recycle
3rd Treatment to reduce toxicity, mobility and volume
4th Storage.

For most Superfund Sites and many RCRA sites, the opportunity for waste minimization is limited to minimizing the residuals produced by recovery or treatment techniques. The opportunity for reuse and recovery of wastes has heretofore been somewhat limited, primarily because of the waste mixtures typically found at these sites. Thus the focus of remediation has been primarily placed on treatment.

This seminar is intended to show how physical and chemical technologies can be used to effect separation as part of a process-based treatment approach. It further intends to focus on techniques which can be used to permit the recovery and reuse of materials. As part of this process-based approach, all media and emissions and discharges must be considered. As noted previously, physical and chemical process are frequently used with other technologies such as other chemical processes, biological and thermal processes, as well as immobilization processes.

The process-based approach proceeds from the assumption that any inorganic contaminant can be removed from its host environment—the question is how to do it.

While there are no hard and fast rules on how to do it, there are certain general principles that have been learned from the past Superfund investigations and from analogous activities such as the exploration of mineral sites. These include:

A. Proper assessment of site conditions. As a general statement, Superfund site investigations provide far less data on the nature of the site necessary for the assessment of treatment of the wastes than do investigations of mineral properties for a similar purpose. Within this area of concern are a number of related issues, for example:

   1. The importance of representative samples. Superfund sites can be quite small and the variability of the contamination can be of major importance in the design of the system.
   2. Other quantitative and qualitative factors. Examples of these include such things as appropriate identification of organic contaminants and speciation of metals, availability of water/power, discharge limitations, noise constraints, etc.

B. Establishment of objectives. The nature of the process approach demands more attention to objective setting than does the technology-based approach—in fact objectives are essential. These include such things as:

1. cost—cost determination/refinement should start at day one. There needs to be at least some sort of comparative cost target identified;
2. time—because of the small size of most Superfund sites, capital costs dominate particularly when mobile treatments are not utilized and "ASAP" yields unreasonable costs,
3. performance objectives—cleanup standards plus things like discharge limitations,
4. prior- and subsequent-sytem requirements—is the inorganic contaminant part of an organic/inorganic contaminant problem, hardware issues, etc.

C. Experience-based assessment of alternatives. The process-based approach is not a "check the box" solution to the problem. This approach benefits from the ability of experts to make intelligent deductions and start the search in the most favorable areas.

D. Treatability studies. Studies specifically tailored to the problem and done specifically to improve the decision-making process. These are discussed in detail in the next section.

E. Assessment of trade-offs. Things like time versus cost or treatment versus other options.

F. Decision making. Decisions made using a rational and common set of parameters.

G. Pilot tests. These should be carefully structured to address the uncertainties in areas of technical concern. This is an activity that needs to be carefully thought out mindful of the pitfalls that can occur when proceeding from pilot-scale to full-scale. Specifically, these pitfalls include such issues of scale—some things scale and some things do not and batch vs. continuous modeling—major surprises can result in the transition from batch to continuous.

H. Site remediation. The final stage in the process of site cleanup.

In contrast, the "technology-based" approach proceeds from a different assumption—not how to do it but rather "can __ be used?" A Priori identification of "applicable" technologies to be assessed presents a number of substantive problems. For one thing it tends to mask the question of objectives—especially if the objectives are believed to be generally understood but are, in fact, not well defined. This leads to a second problem. "Go/No-Go" assessments will almost certainly produce "no-go" answers unless the technology being assessed was applied to essentially identical site conditions—an unlikely set of circumstances at best. Sooner than one would expect, one arrives at the time for decision making. In the technology-based approach, this is the point at which objectives tend to receive belated attention.

If pilot scale operations are conducted, they too generally suffer from late attention to objectives. It is almost certain that the remediation of the site will not be done employing the best technology.

A number of case examples will be cited. The first involves the design of a mineral processing flow sheet by way of analogy. The second involves the design of the United Scrap Lead Superfund site treatment process. The third involves the design of the treatment process for a creosote site in California.

PROCESS-BASED APPROACH

Key Questions

- Can hazardous material be separated to permit recovery, reuse, or recycling?
- Can volume of waste to be treated be reduced?
- Can residuals produced be recovered, reused, or recycled?
- Can volume of residuals to be disposed be minimized?

Physical & Chemical techniques are typically separation technologies and cannot stand alone. Thus they must be used as part of a process.

Hence, a process-based approach.

HIERARCHY OF HAZARDOUS WASTE MANAGEMENT

- Waste minimization/reduction
- 3-R's
  - recovery
  - reuse
  - recycle
- Treatment
  - reduce mobility, toxicity, and volume
- Storage

PROCESS-BASED APPROACH

- Assess conditions
- Establish objectives
- Experience-based assessment of alternatives
- Treatability studies
- Assessment of trade-offs
- Decision making
- Pilot tests
- Site remediation

ASSESS CONDITIONS

- Importance of representative samples
- Other quantitative and qualitative factors

ESTABLISH OBJECTIVES

- Cost
- Time
- Performance
- Prior- and subsequent-system requirements
- Availability of technology

DEFINE SITE CONDITIONS
Soil

- Site-specific meteorological conditions
- Liquid and gas soil pathways

DETERMINE SOIL PROPERTIES

- Soil chemistry
- Soil structure and physical attributes

DEFINE SITE CONDITIONS
Surface Water

- Climatic conditions
- Geographic conditions
- Surface water category
- Hydrogeologic setting

THREE BASIC QUESTIONS CONCERNING CONTAMINANT MOVEMENT, CONTAINMENT AND RECOVERY.

- What is the contaminant?
- Where is the contaminant?
- How extensive is the contamination?

SOME ITEMS TO CONSIDER DURING PHYSICAL AND CHEMICAL CHARACTERIZATION...

- Physical description
- Chemical class
- Metals speciation
- Solubility
- Flash point
- Vapor pressure
- Viscosity
- Density

CHARACTERIZATION

Soil

- Soil stratigraphy
- Soil hydrology
- Surface topography
- Engineered features

DEFINE SITE CONDITIONS

Groundwater

- Subsurface conditions
- Aquifer properties
- Geochemical environment
- Hydrogeologic setting

IDENTIFY POLLUTANT MIGRATION PATHWAYS

Groundwater

- Regional flow
- Site-specific hydrology
- Seasonal trends

DEFINE SITE CONDITIONS

Air

- Climate
- Site-specific meteorological conditions
- Site topography
- Physical features

SAMPLING AND DIAGNOSTIC TOOLS FOR SITE AND CONTAMINANT CHARACTERIZATION

- Preliminary site investigation
- Detailed site investigation

EXAMPLES OF SAMPLING TECHNIQUES

Preliminary Site Investigation

- Soil gas monitoring
- Geophysical surveys
- Surface water sampling
- Limited groundwater sampling

SURFACE GEOPHYSICAL TESTING METHODS

- Ground-penetrating radar (Drums, Mine Burgees-Shafts)
- Electromagnetic conductivity
- Galvanic electrical resistivity
- Seismic methods
- Gravity
- Magnetometer
- Metal detector (Drums, ed...)
- Downhole methods

ANALYTICAL TECHNIQUES

Preliminary Site Investigation

- Typically non-specific General
- Examples
  - TOC
  - TOH
  - specific conductance
  - OVA measurements

SITE-SPECIFIC SAMPLING

Detailed Site Investigation

- Monitoring well networks
- Aquifer tests
- Time series sampling
- Soil and waste characterization

EXPERIENCE BASED ASSESSMENT OF ALTERNATIVES

Detailed Site Investigation

- Not a "check the box" solution
- Start the search with the most favorable technologies
- Need for intelligent deductions

Don't Do your T.S. until
your Ready

TREATABILITY STUDIES

Detailed Site Investigation

- Specifically tailored to problem to improve the decision making process
- Discussed in detail in next session

ASSESSMENT OF TRADE-OFFS

- Time vs. Cost
- Treatment vs. Other options

PILOT TESTS

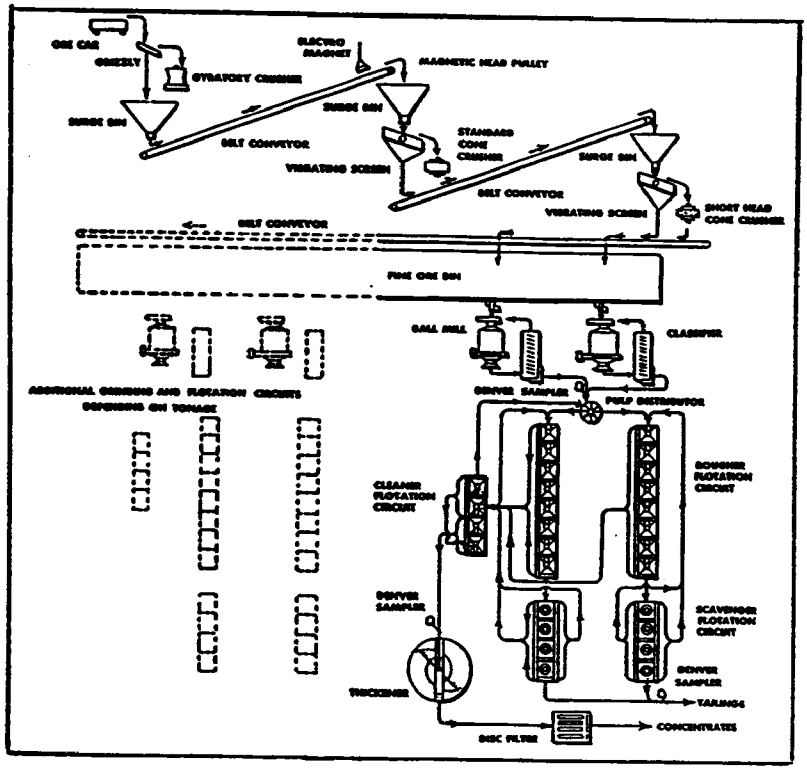
- Issues of scale
- Batch vs. continuous

SITE REMEDIATION

- Implementation of the selected remedy

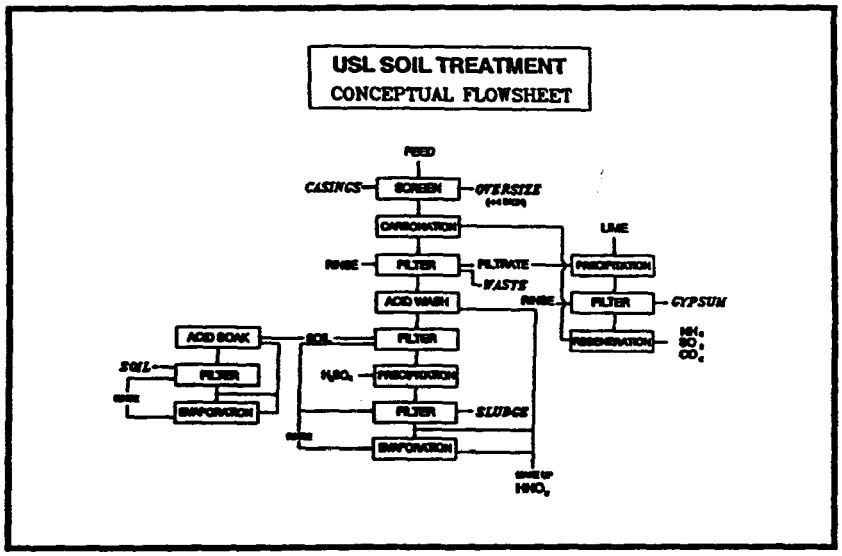
TECHNOLOGY-BASED APPROACH

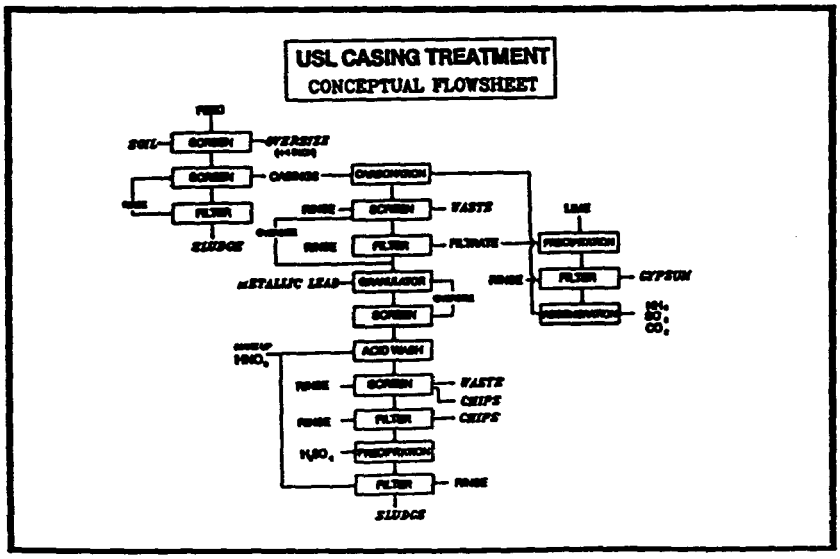
- A priori identification of "applicable" technologies
- Go/no-go assessment
- Decision making
- Pilot operations
- Remediation



COPPER RECOVERY BY FLOTATION

DESIGN OF UNITED SCRAP LEAD TREATMENT PROCESS





TREATABILITY STUDIES AND DATA QUALITY OBJECTIVES

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TREATABILITY STUDIES AND DATA QUALITY OBJECTIVES

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DEFINING TREATABILITY STUDIES

Treatability studies are laboratory or field tests designed to provide critical data needed to evaluate and, ultimately, to implement one or more treatment technologies. These studies generally involve characterizing untreated waste and evaluating the performance of the technology under different operating conditions. These results may be qualitative or quantitative, depending on the level of treatability tests. Factors that influence the type or level of testing needs include: phase of the project [e.g., remedial investigation/feasibility study (RI/FS) or remedial design/remedial action (RD/RA)], technology-specific factors, and site-specific factors.

- Treatability studies conducted during the RI/FS to support remedy selection are generally used to determine whether the technology can achieve the anticipated Record of Decision (ROD) goals and to provide information to support the nine evaluation criteria to the extent possible.

- Treatability studies to support remedy implementation during RD are generally used to verify that the technology can achieve the ROD goals, optimize design and operating conditions necessary to ensure performance, and improve cost estimates.

LEVEL OF TREATABILITY STUDIES

Treatability studies should be performed in a systematic fashion to ensure that the data generated can support the remedy evaluation and implementation process. A well-designed treatability study can significantly reduce the overall uncertainty associated with the decision, but cannot guarantee that the chosen alternative will be completely successful. Care must be exercised to ensure that the treatability study is representative of the treatment as it will be employed (e.g., sample is representative of waste to be treated) to minimize the uncertainty in the decision. The method presented below provides a resource-effective means for evaluating one or more technologies.

There are three levels of tiers of treatability studies: laboratory screening, bench-scale testing, and pilot-scale testing. Some or all of the levels may be needed on a case-by-case basis. The need for and the level of treatability testing required are management decisions in which the time and cost necessary to perform the testing are balanced against the risks inherent in the decision (e.g., selection of a treatment alternative). These decisions are based on the quantity and quality of data available and on other decision factors (e.g., State and Community acceptance of the remedy, new site data). The flow diagram for the tiered approach in Figure 1 traces the stepwise review of study data and the decision points and factors to be considered.

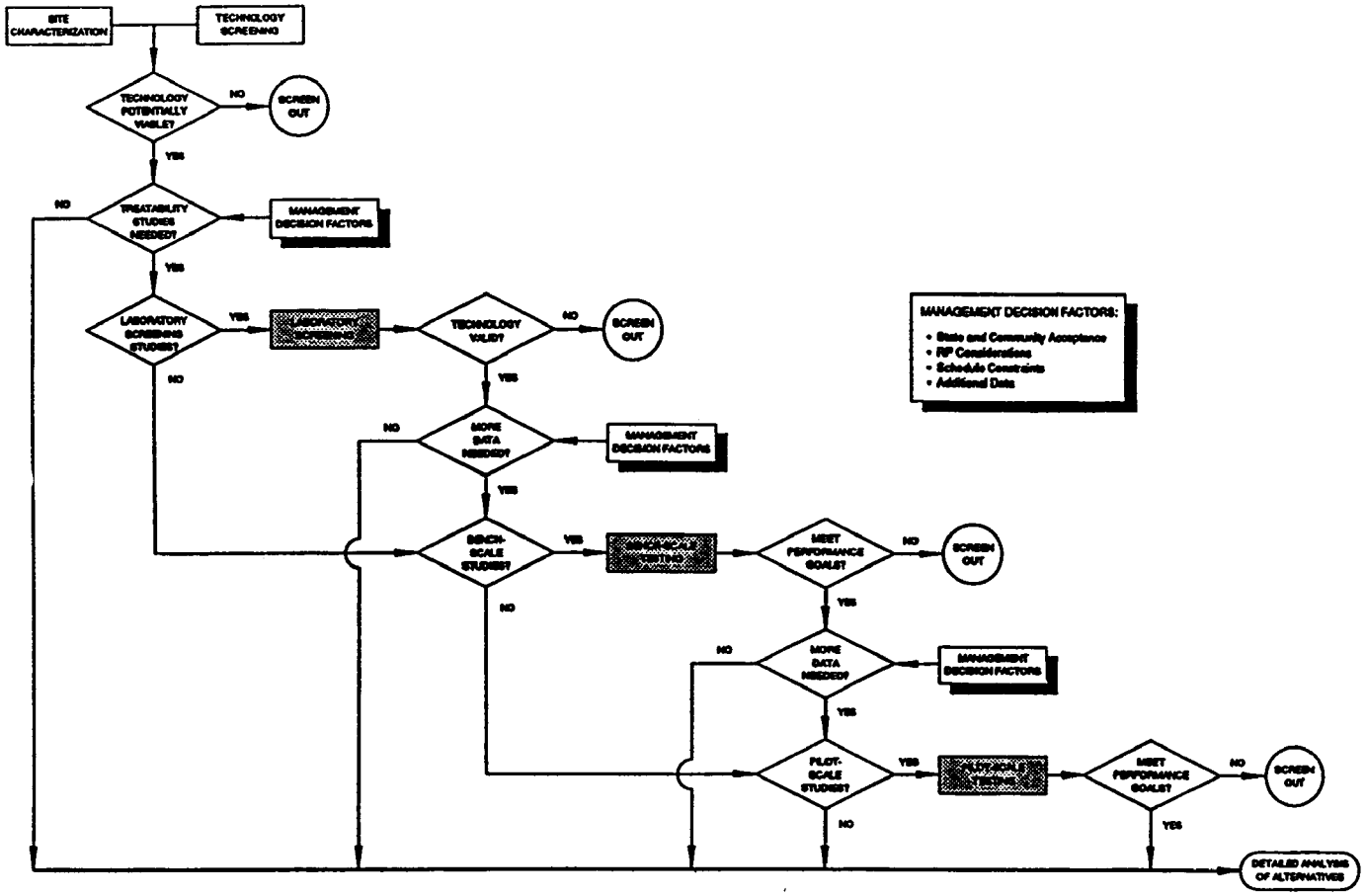


Figure 1. Flow diagram of the tiered approach.

- **Laboratory screening** is the first level of testing. It is used to establish the validity of a technology to treat a waste. These studies are generally low cost (e.g., $10K–50K) and usually require hours to days to complete. They yield data that can be used as indicators of a technology's potential to meet performance goals and can identify operating standards for investigation during bench- or pilot-scale testing. They generate little, if any, design or cost data and generally are not used as the sole basis for selection of a remedy.

- **Bench-scale testing** is the second level of testing. It is used to identify the technology's performance on a waste-specific basis for an operable unit. These studies generally are of moderate cost (e.g., $50K–250K) and may require days to weeks to complete. They yield data that verify that the technology can meet expected cleanup goals and can provide information in support of the detailed analysis of the alternative (i.e., the nine evaluation criteria).

- **Pilot-scale testing** is the third level of testing. It is used to provide quantitative performance, cost, and design information for remediating an operable unit. This level of testing also can produce data required to optimize performance. These studies are of moderate to high cost (e.g., $250K–1,000K) and may require weeks to months to complete. They yield data that verify performance to a higher degree than the bench-scale and provide detailed design information. They are most often performed during the remedy implementation phase of a site cleanup, although this level may be appropriate to support the remedy evaluation of innovative technologies.

Technologies generally are evaluated first at the laboratory screening level and progress through the bench-scale to the pilot-scale testing level. A technology may enter, however, at whatever level is appropriate based on available data on the technology and site-specific factors. For example, a technology that has been studied extensively may not warrant laboratory screening to determine whether it has the potential to work. Rather, it may go directly to bench-scale testing to verify that performance standards can be met.

DETERMINING THE NEED FOR TREATABILITY STUDIES

Treatability studies for remedy evaluation and implementation represent good engineering practice. The determination of the need for and the appropriate level of a treatability study(ies) required is dependent on site-specific factors, the literature information available on the technology, and technical expert judgement. The latter two elements—the literature search and expert consultation—are critical factors in determining if adequate data are available or whether a treatability study is needed to provide those data. Figure 2 provides a decision tree for treatability studies in the RI/FS. Additional studies may not be needed if previous studies or actual implementation have encompassed essentially identical site conditions. The data and information on which this decision is based should be documented. Given the lack of full-scale experience with innovative technologies, pilot-scale testing will generally be necessary in support of remedy selection and implementation.

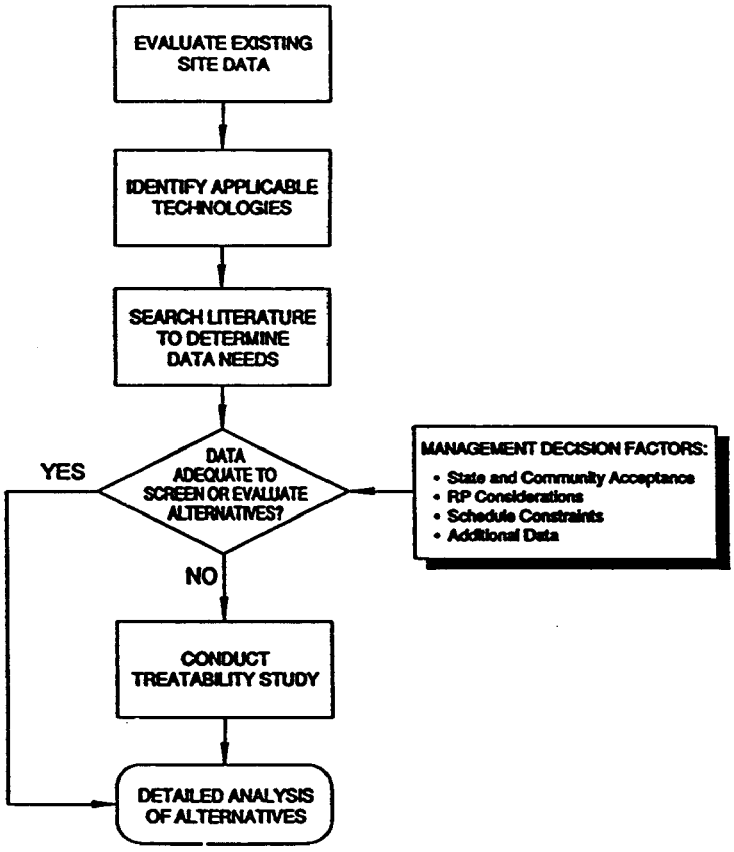


Figure 2. Decision tree showing when treatability studies are needed to support the evaluation and selection of an alternative.

SUPERFUND PROCESS – TIMING OF TREATABILITY STUDIES

Treatability studies should be planned and implemented as soon as it is evident that insufficient information is available in the literature to support the decision necessary for remedy selection or implementation. Treatability testing of technologies may begin during the scoping phase, the initial phases of site characterization and technology screening, and continue through the RI/FS and into the RD/RA to support remedy implementation. Additional treatability studies of alternative technologies or treatment trains also may be needed later in the RI/FS process as other promising remedial alternatives are identified.

For many site types, initial data are available to identify potentially applicable technologies early during the scoping phase of the RI/FS for all or parts of the site. In those cases, the literature search, the planning, and the implementation of the treatability study can proceed. The planning of the studies should coincide with the scoping of the RI/FS to the extent practicable to ensure that data are gathered during the RI to support the technologies and associated treatability studies.

Similarly, treatability studies to support the remedy implementation also should be conducted as early in the RD as appropriate. As with the RI/FS treatability study, additional technology-specific site characterization data may be needed to aid in the design and implementation of the study.

TREATABILITY STUDY GOALS

Each level of treatability study requires appropriate performance goals. These goals should be specified before the test is conducted. The goals may need to be reassessed to determine appropriateness following testing performance as a result of new information (e.g., ARARs), treatment train considerations or other factors. Pre-ROD treatability study goals will usually be based on the anticipated performance standards to be established in the ROD. This is because cleanup criteria are not finalized until the ROD is signed due to continuing analyses and ARARs determinations. The treatability goals should consider the following factors independently or in combination:

- Levels that are protective of human health and the environment (e.g., contact, ingestion, leaching) if treated waste is left unmanaged or is managed;
- Levels that are in compliance with ARARs, including the land disposal restrictions;
- Levels that ensure a reduction of toxicity, mobility, or volume;
- Levels acceptable for delisting of the waste; and
- Levels set by the State or Regional for another site with contaminated media with similar characteristics and contaminants.

Further, the program has as the treatment goal and expectation that treatment technologies and/or treatment trains generally achieve a 90 percent or greater reduction in the concentration or mobility of individual contaminants of concern. This goal complements the site-specific risk-based goals. There will be situations where reductions outside this range that achieve health-based or other site-specific remediation goals, may be appropriate. Treatment technologies should be designed and operated such that they achieve reductions beyond the target level indicated to ensure that the stated goals are achieved consistently.

Laboratory screening of treatability study goals allows for a go/no-go decision. For example, the goal may be a 50 percent reduction in mobility which would indicate the potential to achieve greater reduction (e.g., 90 percent) through additional refinement of the study. The achievement of this goal might indicate the advisability of expending additional resources on a bench-scale test to obtain a more definitive evaluation of the technology. Bench- and pilot-scale testing goals are those needed to select and/or implement the technology. For example, the bench-scale testing goal for solidification/stabilization could be to achieve a 90 percent or greater reduction in mobility of the principal constituents. In addition, the goals for the bench- or pilot-scale studies also may involve multiple waste treatment levels—the performance of which dictates the ultimate disposition of the waste (i.e., clean closure or landfill closure).

Post-ROD treatability study goals should reflect those performance standards specified in the ROD. They should also be achieved in the most resource-efficient manner.

CERCLIS

Treatability studies are coded in CERCLIS under the event code "TS" that provides for separate event coding for each treatability study for a given site. This allows for multiple treatability studies with separate funding (e.g., Federal-, State-, or Responsible Party-lead treatability studies).

PERFORMANCE OF TREATABILITY STUDIES

Fund-lead treatability studies generally will be conducted through the REM or ARCS contractors or their sub-contractors or contractors working for States. A list of vendors that have expressed interest in performing treatability studies has been complied in the "Inventory of Treatability Study Vendors." A preliminary draft copy is scheduled for distribution in January 1990. Companies on this list should be notified of requests for proposals (RFPs) for treatability studies in accordance with the Federal Acquisition Regulations.

Enforcement-lead treatability studies generally will be accomplished through the RP contractor. There may be exceptions to this where the complexity of the site requires alternative options (e.g., State- or Federal-lead treatability studies for all or part of a site). The planning and performance of the study should be directed by the Region to ensure that the study results in the type and quality of data needed to support the decision.

It may be advisable to have indepedent reviews of the treatability study performed particularly when innovative technologies are being considered.

TREATABILITY STUDY PROTOCOLS

Treatability studies need to be carefully planned to ensure that sufficient data of known, documented, and appropriate quality are generated to support the decision. The site-specific treatability study protocol is outlined in the Work Plan and the Sampling and Analysis Plan. These plans should, among other things, clearly describe: the experimental design, the treatability study goals, the Quality Assurance Project Plan, data management and interpretation, and reporting.

The treatability study work assignment is to require that the treatability study be developed in accordance with Agency guidance, factoring in literature, site-specific information, and expert consultation. The "Guide for Conducting Treatability Studies Under CERCLA" provides a general approach for treatability studies and provides a protocol for the preparation of the Work Assignment, Work Plan, Sampling and Analysis Plan, Health and Safety Plan, and the Community Relations Plan. The Agency also is developing a number of technology-specific treatability guidances which should be followed; the first of these on soil washing is scheduled to be issued in the second quarter of FY 1990. For more information on these documents, and other sources of treatability study information, contact Dave Smith at FTS/684-7957 or com. (513) 569-7957. Site-specific technical assistance is available to regional personnel by contacting Dave Smith at the aforementioned telephone numbers.

TREATABILITY STUDY REPORT

The Agency has initiated an effort to ensure the consistency of treatability study reports and to provide a central repository of treatability studies to facilitate information dissemination. The "Guide for Conducting Treatability Studies under CERCLA" contains a standard report format that is to be followed for all treatability study reports. All work assignments and consent decrees are to contain a statement requiring that documents be developed in accordance with Agency policy.

Further, all Funding-lead and enforcement-lead over-sight treatability work assignments are to include a provision requiring that a camera-ready master copy of the treatability study report be sent to the following address:

Attn: Ken Dostal
U.S. Environmental Protection Agency
Superfund Treatability Data Base
ORD/RREL
26 West Martin Luther King Drive
Cincinnati, OH 45268

Information contained in these reports will be available through the Alternative Treatment Technology Information Center (ATTIC). For more information on ATTIC please call FTS 382-5747 or com. 202/382-5747. (See Section 9 for more information on databases).

TECHNICAL ASSISTANCE

Literature information and consultation with experts are critical factors in determining the need for and ensuring the usefulness of treatability studies. A reference list of sources on treatability studies is provided in the "Guide for Conducting Treatability Studies Under CERCLA.

ORGANIZATION OF PRESENTATION

- Overview of treatability studies
- Protocol for conducting treatability studies
- Sources of treatability information

REQUIREMENT FOR ACTION

"To evaluate the application of treatment technologies to particular sites, it is essential to conduct laboratory or pilot-scale tests on actual wastes from the site, including, if needed and feasible, tests of actual operating units prior to remedy selection. These 'treatability tests' are not currently being performed at many sites to the necessary extent, or their quality is not adequate to support reliable decisions."

From: A Management review of the Superfund Program, U.S. EPA. 1989.

OVERVIEW OF TREATABILITY STUDIES

TREATABILITY STUDIES

The testing of a remedial alternative in the laboratory or field to obtain data necessary for a detailed evaluation of its feasibility

REMEDY SELECTION CRITERIA

- Overall protection of Human Health and the Environment (HHE)
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)
- Implementability
- Reduction of toxicity, mobility or volume

REMEDY SELECTION CRITERIA (continued)

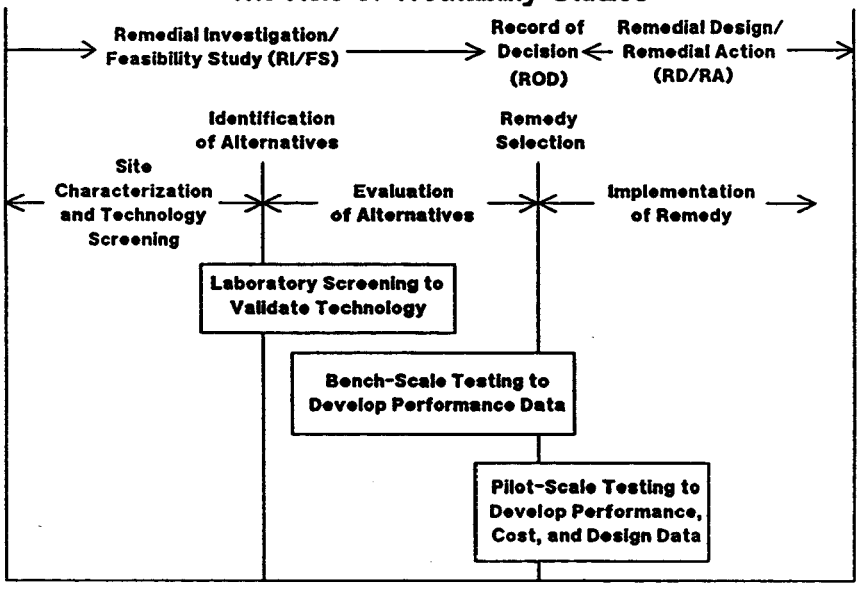
- Short-term effectiveness
- Cost
- Long-term effectiveness
- State acceptance
- Community acceptance

TIERS OF TREATABILITY TESTING

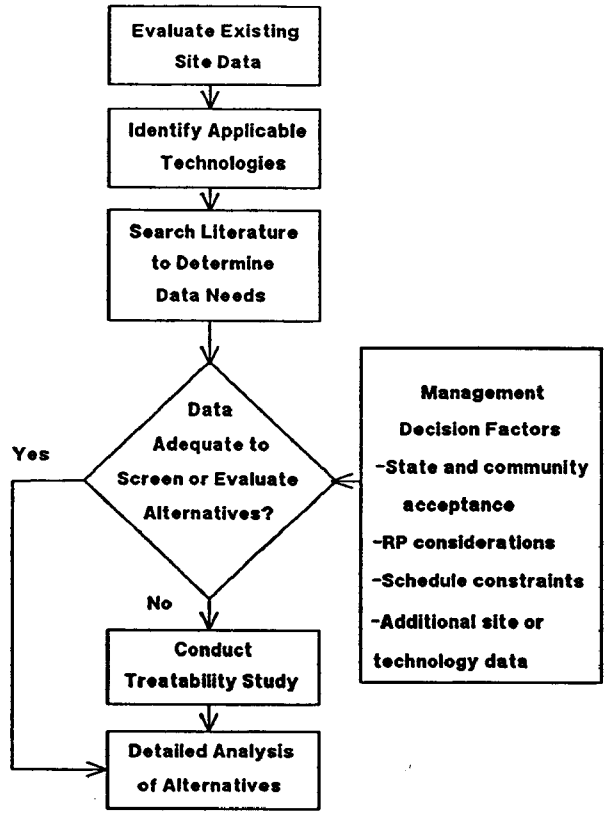
- Laboratory screening
- Bench-scale testing
- Pilot-scale testing

Proof of Treatability Concept

The Role of Treatability Studies



WHEN TREATABILITY STUDIES ARE NEEDED



LABORATORY SCREENING

Jar Tests or Beaker Studies Performed in the Laboratory

- Relatively low costs
- Short time to perform
- Low levels of quality assurance/ quality control (QA/QC)
- Qualitative performance data
- No design or cost information

BENCH-SCALE TESTING

Bench-Top Studies Performed in Laboratory or Field

- Moderate costs
- Moderate amounts of time to perform
- Moderate to high levels of QA/QC
- Quantitative performance data
- Some design and cost information

PILOT-SCALE TESTING

Pilot-Plant Studies Performed in the Field

- High costs
- Long amounts of time to perform
- Moderate to high levels of QA/QC
- Quantitative performance data
- Detailed design, cost and optimization information

MANAGEMENT DECISION FACTORS

- State and community acceptance
- Responsible party considerations
- Schedule constraints
- Additional site or technology data

SPECIAL CONSIDERATIONS

- Unit operations for innovative technologies
- Treatment trains
- In-situ treatment technolgies

TREATABILITY STUDIES

- Aid in the selection of the remedy
- Aid in the implementation of the selected remedy

PROTOCOL FOR CONDUCTING TREATABILITY STUDIES

PROTOCOL

- Establishing data quality objectives
- Selecting a contracting mechanism
- Issuing the work plan
- Preparing the work plan
- Preparing the sampling and analysis plan

General Requirements

PROTOCOL
(continued)

- Preparing the health and safety plan
- Conducting community relations activities
- Complying with regulatory requirements
- Executing the study
- Analyzing and interpreting the data
- Reporting the results

ESTABLISHING DATA QUALITY OBJECTIVES

DATA QUALITY

A measure or description of the types and amounts of error associated with a data set

generate Data of a known Quality

DQOs

Are qualitative and quantitative statements of the data quality needed to support decisions for regulatory actions

PURPOSE OF DQOs

- Establish an appropriate level of control over errors (that are controllable)
- Obtain sufficient information to describe all known sources of error (to the extent possible)

Pocket Guide for Project Plans

DATA SET QUALITY CHARACTERISTICS

PARCC

- Precision (P)
- Accuracy (A)
- Representativeness (R)
- Completeness (C)
- Comparability (C) - between 2 Labs

DQO DEVELOPMENT PROCESS

- Stage 1 Decision maker input
- Stage 2 Problem clarification
- Stage 3 Alternatives development and approach selection
- Stage 3+ Data collection detailed design

SUMMARY OF ANALYTICAL LEVELS
Level I

- Field screening or portable instruments
- Usually not compound-specific
- Not quantifiable
- Indication of contamination presence
- Few QA/QC requirements

SUMMARY OF ANALYTICAL LEVELS
Level II

- Portable instruments or mobile laboratory
- Organics by GC
- Inorganics by AA, ICP, or XRF
- Detection levels vary from ppm to ppb
- Tentative identification of compounds
- Limited mostly to volatile organics & metals
- Moderate QA/QC
- Data typically in concentration ranges

Bench Scale
or
Pilot Scale
Level Testing
Require Much
Greater QA/QC

SUMMARY OF ANALYTICAL LEVELS
Level III

- Organics/inorganics in offsite laboratory
- May use CLP procedures
- May use CLP laboratory
- Tentative compound identification in some cases
- Detection limits similar to CLP
- Rigorous QA/QC

SUMMARY OF ANALYTICAL LEVELS
Level IV

- HSL organics/inorganics by GC/MS, AA, ICP, HPLC
- Low ppb detection limits
- Tentative ID of non-HSL parameters
- Validation may take several weeks
- Goal is data of known quality
- Rigorous QA/QC

SUMMARY OF ANALYTICAL LEVELS

Level V

- Analysis by nonstandard methods
- May require method development/modification
- Method specific detection limits
- Probably require special lead time
- Method-specific data quality

SELECTING A CONTRACTING MECHANISM

- REM and ARCS contracts
- Technical assistance and support contracts
- Request for proposals

ISSUING THE WORK ASSIGNMENT

(By EPA)

- Background
- Test objectives
- Approach
- Reporting requirements
  - -Deliverables
  - -Monthly reports
- Schedule
- Level of effort

PREPARING THE WORK PLAN
(By Contractor)

- Project description
- Remedial technology description
- Test objectives
- Experimental design and procedures
- Equipment and materials
- Sampling and analysis
- Data management
- Data analysis and interpretation

PREPARING THE WORK PLAN
(By Contractor)

- Health and safety
- Residuals management
- Community relations
- Reports
- Schedule
- Management and staffing
- Budget

PREPARING THE SAMPLING AND ANALYSIS PLAN

- Field sampling plan
- Quality assurance project plan

PREPARING THE HEALTH AND SAFETY PLAN

- Hazard analysis
- Employee training
- Personal protective equipment
- Medical surveillance
- Personnel and environmental monitoring

PREPARING THE HEALTH AND SAFETY PLAN (continued)

- Site control measures
- Decontamination procedures
- Emergency response plan
- Confined-space entry procedures
- Spill containment program

CONDUCTING COMMUNITY RELATIONS ACTIVITIES

- Overview community relations plan
- Capsule site description
- Community background
- Community relations program highlights
- Community relations activities & timing
- Contact list of key community leaders
- Suggested locations meetings & information

COMPLYING WITH REGULATORY REQUIREMENTS

- Volume of waste to be tested
- Availability mobile lab or treatment
- Site accessibility and restrictions
- Availability of onsite utilities
- Mobilization/demobilization & per diem costs
- Duration of tests
- State and community acceptance

REPORTING THE RESULTS

Introduction

- Site description and history
- Waste stream matrices and pollutants
- Remedial technology treatment process and operating features
- Previous treatability studies at site
- Conclusions and recommendations

REPORTING THE RESULTS

Treatability Study Approach

- Test objectives and rationale
- Experimental design and procedures
- Equipment and materials
- Sampling and analysis
  - -Waste stream
  - -Treatment process
- Data management
- Deviations from the work plan

REPORTING THE RESULTS

Results and Discussion

- Data analysis and interpretation
  - -Waste stream characteristics
  - -Treatability study data
  - -Comparison to test objectives
- Residuals management
- Quality assuance/quality control
- Costs/schedule for performing the treatability study
- Key contacts

SOURCES OF TREATABILITY INFORMATION

- Reports, documents, guidance
- Electronic data bases
- EPA personnel

MATERIALS HANDLING INCLUDING DEBRIS SEPARATION AND DECONTAMINATION

Abstract 3-2

Slides 3-9

MATERIALS HANDLING, DEBRIS SEPARATION AND DECONTAMINATION

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Recent figures on the number of hazardous waste sites in the United States indicate that there are approximately 22,000–24,000 uncontrolled/CERCLA sites, 3,000 RCRA–permitted treatment/storage/disposal sites, another 10,000 locations where hazardous wastes are currently generated but not treated, stored, or disposed, and 2 to 5 million underground storage tanks of which it is estimated that 25 percent are leaking.

The policy of the EPA's Office of Solid Waste and Emergency Response (OSWER), which is responsible for implementing the 1984 Hazardous Solid Waste Amendment (HSWA) requirements, is to discourage the excavation and reburial "disposal" philosophy for CERCLA waste and debris. Instead, OSWER encourages the use of on–site technologies to eliminate or reduce the hazardous character of the waste materials, since on–site treatment achieves more positive control than containment. In the future, off–site disposal to engineered and protected landfills will only be allowed when no destruction technology is available, or for "pretreated" soil and debris materials complying Best Demonstrated Available Treatment (BDAT) levels, as promulgated under the impending 1988 Land Ban legislation.

This body of legislation has created a pressing need for more economical and effective technologies to detoxify material at existing hazardous waste sites. As landfills continue to close, disposal becomes more expensive and as hazardous waste transportation is more stringently regulated, on–site waste destruction or volumetric reduction technologies is becoming far more desirable, providing that technologically feasible, environmentally safe, and economically viable treatment systems can be developed.

In order to destroy or reduce the hazardous character of any contaminated material, any treatment technology selected must receive a "feedstock" having a predetermined range of physical/chemical characteristics in order to assure reliable treatment efficiencies and cost–effectiveness. The types of contaminated materials identified and discussed in Remedial Investigation/Feasibility Study (RI/FS) reports are primarily soils, sludges, and liquids. The debris component was previously an issue in remediation if the contaminated matrix consisted primarily of a mixture of materials (i.e., building demolition debris or sanitary landfill wastes, such as household trash and garbage). On a Superfund site, such materials may be small in volume but may be the cause of all of the process upsets to a treatment system. Current practice involves the time–consuming task of individual decisions regarding the separation of potentially damaging materials. The land disposal rules enacted in November 1988, addresses the disposition of feedstock and site debris, as well as contaminated soil, under the Land Ban legislation.

TYPES OF MATERIALS

In order to identify likely feedstock handling problems as applied to feedstock preparation systems, a statistical sample of the 888 NPL sites was studied. This sample was surveyed for the types and sizes of solids contamination, the presence of sludges, the presence of free liquids, and the presence of sediments. The results of this survey

are summarized in Figure 1, (see page 3-9) which shows the frequency of occurrence of these classes of materials. This sample is representative of NPL wastes sites. However, these NPL sites are significantly biased in their emphasis on the liquid phase, which is a significant criterion for inclusion on the NPL list. The results shown in Figure 1 should not be considered representative of the total national population of waste sites. Analysis of these sites indicates that groundwater and/or surface water contamination was present at almost all sites.

The most important site variable affecting handling of materials of the type found on Superfund sites appears to be moisture content, which drastically affects the gross physical properties of the waste. The moisture content of raw municipal waste varies considerably from the sludge effluent of the Publicly Owned Treatment Works (POTWs) to relatively dry household garbage. The moisture content of the NPL site waste materials likewise varied from free liquids in ponds, as found at the Saco Tannery Waste Pits site, to the dry particulate dusts of the Iron Bound Area dioxin sites.

The four most common material types found at Superfund sites were soils, sludges, municipal solid waste, and free liquids. Soil contamination was the result of both placement of the contaminant directly on the soil and the placement of soil material over a contaminated site, as would occur in the closing of a lagoon. Sludges of both industrial and municipal origin were co-deposited with soil material in many cases. In addition, sludges were often found to be applied to municipal solid wastes. The defluidization of the sludges led to contamination of other materials. Due to this mixing of contaminated and noncontaminated materials, contaminated material types found at NPL sites cover a wide range of sizes and concentrations of contaminants.

SUPERFUND SITE DEBRIS

Debris is commonly defined as out-of-specification material which cannot be handled by a given treatment system and may, in fact, damage the processing equipment. Debris defined in this sense (i.e., on the basis of treatability) does not necessarily imply a separation based on level of contamination. For instance, oversized debris may or may not require remedial treatment by alternate technologies or special pretreatment.

Specific items of solid debris and contaminated materials found at Superfund sites vary considerably in nature, but most can be grouped into the following nine general categories:

- Cloth.
- Glass.

- Metals (ferrous/nonferrous).
- Paper.
- Plastic.
- Rubber.
- Wood.
- Construction/demolition materials (e.g., concrete, brick, asphalt).
- Electronic/electrical devices.

In addition to the wide range of debris types, the quantity of debris at sites also varies considerably. It was "unofficially" estimated in the above survey that debris at site varies on a volumetric basis from less than 1 percent to greater than 80 percent. The larger volume occurs at sites where demolition debris or sanitary landfill wastes have been disposed along with hazardous materials.

A preliminary assessment of each of the six mobile on-site treatment technologies was conducted to determine the maximum size of debris and material that could be subjected to the treatment process. An examination of the six mobile treatment technologies discussed herein indicated that all could generally accept 1-in. and smaller materials. There is, however, considerable variation in the acceptable range of feed material sizes for each specific technology. For instance, within the category of incineration, fluidized-bed incineration requires that the feed particle size be approximately the same as the bed particle size for optimum performance, while rotary kilns may, in principle, accept material sizes up to the kiln's diameter. Since the feed size for a given on-site treatment unit must be tailored to provide the requisite particle diameter, debris is a relative term.

TABLE 1. DEBRIS SIZE REQUIREMENTS FOR MOBILE ON-SITE TREATMENT

Maximum debris size	Technology
1-2 in.	Biological Degradation
1/2-in.	Chemical Treatment (K-PEG)
effective 6 in.	Incineration
1/4-in.	Low-Temperature Desorption
2 in.	Physical Treatment (Soil Washing)
1/4-in.	Solidification/Stabilization

Debris larger than the maximum allowable size must be segregated from the feedstock material and handled separately. This oversized material must then either be treated independently or reduced in size in order to meet the feedstock specifications of the on-site treatment equipment. A common problem encountered at NPL sites is the determination of representative average contamination levels on large debris, such as stone, wood pallets, automobiles, and buildings.

A common operational problem in on-site remedial actions is material management to produce a uniform feedstock from nonhomogeneous site materials. The preliminary information collected on debris indicates that current handling procedures at hazardous waste sites range from "elaborate separation and recycling" to "no separation." Following site remediation, processed material and debris is either (1) sent for ultimate disposal in a secure landfill; (2) decontaminated to levels allowing disposal in a municipal landfill; (3) used as material for construction foundation bedding; (4) recycled as a recoverable resource; or (5) "delisting" on-site to a nonhazardous status.

Historically, the selection of material-handling practices has been determined by the following factors:

- Technology feedstock requirement.
- Type of contamination.
- Type of debris (size, shape, phase, form, Btu and recycling value).
- Quality of debris (percentage by volume or weight).
- "Clean-up" standards or target levels. (Federal, state, local, private).
- Potential for decontamination of the debris.

Once contaminated debris has been separated from the hazardous waste material undergoing treatment, it must either be disposed in a secure landfill, stored for future approved treatment (i.e., dioxin-contaminated material), or decontaminated. The determination that debris is contaminated is generally an assumption that is made with little or no analytical testing. In some instances, monitoring devices, such as an HNU/Organic Vapor Analyzer (OVA) or a Geiger counter are utilized to determine if a particular material is contaminated with volatile organic compounds or is radioactive.

Decontamination of debris is possible for contaminants that can be recovered by aqueous washing, either through solution or physical separation. Soluble contaminants can be washed, rinsed, or otherwise surface cleaned or removed when associated contaminated soil is cleaned off. Insoluble and inorganic (heavy metal) contaminated fine soil material can sometimes be successfully separated from debris by high-pressure washing or vibratory separation, allowing the oversized material to be disposed of safely. Some contaminants, such as dioxin, are not generally considered to be candidates for decontamination. These compounds are sent to interim storage to await either incineration or alternate approved treatment. Impervious debris, such as steel, brass, and copper, are generally surface decontaminated and recycled, when possible. Due to its type, form, or surface area, most debris cannot be subjected to current or proposed testing procedures (EP-TOX [Extraction Procedure Toxicity Testing], TWA [Total Waste Analysis], and TCLP [Toxicity Characteristic Leaching Procedure]) to determine if it is hazardous. Such determinations are generally made by consensus among the participating regulatory parties at the Regional, state, and local levels. Debris that is determined to be nonhazardous can be disposed of as industrial or municipal waste in a sanitary landfill. Debris that is deemed hazardous by the regulatory parties involved must then be incinerated, decontaminated, or otherwise disposed of in a secure landfill.

HAZARDOUS MATERIAL HANDLING CHARACTERISTICS

This investigation found that the costs of pretreatment of hazardous material were several times the cost of treating similar, uncontaminated materials. These cost differences were principally due to differences in material handling procedures, safety requirements, dust and vapor control, and process equipment used and, to a lesser extent, differences in the properties of the material being processed.

Materials processed at hazardous waste sites are in many respects similar to those from nonhazardous sites. Differences are principally the variability of material sizes encountered. In most instances, there is no change in gross physical properties due to a change in the concentration of a specific compound significantly affecting the operation of feedstock preparation equipment. The gumbo sediments in a creosote-

contaminated bayou can be as effectively processed as the naturally organic-rich sediment occurring in an adjacent bayou. Differences, such as increased adhesion due to oil and grease in sand, can normally be tolerated by process equipment. In practice, differences occur, principally as a result of operational changes caused by the presence of hazardous material.

Material processing in its simplest form requires (1) excavation; (2) movement to the treatment process; and (3) movement from the treatment process to disposal or further treatment. Each of these operations must be modified to accommodate the presence of hazardous material.

When working with nonhazardous materials, equipment operators were less constrained by material placement, permitting faster excavation with the same equipment. Nonhazardous materials are generally excavated using larger equipment that discharges materials in a less controlled fashion. These observations hold true within specific layers and at specific depths of excavation.

Dust, vapor, and airborne emission control has been virtually nonexistent at nonhazardous material sites. Health and safety concerns related to the contaminants' toxicity also led to the adoption of slow and careful excavation practices at hazardous material sites. In general, health and safety concerns required continuous, careful documentation of the procedures, quantities, and disposition of materials throughout the on-site treatment process at hazardous material sites, thereby increasing costs greatly.

There are many types of site remediation activities related to excavation that result in fugitive dust and vapor emissions. Every unit process that is applied to the contaminated materials on a removal/remediation site may be a potential source of these emissions. These activities include:

- Soil, sludge, or sediment excavation
- Sludge/sediment dredging
- Soil, sludge, or sediment loading
- On-site/off-site transport
- On-site staging/stockpiling
- General site vehicular traffic
- Inactive face of an excavation
- Long-term stockpiling/storage on-site
- Processing of soil for on-site treatment
- Intrusive site/remedial investigation or design phase sampling activities.

Unit operations that may require dust and vapor controls are discussed in the following subsections.

Soil, Sludge, or Sediment Excavation

Soil, sludge, or sediment is typically excavated using heavy equipment such as:

- Backhoe
- Front-end loader
- Bulldozer
- Crane with dragline or clamshell.

Dust and vapor emission points include:

- Equipment tracks/tires
- Newly exposed excavation face
- Newly excavated soil equipment bucket.

The selection of excavating equipment and the choice of operational technique clearly affect the fugitive emission generation source points, the rates of emissions, and the surface areas that might have to be controlled by suppression technologies.

At times, it may be necessary to stockpile contaminated soil on site for extended periods of time. An uncovered soil stockpile represents a potential dust and vapor emission source due to the action of wind and diffusion of vapors to the surface of the stockpile. The emission rate is likely to be initially higher than that for the original in-place soils because it has been recently disturbed and is likely to be more loosely compacted.

While this operation is not directly associated with excavation, greater emphasis is now being placed on on-site treatment. Many on-site treatment technologies, such as rotary kiln incineration, require some preliminary treatment and handling steps before treatment. These operations may include:

- Soil screening
- Rock crushing
- Conveyor belts
- Feed/storage hoppers
- Shredding.

In the planning stage, it is important to be aware that unit operations unrelated to excavation are also sources of potential dust and vapor emissions.

Table 2, shown on page 3-27, presents examples of practical decontamination methods for debris and structural materials.

BEST MANAGEMENT PRACTICES FOR DEBRIS
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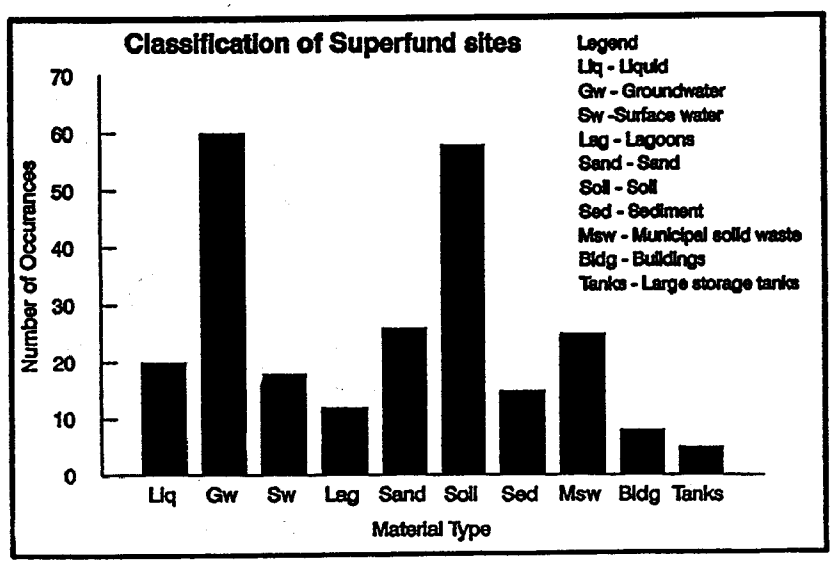
PRESENTATION OVERVIEW

- Debris separation and segregation
- Debris decontamination
- Feedstock preparation

MATERIALS HANDLING/SEPARATION

Debris and trash may be typically a small component of the material requiring treatment on-site...
...but this small component may cause the majority of the process operation problems and "upsets"



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Guide for EPA #600/52-85/028
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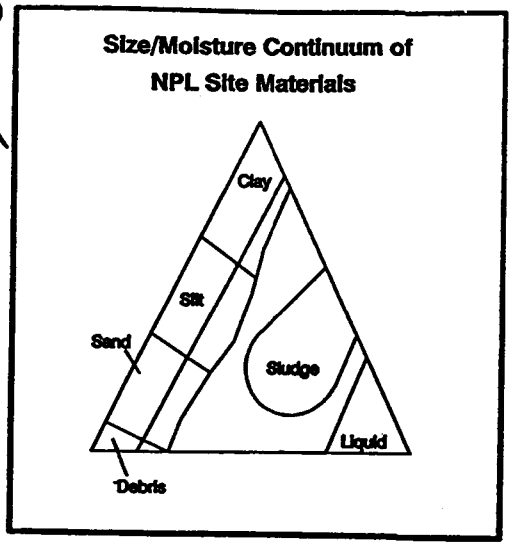
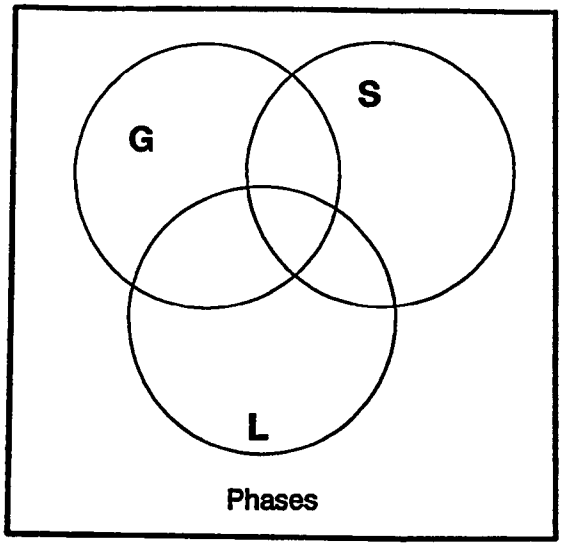
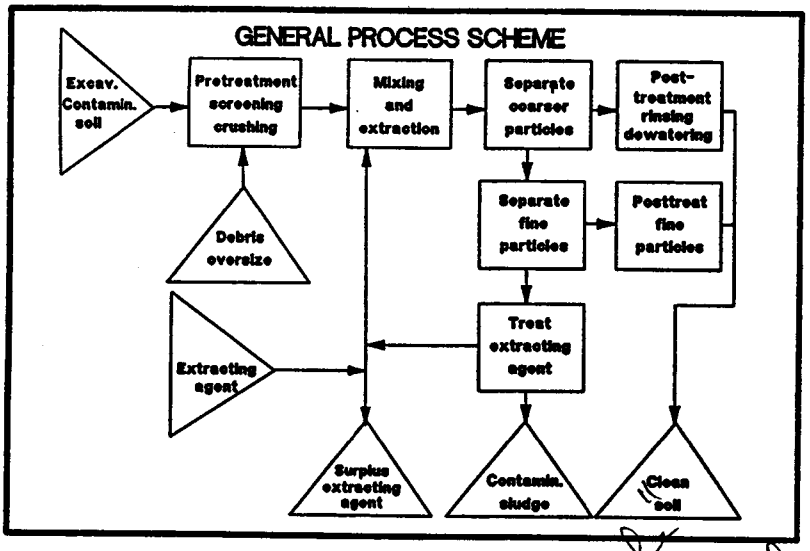






GENERAL PROCESS SCHEME

- Soil pretreatment
  - -Dry screening to remove large objects
  - -Metal removal
  - -Crushing to size material
  - -Wet screening to separate sized material
- Mixing and extraction
  - -Transfer contaminants to extraction fluid
  - -Detach fine particles from coarse particles

(1 of 4)

Perries Chem Eng Guide McGraw Hill (Try to get an old edition)

GENERAL PROCESS SCHEME

- Separation of coarse soil
  - -Separate cleaned coarser soil from extraction fluid and fine soil particles (fine sand, silt, and clay)
- Soil posttreatment
  - -Rinsing to remove contaminants
  - -Dewatering

(2 of 4)

GENERAL PROCESS SCHEME

- Separation of fine particles
  - -Separate fine particles from extraction fluid and finer particles that can't be cleaned or easily separated
- Fine particles posttreatment
  - -Secondary extraction
  - -Rinsing to remove contaminants
  - -Dewatering

(3 of 4)

GENERAL PROCESS SCHEME

- Treatment of extraction fluid
  - -Remove contaminants
  - -Discharge fraction/recycle remainder
  - -Add chemicals

(4 of 4)

SIZE REDUCTION EQUIPMENT

- Primary crushers
  - -jaw crushers
  - -gyratory crushers
- Secondary crushers
  - -hammer mills
  - -roll crushers
  - -cone crushers

SCREENING EQUIPMENT

Solid-Solid; Liquid-Solid Separation

- Grizzly (coarse particles)
- Sieve bend
- Trommel (revolving screen)
- Vibrating
- Shaking
- Rotary

CLASSIFICATION EQUIPMENT

Size Separation via Settling Rate

- Sedimentation tank
- Lamella thickener
- Elutriator (upflow classifier)
- Inclined spiral classifier
- Hydrocyclone
- Centrifuge

GRAVITY CONCENTRATION EQUIPMENT

Separation via Density

- Shaking table
- Dense medium cyclone

FLOTATION

Separation via Surface Properties

- Solid-solid separation
- Solid-liquid separation
- Liquid-liquid separation

DEWATERING

Solid-Liquid Separation

- Thickening (40-60% solids)
- Filtration (75-90% solids)
- Centrifugation (75-90% solids)

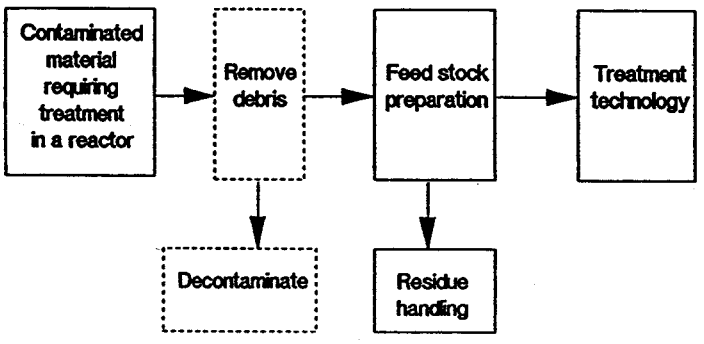
MIXING AND EXTRACTION DEVICES

Vigorous Action to Separate Contaminants and Soil Particles From Each Other

- Impellers
  - -Propellers
  - -Turbine
- Water knife (60 psig)
- High pressure jet pipe (5000 psig water)
- Low frequency vibration unit

TREATMENT OF EXTRACTION FLUID

- Metal precipitation
- Concentration/separation of contaminants
  - -Coagulation
  - -Flocculation
  - -Thickening
  - -Dewatering
- Polishing for discharge
  - -Ion exchange
  - -Activated carbon
  - -Microfiltration



DEBRIS IDENTIFICATION

Cloth
- Rags
- Tarps
- Mattresses

Glass
- Bottles
- (white, brown, green, clear, blue)
  Windows

Ferrous Metals
- Cast iron
- Tin cans
- Slag

Nonferrous Metals
- Stainless steel
- Aluminum
- Brass
- Copper
- Slag

Metal Objects
- Autos/vehicles
- 55-gallon drums/containers
- Refrigerators
- Tanks/gas cylinders
- Pipes
- Nails
- Nuts and bolts
- Wire and cable
- Railroad rails
- Structural steel

Construction Debris
- Bricks
- Concrete blocks
- Asphalt
- Stones and rocks
- Reinforced concrete pipe
- Wood
- Steel beams
- Asbestos insulation and roofing/siding shingles
- Fiberglass insulation
- Fiberglass tanks

Paper
- Books
- Magazines
- Newspaper
- Cardboard
- Packing

Plastic
- Buckets
- Pesticide containers
- Six-pack retainer rings
- Thin plastic sheets
- Plastic bags
- Battery cases

Rubber
- Tires
- Hoses
- Insulation
- Battery cases

Wood
- Stumps and leaves
- Furniture
- Pallets
- Plywood
- Railroad ties

Electronic/Electrical
- Televisions
- Transformers
- Capacitors
- Radios

DEBRIS COMPONENTS AND CHARACTERISTICS

Component	Characteristic
Brick and rock	Porous non-destructible
Concrete	Porous non-destructible
	Non-porous non-destructible
Glass	Non-porous non-destructible
Metals	Non-porous non-destructible
Plastic	Porous destructible
(1 of 2)	Non-porous destructible

DEBRIS COMPONENTS AND CHARACTERISTICS

Component	Characteristic
Rubber	Porous destructible
	Non-porous destructible
Wood	Porous destructible
Cloth	Porous destructible
Paper	Porous destructible
Equipment and structures	Porous destructible and non-destructible
(2 of 2)	Non-porous destructible and non-destructible

INVENTORY OF CONTAMINANT GROUPS

- Volatile organics
- Base neutrals (PAHs)
- Acid extractables (e.g. polar organics)
- Pesticides & chlorinated aromatics
- PCBs, dioxins and furans
- Nitrated compounds
- Metals
- Cyanide

CONTROLLING FACTORS IN FEEDSTOCK PREPARATION AND DEBRIS HANDLING

- Feedstock size requirements of ultimate treatment technology
- Type of contaminant present
- Type of dominant matrix
- Type of debris (e.g. size, shape, phase, form, BTU, recycling value)

(1 of 2)

CONTROLLING FACTORS

- Quantity of debris (percentage by volume or weight)
- "Clean-up" standards or target levels (federal, state, local, private)
- Potential for decontamination of the debris

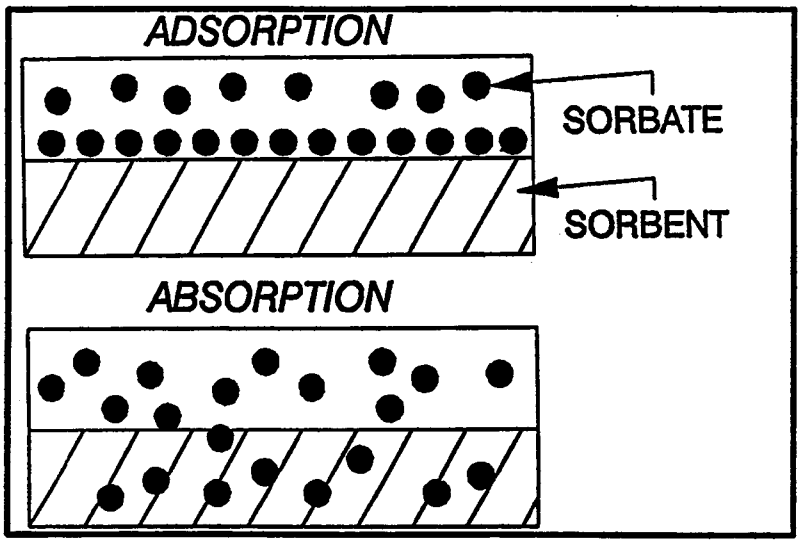
(2 of 2)

REMOVAL TECHNIQUES

- Excavation
- Dredging

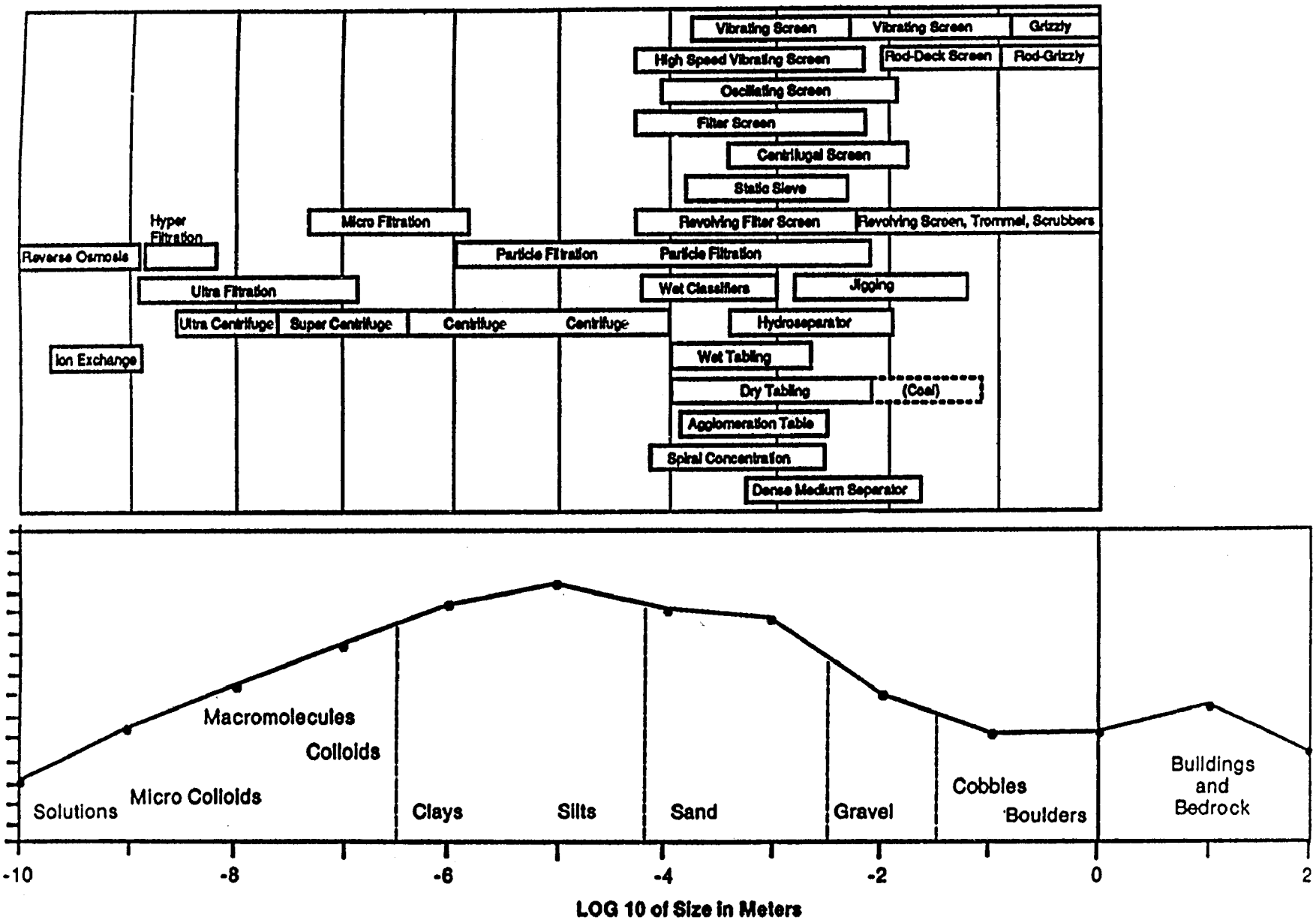
WHY SEPARATION

- Reduce volume to be treated
- Reduce volume to be disposed



SEPARATION TECHNOLOGIES

Use for Extracting and Concentrating Contaminants in Preparation for Treatment or Disposal



Frequency of occurence/size relationship for processing equipment.

SEPARATION TECHNOLOGIES

- Screen
- Trommel
- Grizzly
- Vibratory screen
- Cyclone
- Jig
- Classifier
- Table

(1 of 3)

SEPARATION TECHNOLOGIES

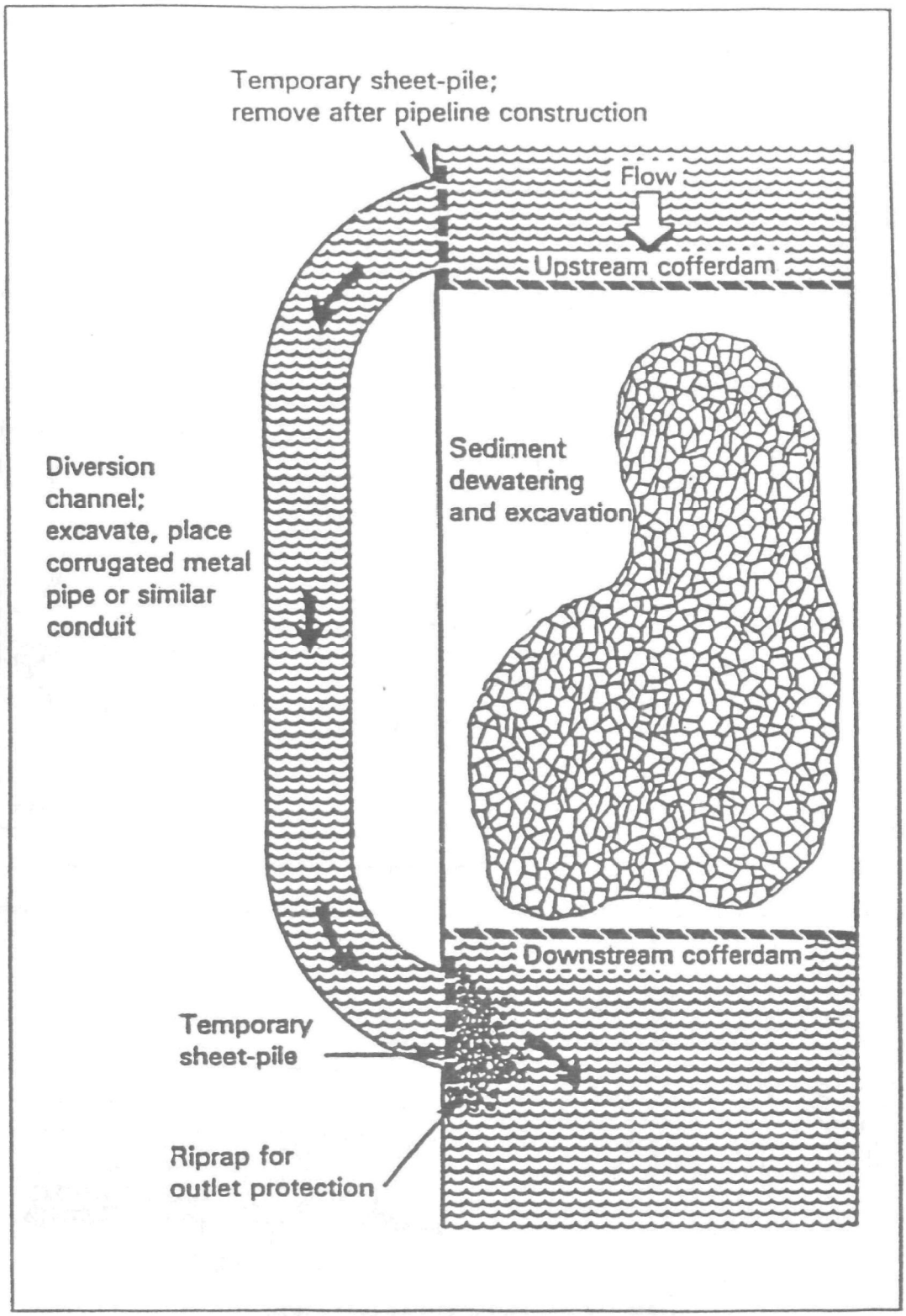
- Oil-water separator
- Soil sifter
- Trash screen
- Trash centrifuge
- Clarifier
- Air stripping

(2 of 3)

SEPARATION TECHNOLOGIES

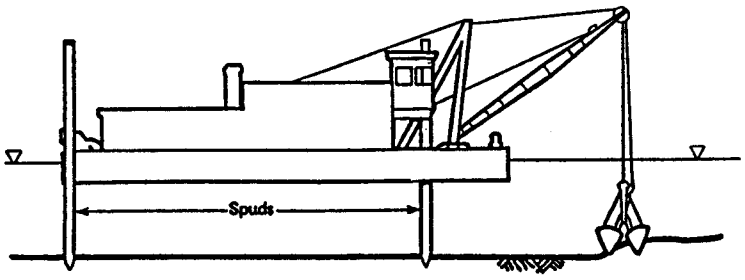
- Separation nozzle
- Particle filtration
- Micro- & ultrafiltration
- Ion exchange
- Reverse osmosis
- Electrodialysis

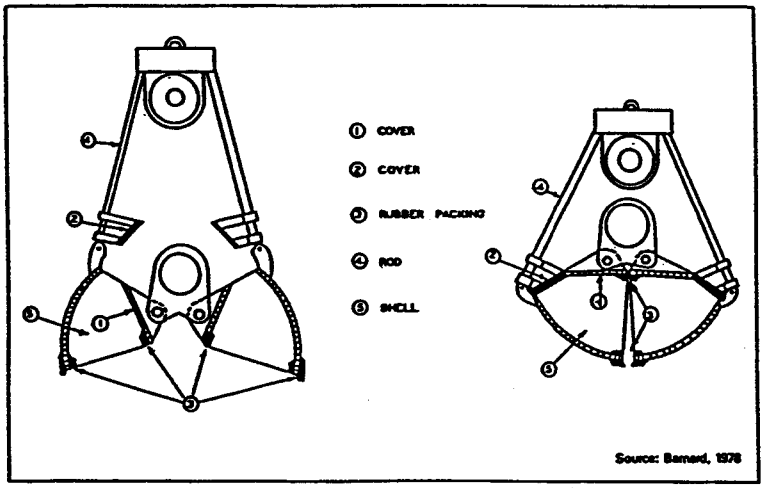
(3 of 3)



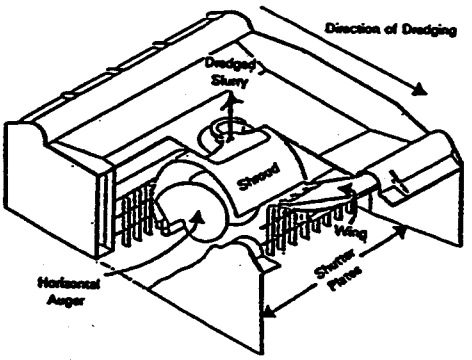
Streamflow Diversion for Sediment Excavation Using Two Cofferdams and Diversion Channel

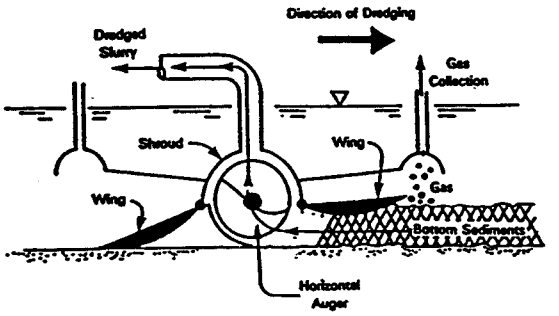
EXAMPLE OF MECHANICAL DREDGING EQUIPMENT.



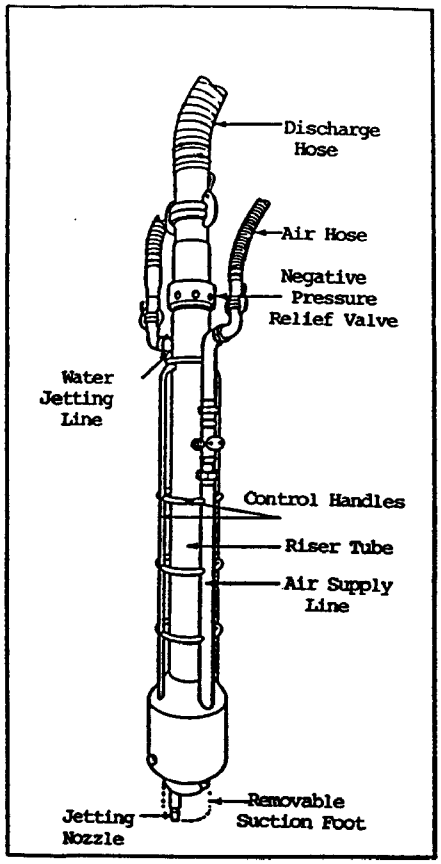


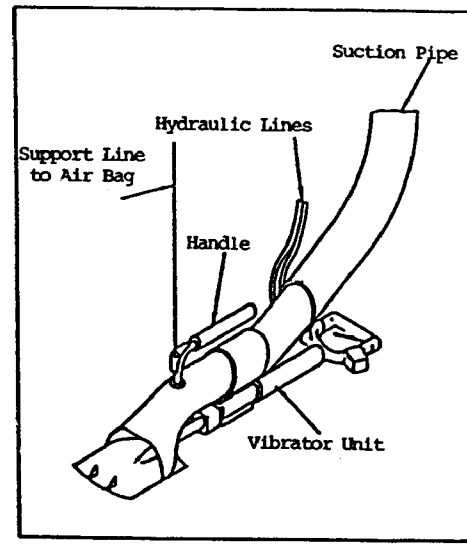
Open and Closed Positions of the Watertight Bucket





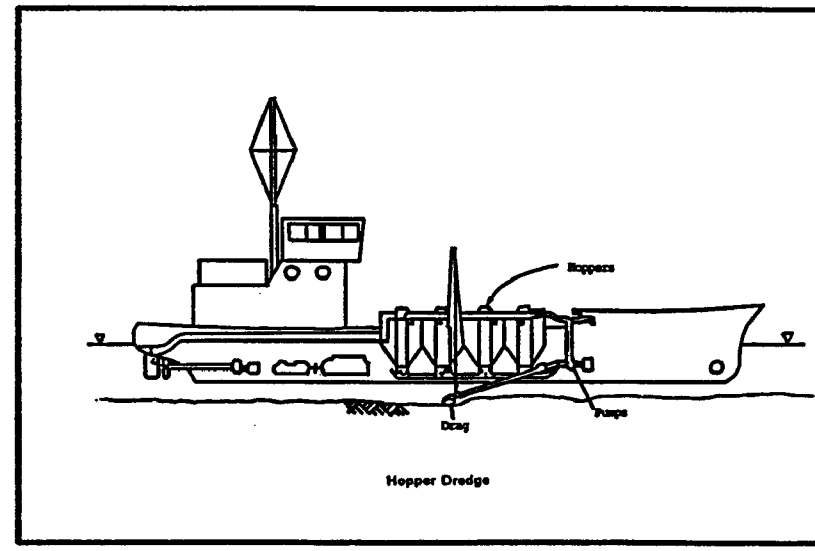
Section and Schematic of Cleanup Dredge Head



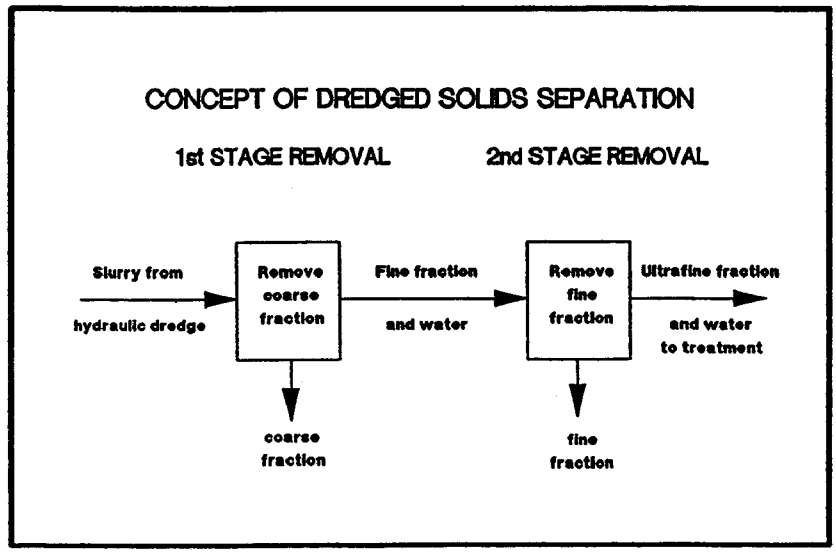


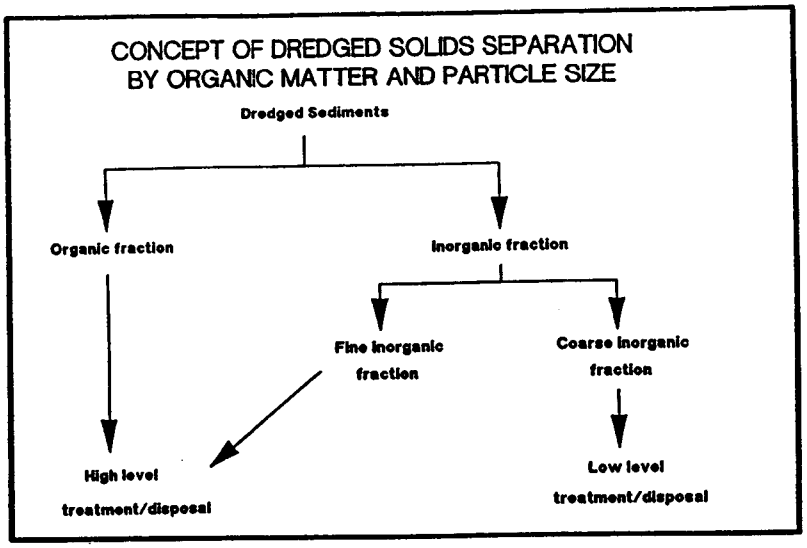
Diver-Operated Hand-Held Dredges

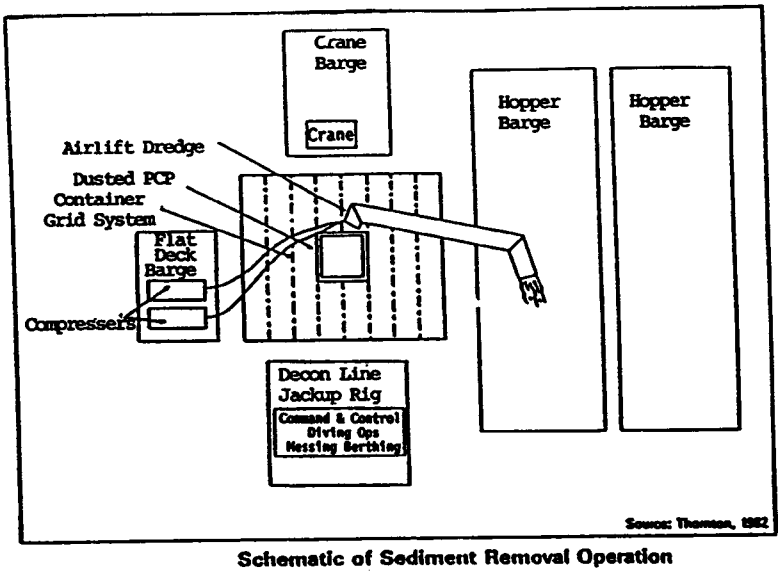
Source: Alluvial Mining, 1984



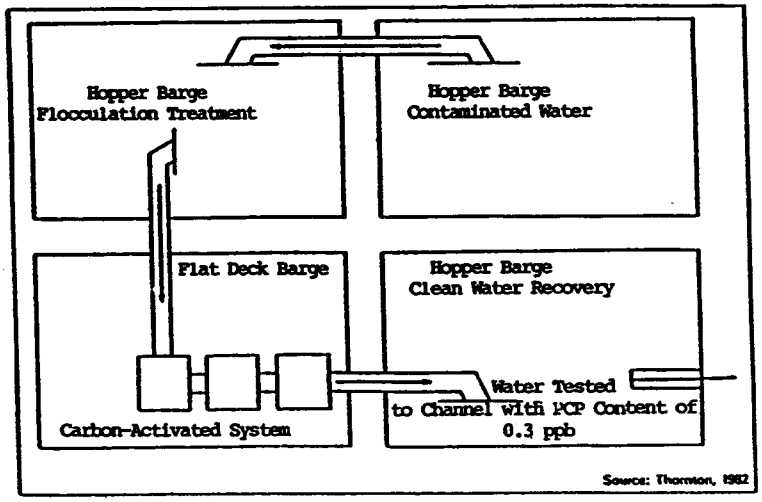
Hopper Dredge



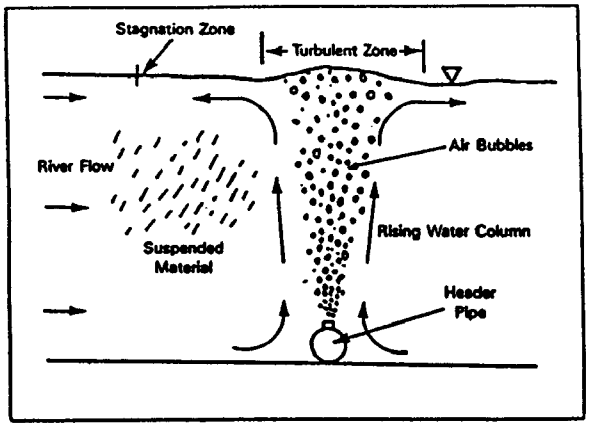




Schematic of Sediment Removal Operation



Schematic of Supernatant Water Treatment System



Control of Resuspended Material Using a Pneumatic Barrier

INVENTORY OF DEBRIS DECONTAMINATION METHODS

Chemical Extraction

- Dechlorination
- RadKleen
- Solvent washing
- Vapor phase solvent extraction
- Acid etching
- Bleaching

INVENTORY OF DEBRIS DECONTAMINATION METHODS

Physical Removal

- Low temperature thermal desorption
- Dusting/vacuuming/wiping
- Gritblasting
- Hydroblasting/waterwashing
- Steam cleaning
- Drilling and spalling

INVENTORY OF DEBRIS DECONTAMINATION METHODS

Passive Treatment

- Microbial degradation
- Photochemical degradation

INVENTORY OF DEBRIS DECONTAMINATION METHODS

Destruction

- Incineration
- Flaming
- Ultraviolet flash blasting

INVENTORY OF DEBRIS DECONTAMINATION METHODS

Sealing/Solidification

- Encapsulation/solidification
- Painting/coating
- K-20 sealant

DECONTAMINATION OF BUILDINGS, EQUIPMENT AND SOME DEBRIS

EXAMPLES OF PRACTICAL DECONTAMINATION METHODS FOR VARIOUS CONTAMINANTS AND STRUCTURAL MATERIALS[a]

Contaminant	Material: Brick	Concrete	Glass	Metal	Plastic	Wood	Equipment & auxiliary structures
Asbestos	1,3,4,5,6	1,3,5,6	1,3,4,5,6	1,3,4,5,6	1,3,4,5,6	1,3,4,5,6	1,3,4,5,6
Acids	2,3,4,6,7,8,9,13	2,3,6,7,8,9, 10,13,18	2,3,4,6,9,13	2,3,4,6,7,8, 9,13	2,3,4,6,9,13	2,3,4,6,7,9, 13	2,3,4,6,7,8, 9,13
Alkalis	2,3,4,6,7,8, 9,13,15	2,3,6,7,8,9, 10,13,15,18	2,3,4,6,9,13 15	2,3,4,6,7,8 9,13,15	2,3,4,6,9,13	2,3,4,6,7,9 13,15	2,3,4,6,7,8 9,13,15
Dioxins	2,3,4,5,6,7,9,11, 12,13,15,19,20,21	2,3,5,6,7,9,10, 11,12,13,14,18, 19,20,21	2,3,4,5,6,9,11, 12,13,14,20,21	2,3,4,5,6,9,11, 12,13,14,20,21	2,3,4,5,6,9,11, 12,13,14,20,21	2,3,4,5,6,9, 11,12,13,14, 19,20,21	2,3,4,5,6,7,8,9 11,12,13,14,20,21
Explosives	2,3,4,6,7,8,9,11, 12,13,14,17	2,3,6,7,8,9,10, 11,12,13,14,17,18	2,3,4,6,11,12, 13,14	2,3,4,6,7,8,9, 11,12,13,14,17	2,3,4,6,9,11,12, 13,14	2,3,4,6,7,9, 11,12,13,14	2,3,4,6,7,8,9,11, 12,13,14,17
Heavy metals and cyanide	2,3,4,5,6,7,8,9, 12,13,14,15,19	2,3,5,6,7,8,9, 10,12,13,14,15, 18,19	2,3,4,5,6,12,13, 14,15	2,3,4,5,6,7,8,9, 12,13,14,15	2,3,4,5,6,9,12, 13,14	2,3,4,5,6,7, 9,12,13,14, 15,19	2,3,4,5,6,7,8,9, 12,13,14,15
Low-level radiation	2,3,4,6,7,8,9,11, 12,13,14,17	2,3,6,7,8,9,10, 11,12,13,14,17,18	2,3,4,5,6,11 12,13,14	2,3,4,6,7,8,9, 11,12,13,14,17	2,3,4,6,9,11,12, 13,14	2,3,4,6,7,9, 11,12,13,14	2,3,4,6,7,8,9,11, 12,13,14,17
Organic solvents	2,3,4,6,7,8,9,11 12,13,14,20,21	2,3,6,7,8,9,10, 11,12,13,14,18, 20,21	2,3,4,6,9,11,12, 13,14,20,21	2,3,4,6,7,8,9, 11,12,13,14, 20,21	2,3,4,6,9,11,12, 13,14,20,21	2,3,4,6,7,9, 11,12,13,14, 20,21	2,3,4,6,7,8,9,11, 12,13,14,20,21
Pesticides	2,3,4,5,6,7,8,9, 11,12,13,14,16,19, 20,21	2,3,5,6,7,8,9, 10,11,12,13,14, 16,18,19,20,21	2,3,4,5,6,9,11, 12,13,14,20,21	2,3,4,5,6,7,8, 9,11,12,13,14, 16,20,21	2,3,4,5,6,9,11, 12,13,14,20,21	2,3,4,5,6,7, 9,11,12,13,14, 16,19,20,21	2,3,4,5,6,7,8,9, 11,12,13,14,16, 20,21
PCBs	2,3,4,5,6,7,8,9, 11,12,13,14,19, 20,21	2,3,5,6,7,8,9,10, 11,12,13,14,18, 19,20,21	2,3,4,5,6,11,12, 13,14,20,21	2,3,4,5,6,7,8, 9,11,12,13,14, 20,21	2,3,4,5,6,9,11, 12,13,14,20,21	2,3,4,5,6,7,9, 11,12,13,14, 19,20,21	2,3,4,5,6,7,8,9, 11,12,13,14,20,21

Key for decontamination methods:

1. Asbestos abatement
2. Absorption [b]
3. Demolition [c]
4. Dismantling
5. Dusting/vacuuming
6. Encapsulation
7. Gritblasting [e]
8. Hydroblasting/waterwashing
9. Painting/coating
10. Scarification [e,f]
11. RadKleen
12. Solvent washing
13. Steam cleaning
14. Vapor-phase solvent extraction
15. Acid etching
16. Bleaching
17. Flaming
18. Drilling and spalling [e,f]
19. K-20 sealant
20. Microbiol degradation
21. Photochemical degradation

[a] Refer to individual method descriptions to determine whether an indicated technique has actually been used to treat a particular contaminant/structural material combination, or whether the method is viewed as potentially applicable.
[b] Applicable only to liquids.
[c] Some contaminant residues (e.g., asbestos, explosives, toxic residues) may have to be neutralized, stabilized, or removed prior to demolition to prevent explosions or emissions.
[d] Applicable only to particulates and solids.
[e] Not recommended for removing highly toxic residues or highly sensitive explosives, unless particulates can be controlled.
[f] Applicable only to concrete.

SUMMARY OF NON-ABRASIVE PHYSICAL CLEANING METHODS FOR REMOVAL OF SURFACE CONTAMINATION

	HIGH PRESSURE WATER (200-700 atm)	ULTRA HIGH WATER (1,000-4,000 atm)	HIGH PRESSURE FREON	ULTRASONIC	VACUUM
REMOVAL OF BASE METAL	Negligible	Slight	None	None	None
AREA OF APPLICATION	Internal/ External	Internal/ External	Removable Parts	Immersion of Removable Parts	External
QUANTITY OF WASTE PRODUCED	Moderate - Large	Moderate - Large	Small	Small	Small
WORKER EXPOSURE	Moderate	Moderate	Low	Low	Low
OVERALL COST	Moderate	Moderate-High	High	Low - Moderate	Low
COMMENTS	May not remove tightly adhering surface films	Removes tightly adhering contaminants.	Effectively cleans cloth, rubber, and plastic.	Very effective for cleaning small parts.	Removes weekly adhered, wet or dry contaminants

SUMMARY OF ABRASIVE METHODS FOR REMOVAL OF SURFACE CONTAMINATION

	MECHANICAL METHODS (pigs)	MECHANICAL METHODS (brushes)	ABRASIVE CLEANING (wet)	ABRASIVE CLEANING (dry)	DRY ICE BLASTING
REMOVAL OF BASE METAL	Slight	Negligible	Can be carefully contained	Capable of severe abrasion	Negligible
AREA OF APPLICATION	Internal	Internal/ External	Internal/ External	Internal/ External	External
QUANTITY OF WASTE PRODUCED	Moderate	Moderate	Large	Large	Small
WORKER EXPOSURE	Low	Moderate	Moderate	High	Moderate
OVERALL COST	Low	Low	Moderate	Moderate	Moderate
COMMENTS	Flexible and compressible Cleans-small diameter pipes.	Wide range of brush sizes and bristle stiffness.	Removes tightly adhering material. No air pollution.	Dust may be explosive.	Useful for removing smearable contaminants.

SUMMARY OF CHEMICAL DEGRADATION METHODS
FOR REMOVAL OF SURFACE CONTAMINATION

	HIGH INTENSITY LIGHT	UV LIGHT CLEANING	ELECTRO POLISHING
REMOVAL OF BASE METAL	None	None	Can be carefully controlled
AREA OF APPLICATION	External	External	External/ Internal
QUANTITY OF OF WASTE PRODUCED	Small	Small	Moderate
WORKER EXPOSURE	Low	Low	Moderate
OVERALL COSTS	Low-Moderate	Low-Moderate	Moderate-High
COMMENTS	Most effective on flat surfaces	Gross contamination must be removed first for UV to be effective	Contaminated object must be immersed in a liquid bath

SUMMARY OF SOLUBILIZATION METHODS FOR
REMOVAL OF SURFACE CONTAMINATION

	FOAMS, GELS, AND PASTES	DETERGENTS, AQUEOUS SURFACTANTS	ORGANIC SOLVENTS
REMOVAL OF BASE METAL	None-Slight	None	None-Slight
AREA OF APPLICATION	Internal/ External	Internal/ External	Internal/ External
QUANTITY OF WASTE PRODUCED	Small	Large	Moderate
WORKER EXPOSURE	Foam: low Gels & Pastes: Moderate	Moderate	Moderate
OVERALL COSTS	Moderate-High	Moderate	Moderate-High
COMMENTS	Gels and pastes cannot be easily applied to the inside of small diameter pipes	Formulations may be tailored to specific contaminants	May be flammable, and/or damage non-metal surfaces. Limited effectiveness on vertical surfaces

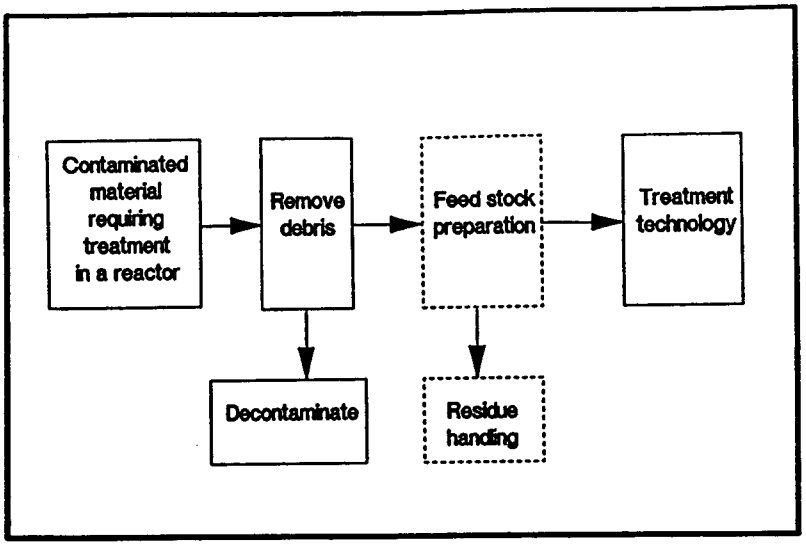
DEBRIS HANDLING AT SUPERFUND SITES

Site Name	Contact	EPA Region	Major Contaminant	Recommended Clean-Up Alternative	Debris Types	Debris Handling
1. Kane & Lombard	Charles Kufs	III	Organics, Metals	Incineration Soil Washing Containment In-situ Vitrification (ISV)	Concrete Rocks Metals	Presorting and Shredding
2. Ambler Asbestos	Frank Finger	III	Asbestos, $CaCO_3$	ISV Containment Capping Off-site Land Disposal	None Reported	
3. Myers Property	Victor Velez	II	Organics, Metals	Solidification/Stabilization Biological Degradation Soil Washing Off-site Land Disposal (untreated waste)	Pebbles Boulders Wood Bolts	
4. Fried Industries	Victor Velez	II	Organics	Biological Degradation Low Temperature Thermal Stripping Incineration Soil Washing	Drums	
5. Roebling Steel	George Anastos	II	Metals, Organics, Asbestos	FS Not Done; RI in Progress Partial Emergency Removal Action	Tires Shredded Rubber Shredded Plastic Concrete Baghouse Dust Buildings and Metals Wire, Cables	
6. Morgantown	Ralph Shapot	III	Organics, Metals	Capping Incineration	Tires Refrigerators Wood Concrete Cloth	Separation
7. Southern MO	Jay Motwani	III	Organics, Dioxins	Biological Degradation Incineration Soil Washing ISV Activated	Railroad Ties Rails, Wood Concrete, Rock	
8. Cryochem	R. Purcell	III	Organics	Work Plan Stage	No Debris	
9. Shaffer	—	III	PCBs	Methanol Extraction	Tires Large Stones	Vibratory Screen-Set Aside
10. Montgomery Bros.	T. Massey	III	Organics	Off-site Disposal	Drums Residential Trash	Off-site Disposal
11. Bridgeport Oil	D. Lynch	II	Oil Water	Incinerate Lagoon Contents	Wood, Drums Tanks Buildings	Clean Tanks
12. Swissvale	J. Downey	III	Dioxins, PCBs	Off-site Disposal in Secure Landfill and Recycling	Buildings Metals Drums	Dioxins to Secure Landfill; Steel Decontaminated and Recycled to Steel Mill

Continued

DEBRIS HANDLING AT SUPERFUND SITES (CONTINUED)

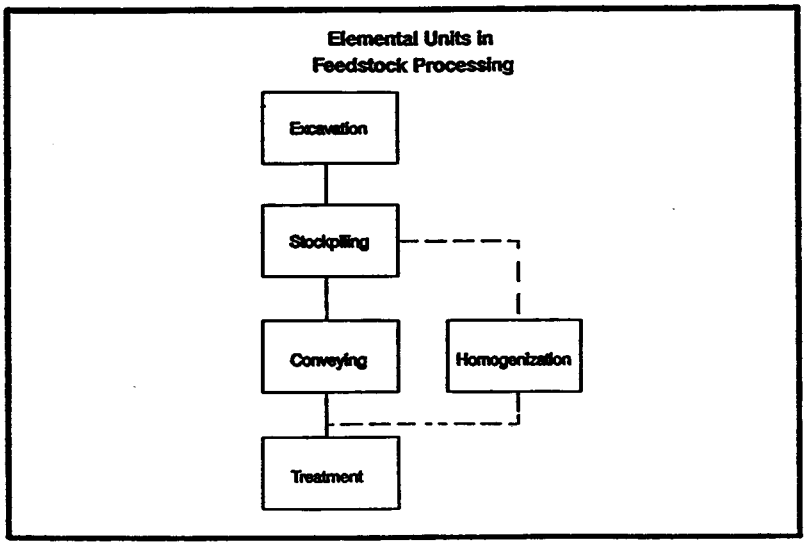
Site Name	Contact	EPA Region	Major Contaminant	Recommended Clean-Up Alternative	Debris Types	Debris Handling
13. Allied-Hopkins	---	V	Toxaphene, DDT Xylene	Incineration Off-Site Disposal	Railroads Ties Rails Concrete Pad Blocks	Rails Decontaminated for Re-Use Railroad Ties Concrete to Secure Landfill
14. Baird & McGuire	Ms. Sanderson	I	Cresote, Dioxins	Incineration Off-site Disposal	Tanks Wood Buildings Masonry	Metal-Recycled Wood-Shredded and Incinerated Masonry-Off-Site Disposal
15. Metaltec/ Aerosystem, NJ	M. Rusin	II	TCE	Heat Treatment Rotary Dryer	No Debris Large Stones	Screening of Stones/Rocks
16. Syncon	E. Finnerty	II	Pesticides PCBs, Metals	Off-site Disposal On-site Capping	Buildings Tanks Piping, Heat-Coils	Buildings and Tanks-Decontaminated for Future Use Piping, etc, -Off-site Disposal
17. Delaware City	G. Chodwick	III	PVC, TCE	Off-site Disposal Reuse of Recoverable Product	No Debris	Reuse of Recoverable Product
18. Drake Chemical	T. Legel	III	Organics and Inorganics	Off-Site Disposal	Furniture Piping	Off-Site Disposal
19. Coleman Evans	C. Teepen	IV	PCP	Incineration	Miscellaneous	Separation with Shredding and Recycling of Metals
20. Hollingsworth	E. Zimmerman	IV	TCE, Metals	Vacuum Extraction	None	
21. MowGray Engineering	J. Trudeau	IV	PCBs	Solidification	None	
22. Sapp Battery	E. Moore	IV	Lead, Cadmium	Solidification	Battery Cases	Crushing
23. LaSalle Electrical	B. Cattiche	V	PCBs	Incineration	Roots, Sticks, Stones	Screening
24. Metamora Landfill	J. Tanaka	V	VOCs, Metals	Incineration		
25. Geneva Industries	D. Williams	VI	VOCs, PCBs PAHs	Off-Site Disposal	Tanks Prefabricated Buildings Cracking Tower Houses	Off-Site Disposal
26. United Creosoting	D. Williams	VI	PCPs, PAHs	On-Going Investigation		Clean Wipe Samples Recycle
27. Denver/ROBCO	J. Brink	VIII	Radiation	Off-Site Disposal Wood	Miscellaneous Masonry	Separation of Materials



MATERIALS HANDLING/SEPARATION

Feedstock Preparation is...

- The physical screening and sizing of contaminated soil and debris for subsequent "ultimate" treatment technologies
- The "leveling" of contaminant concentrations in the waste feed to allow for smoother unit process operations and minimize system upsets

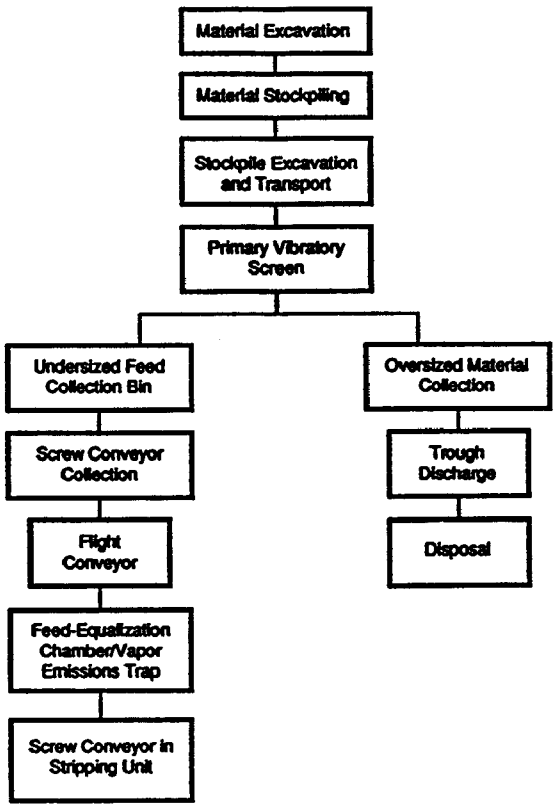


SIZE LIMITATIONS OF ULTIMATE TREATMENT TECHNOLOGIES

Technology	Maximum Debris Size
Incineration	6" (effective)
Low temperature desorption	1/4"
Chemical dechlorination	1/2"
Solidification/stabilization	1/4"
Soils washing	2"
Biological degradation	1/2"

FEEDSTOCK PREPARATION

- Physical pre-processing of over-sized material conditioning
  - -crushing
  - -shredding
  - -screening
  - -jigging
  - -separation
  - -dewatering, etc.
- Chemical preconditioning, such as neutralization, oxidation/reduction, etc



LT³ Feedstock preparation process flow diagram.

(Weston, 1988)

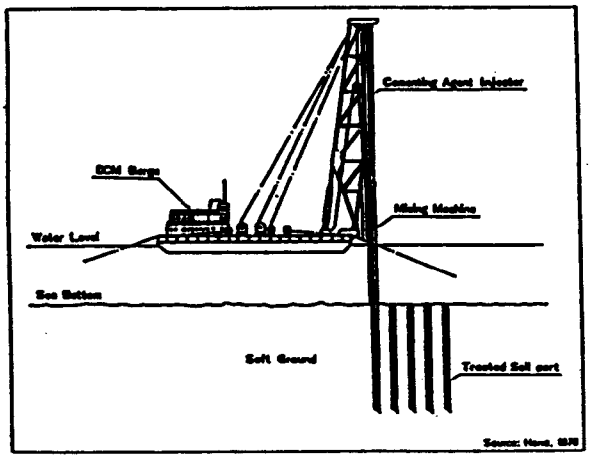
SCREENING

Function: Separate oversized or incompatible waste

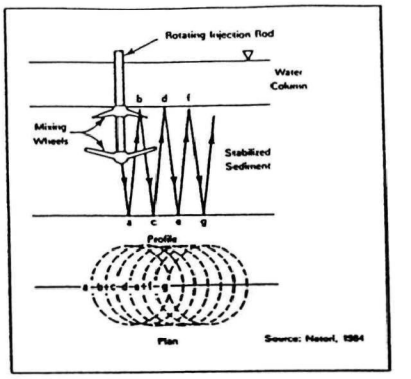
- Equipment
  - -rotary screens
  - -vibrating screens
  - -stationary screens

ASSESSMENT OF FEEDSTOCK PREPARATION TECHNOLOGIES

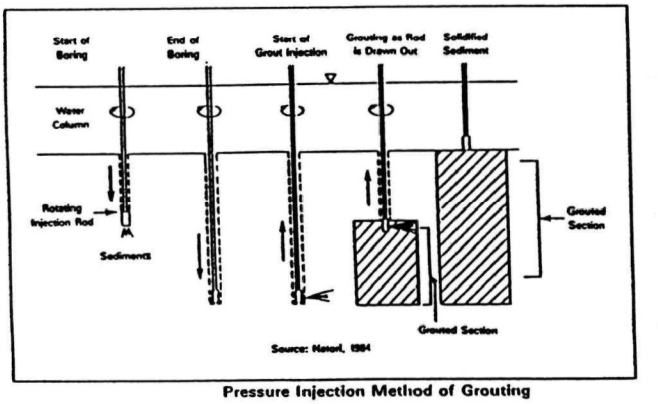
	Status	Function	Application	Cost
Crushing/ grinding	commercial	size reduction	high	low
Screening/ separation	commercial	separate oversized materials	high	low
Magnetic	commercial	presort	ferrous metals only	low



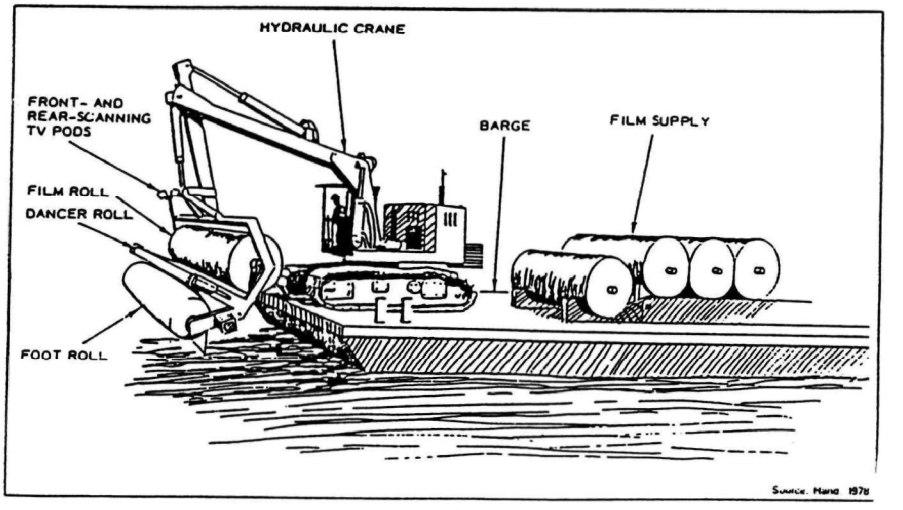
Fixation by Deep Chemical Mixing Method



Continuous Mixing Methods of Grouting



Pressure Injection Method of Grouting



Deck Arrangement for Barge-Mounted Apparatus for Preform Film Overlay System

SEPARATION OF INORGANIC CONTAMINANTS FROM SOILS AND SLUDGES

Abstract 4-2

Slides 4-4

SEPARATION OF INORGANIC CONTAMINANTS FROM SOIL AND DEBRIS

Bill Schmidt
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Superfund site inorganic contamination treatment is a special case of mineral production in which the value of the removed contaminant is generally measured in terms of factors other than market value of the metal extracted. The technology issues are essentially identical to those of mineral processing and are based on the fact that, with the proper choice of technique, any inorganic material can be separated from its host environment.

There are a number of general considerations that need to be considered by the decision maker faced with the problem. For example, SARA speaks to "...reduction in the toxicity, mobility, or volume.."—is volume reduction a goal or means to an end? Physical separation (beneficiation) of the material can meet the third part directly and contribute to the attainment of the first two SARA objectives. Another is comminution or size reduction. Crushing/grinding can often prove beneficial for Superfund treatment problems. Examples are provided of both typical minerals industry reasons for comminution as well as Superfund applications.

There are a number of subsets of the separation problem. One involves the separation of metals or compounds with physical properties different than the host matrix. The basic rule of thumb is that, if you can see the offending material, you can physically separate it. There are a number of techniques that might be employed. For example:

A. Size separation
B. Gravity separation
   1. Heavy media
   2. Spiral Concentrators
   3. Tabling
   4. Jigging
   5. Air/water classification
   6. Other
C. Magnetic separation
   1. Conventional
   2. High gradient
D. Electrostatic
E. Flotation
   1. Chemically enhanced
      a. Standard Flotation Cells
      b. Column Flotation
      c. Air–Sparged Hydrocyclone
   2. REDOX
F. Other
   1. Color
   2. Shape

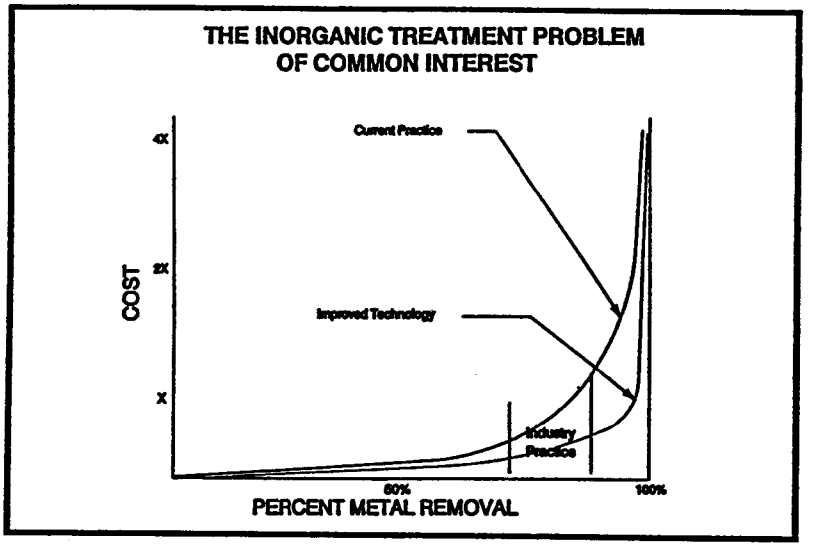
Another class of problem involves separation of metals or compounds with physical properties similar to the host matrix. There are a number of options here including:

A. Leaching (Corrosion)
   1. Water
   2. Acid/Base
   3. Other
      – Microbes
B. Thermal
   (Many tend to think of thermal techniques as contaminant "destruction" rather than the tool for altering the form of the compound that it really is. In the case of metals, which cannot be destroyed, one can increase or decrease the oxidation state, change the form of the compounds, selectively separate one metal (or form of metal) from another, etc.)
   1. Incineration
   2. Pyrolysis
   3. Other
C. Recovery of the Inorganic Contaminant
   1. Precipitation
   2. Electrowinning
   3. Solvent Extraction
   4. Ion Exchange
   5. Reverse Osmosis
   6. Other
      – Microbes
      – Other Novel

In assessing the options, one must also be mindful of other considerations. For example, what are the true objectives of treatment operation? Are there combinations of technologies that ought to be considered? In mineral processing practice, rarely are the unit operations described above employed singly—but rather, almost always in combinations. Are there multiple contaminants? If so, one needs to be mindful of the need to investigate the fate of all of the contaminants of concern. Are there organics and organometallics? There is also the need to give careful consideration to process residuals and byproducts e.g., off gasses, leachates and solid residuals.

BUREAU PERSPECTIVE

- Superfund inorganic contamination treatment is a special case of mineral production
- Any inorganic material can be separated from its host environment



PERFORMANCE QUESTIONS

- Are results typical or best results?
- What size soil fractions were cleaned?
- How reproducible are results?
- Will results meet site-specific U.S. regulatory standards?

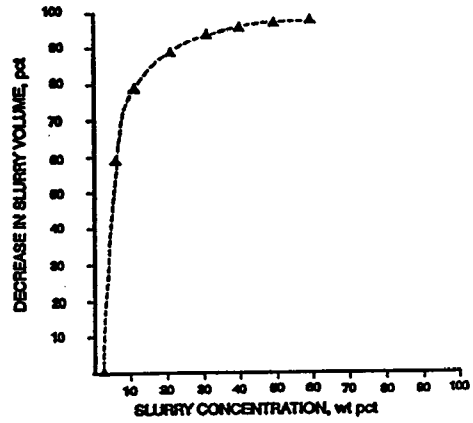
A RECOMMENDED APPROACH

- Thoroughly characterize sites and define potential remediation problems
- Develop remediation procedures based on site data and laboratory data
- Prove procedures in tests
- Remediate sites

VOLUME REDUCTION

- Goal or means to an end?
- SARA - "..reduction in the toxicity, mobility, or volume.."

Effect of Increase in Slurry Concentration On Volume of Slurry



SEPARATION

- Meets volume reduction goals directly
- Indirectly contributes to attainment of toxicity and mobility goals

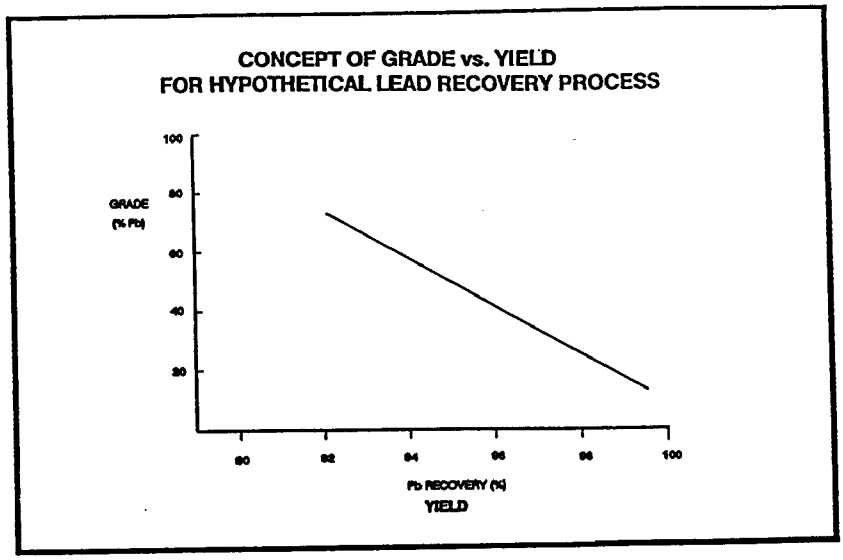
COMMINUTION

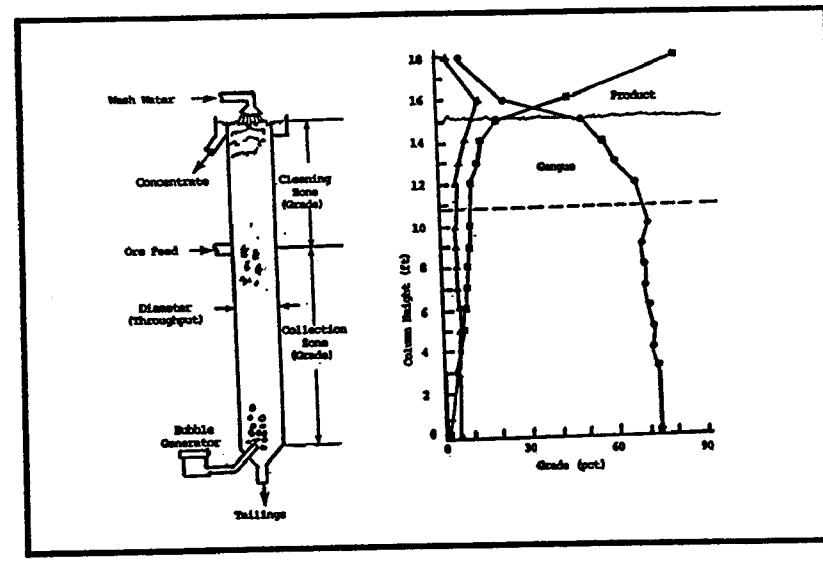
Crushing/grinding is often beneficial for Superfund treatment problems

TRADEOFFS

Grade vs. Yield

- Separation is relatively inexpensive
- Practical limitations





METALS OR COMPOUNDS

WITH PHYSICAL PROPERTIES

DIFFERENT THAN

THE HOST MATRIX

"If you can see
the offending material,
you can physically
separate it"

SIZE SEPARATION

- Screens, vibrating screens, etc.
- Application to oversize, non-contaminating materials

GRAVITY SEPARATION

- Heavy media
- Spiral concentrators
- Tabling
- Jigging
- Air/water classification
- Other

MAGNETIC SEPARATION

- Conventional
- High gradient

ELECTROSTATIC SEPARATION

FLOTATION

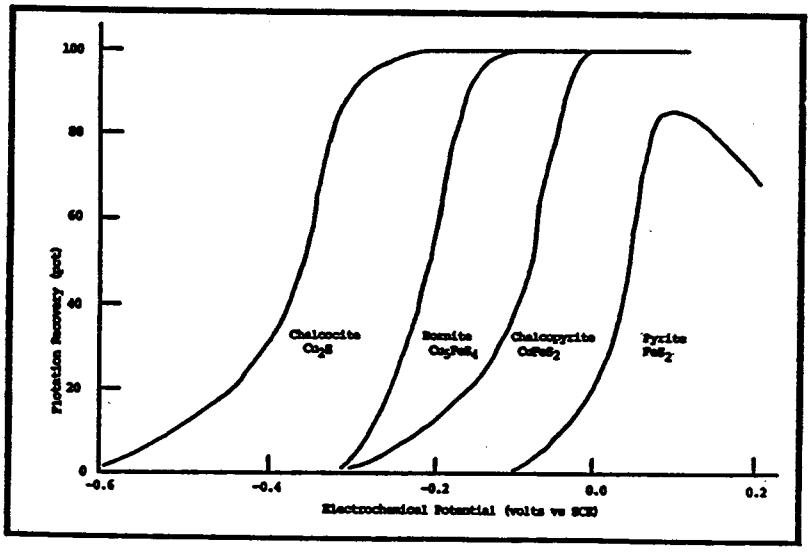
- Chemically enhanced
- REDOX

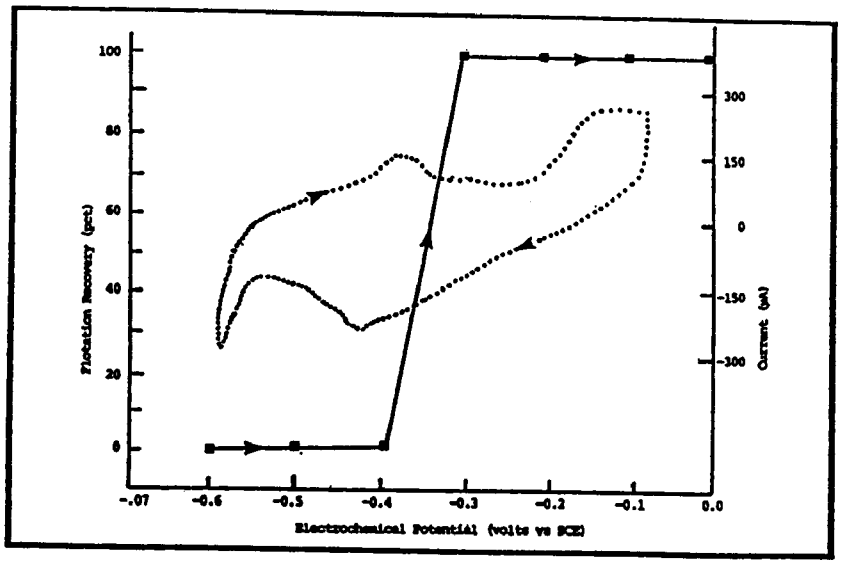
CHEMICALLY ENHANCED FLOTATION

Chemically "waterproofs" the material of interest which causes air bubbles to adhere and float it to the surface of the liquid

REDOX

Sometimes the surface properties of the mineral of interest can be controlled, e.g., by controlling oxygen-exposure during the grinding of sulfide ores





OTHER SEPARATION CRITERIA

- Color
- Shape

METALS OR COMPOUNDS WITH PHYSICAL PROPERTIES SIMILAR TO THE HOST MATRIX

LEACHING
(Corrosion)

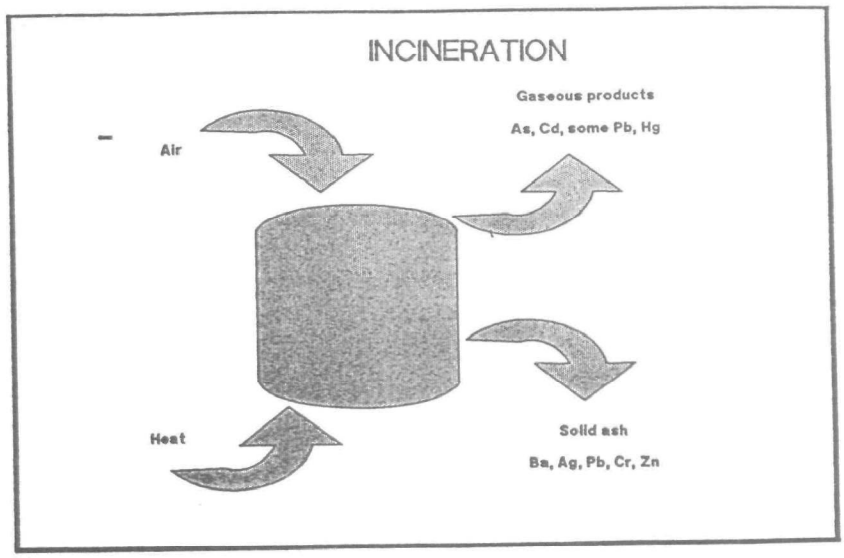
- Water
- Acid/base
- Other
  -Microbes

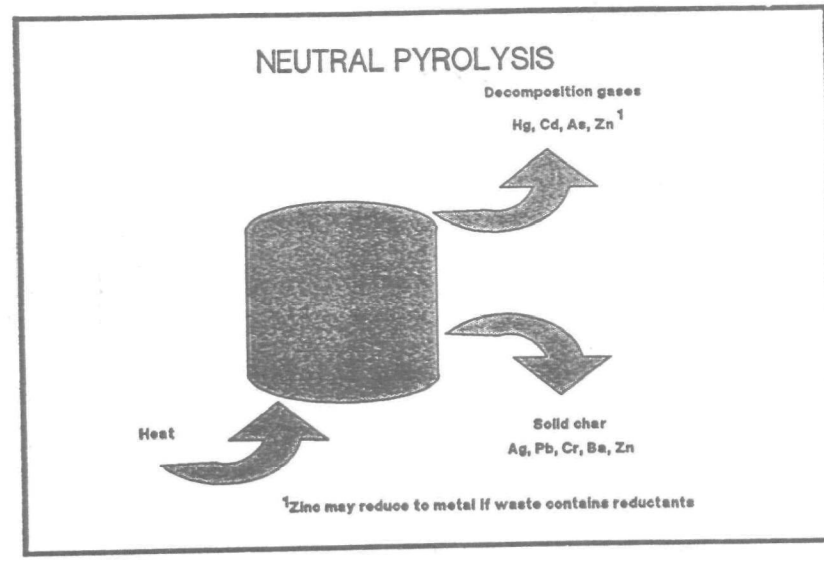
THERMAL TECHNIQUES
Altering the Form of the Compound

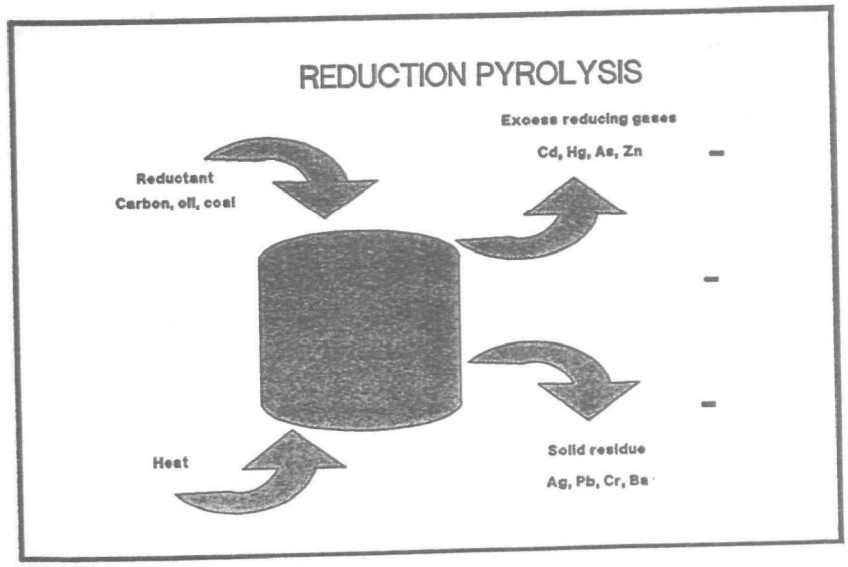
- Increase/decrease oxidation state
- Change form of compounds
- Selectively separate one metal from another

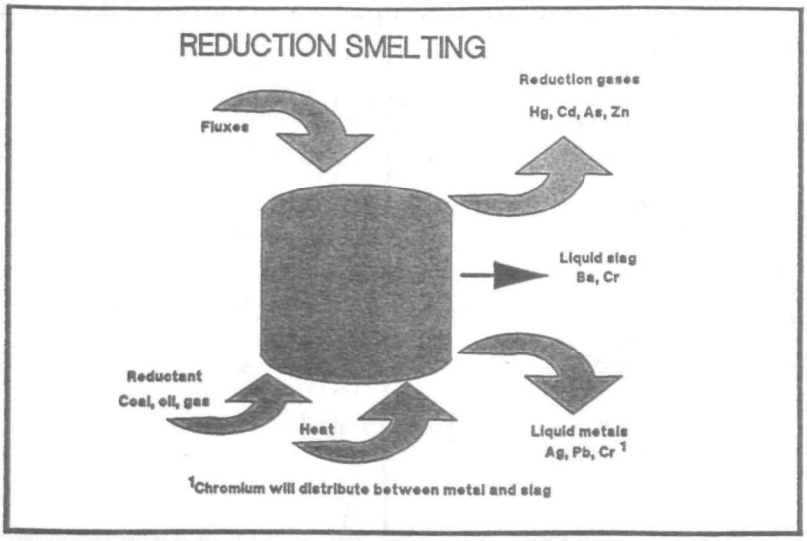
THERMAL PROCESSES

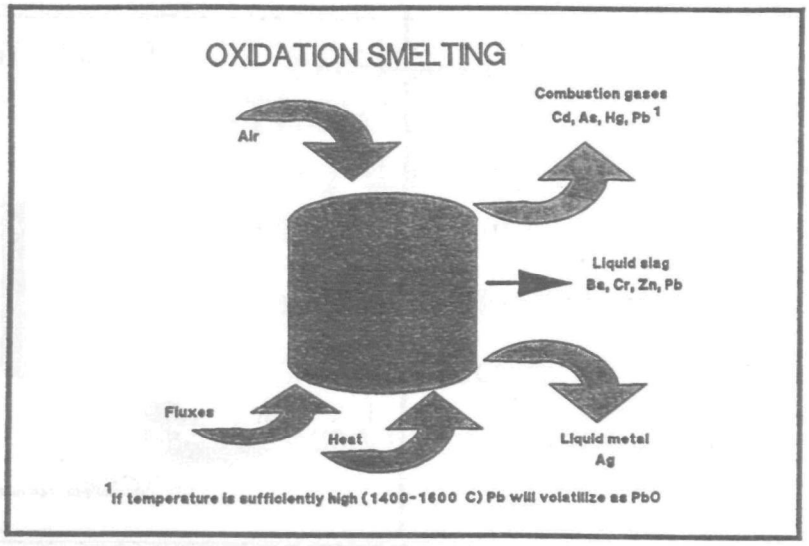
- Incineration
- Pyrolysis
- Other


INCINERATION
Air
Gaseous products
As, Cd, some Pb, Hg
Heat
Solid ash
Ba, Ag, Pb, Cr, Zn


NEUTRAL PYROLYSIS
Decomposition gases
Hg, Cd, As, Zn 1
Heat
Solid char
Ag, Pb, Cr, Ba, Zn
1Zinc may reduce to metal if waste contains reductants


REDUCTION PYROLYSIS
Excess reducing gases
Cd, Hg, As, Zn
Reductant
Carbon, oil, coal
Heat
Solid residue
Ag, Pb, Cr, Ba





VAPOR PRESSURES FOR SELECTED METALS

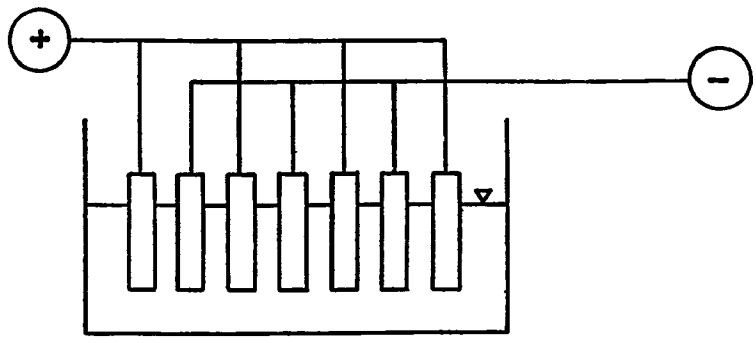
Metals	100 mm Hg V.P.	760 mm Hg V.P.
Ag	1865°C	2212°C
Cd	611	765
Hg	261	357
Pb	1421	1744
Cr	2139	2482
As	518	760
Ba	1301	1638
Zn	736	907

VAPOR PRESSURES FOR SELECTED OXIDES

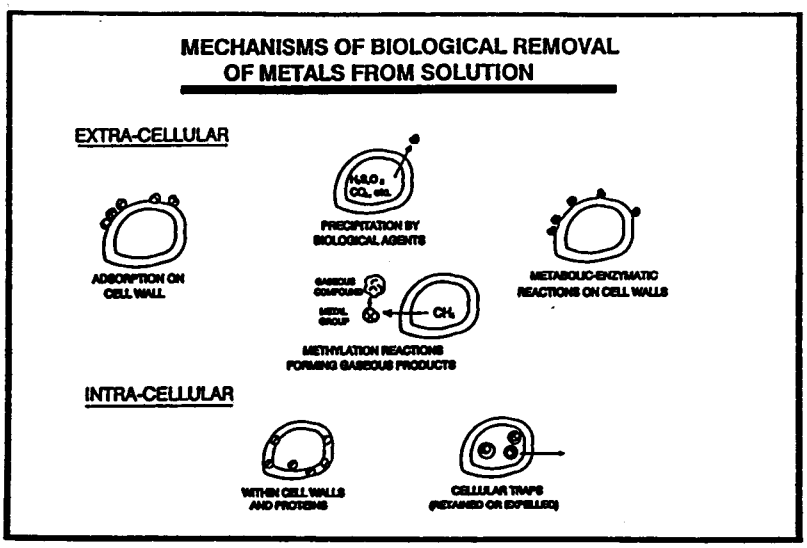
Oxides	100 mm Hg V.P.	760 mm Hg V.P.
CdO	1341°C	1559°C
As_2O_3	332	457
PbO	1265	1472

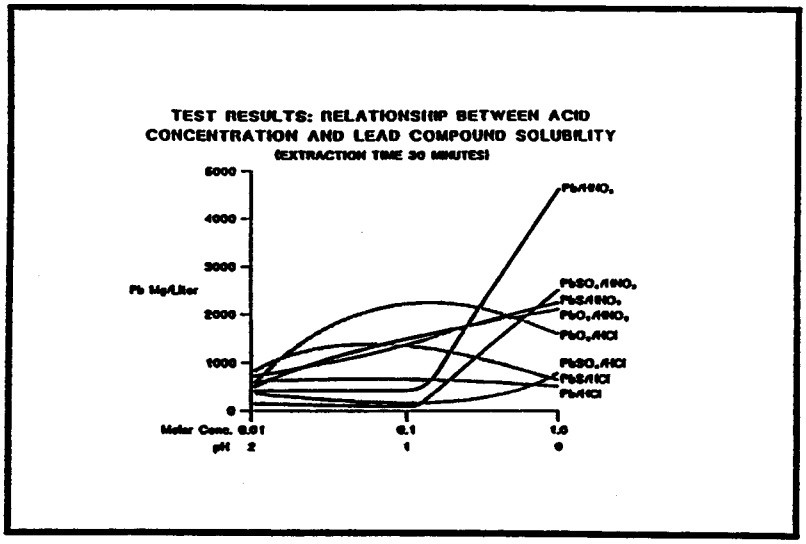
RECOVERY OF THE INORGANIC CONTAMINANT

- Precipitation
- Electrowinning
- Solvent Extraction
- Ion Exchange
- Reverse Osmosis
- Other
  - -Microbes
  - -Other novel



Electrolytic Refining





SPECIAL CONSIDERATIONS

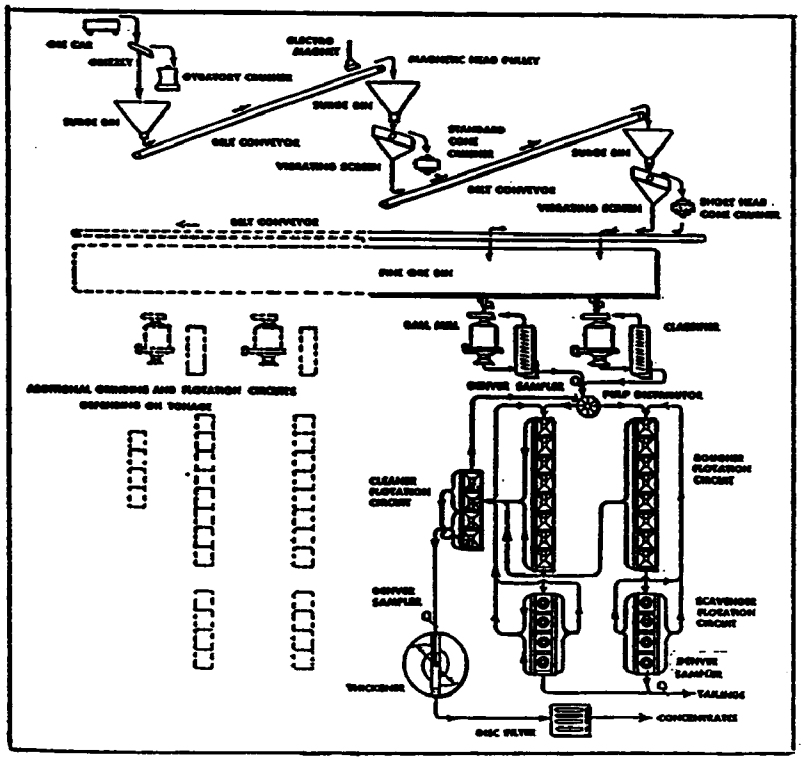
- Objectives of treatment operation
- Combinations of technologies
- Multiple contaminants
- Organics and organometallics
- Process residuals/byproducts

OBJECTIVES OF TREATMENT OPERATION

- Desired product
- Other constraints
  - -time
  - -noise
  - -cost

COMBINATIONS OF TECHNOLOGIES

In mineral processing practice, rarely are unit operations employed singly



COPPER RECOVERY BY FLOTATION

MULTIPLE CONTAMINANTS

Need to be mindful of the need to investigate the fate of all of the contaminants of concern

ORGANICS AND ORGANOMETALLICS

- In general, outside realm of minerals industry experience
- Certain relationships can be postulated
  - -effect of thermal treatment on mixed contaminant wastes
  - -effect of air-sparging on volatile organics
- More research needed

PROCESS RESIDUALS/BYPRODUCTS

- Off gases
- Neutralization
- Flushing
- Dewatering/reconstruction

SEPARATION AND TREATMENT OF INORGANICS IN AQUEOUS MATRICES

Abstract 5-2

Slides 5-6

SEPARATION AND TREATMENT OF INORGANICS IN AQUEOUS MATRICES

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INTRODUCTION

The improper disposal of partially treated and untreated hazardous wastes often poses problems as these hazardous materials slowly migrate from their disposal areas and contaminate soil, groundwater and surface waters. Similarly, these discharges to publicly owned treatment works (POTWs) may impact the efficacy of the treatment process, pass through the treatment plant untreated, or partition to and contaminate the sludge if present at significant concentrations. One class of hazardous materials that must be addressed is inorganics in an aqueous matrix. Potential avenues for avoiding these problems include pretreatment of the wastes to render them less toxic or more amenable to subsequent treatment processes, treatment of the liquid waste (primarily focused at the separation of solids from the liquid), and reclamation of the hazardous constituents.

PRETREATMENT

Pretreatment of inorganic waste streams may typically include neutralization, oxidation or reduction, and solids/liquid separation. These physical–chemical unit processes by themselves or in conjunction with one another are often required prior to implementing subsequent treatment or reclamation processes.

Neutralization involves combining either an acid or a base with a hazardous waste stream to adjust the liquid pH to acceptable levels. Neutralization may be required as a pretreatment or post–treatment process. Lime, calcium hydroxide, caustic, soda ash, and ammonium hydroxide are common bases; sulfuric acid, hydrochloric acid, and nitric acid are common acids used for neutralization. Acid–base reactions are among the most prevalent of the chemical processes used in water and wastewater treatment. It is fortunate that commercially available acids and bases are relatively low in cost. The availability of "waste chemicals" for providing neutralization should not be overlooked. For example, pickle liquor from the steel industry is useful both for its acid value and for its iron content useful as a coagulant; and also sludge from lime–soda water softening is a good source of alkali for neutralization of acid wastes.

Chemical reduction involves the transfer of electrons from one compound to another, and is used to either render compounds nontoxic, or transform it to a form which can be removed by subsequent chemical or physical unit treatment processes. It is best applied to liquid wastes free of organic compounds. It is widely used in industry to control hexavalent chromium wastes, and to remove and/or recover mercury from mercury cells in chlor–alkali manufacturing. Chemical reduction is also a common hazardous waste technology for reducing complexed or chelated metals, such as copper and nickel, found in aqueous metal plating wastes. Precipitation of recovered metals is required after reduction, if not already accomplished. Filtration often follows.

Chemical oxidation, the antithesis of reduction, is also a viable treatment alternative for certain inorganic waste streams. This process is particularly applicable for the destruction of cyanide and for changing the oxidation state of certain metals such as arsenic in order to permit the removal by subsequent unit sedimentation or filtration processes.

Solids/liquid separation in water and wastewater treatment includes the processes for removal of suspended solids from water by sedimentation, dissolved air flotation, centrifugation, screening and filtration. Selection of the specific process or combined processes for removal of suspended solids from water depending on the character of the solids, their concentration, and the required filtrate clarity. For example, large or dense particles could probably be removed by simple screening or sedimentation. In contrast, fine solids may require both sedimentation and filtration, usually aided by chemical treatment.

TREATMENT

Treatment processes for removing inorganics from an aqueous environment include coagulation/flocculation, precipitation, media filtration processes, and adsorption.

The processes of coagulation and flocculation are employed to separate suspended solids from water whenever their natural subsidence rates are too slow to provide effective clarification. Particles in suspension within an aqueous matrix are stabilized by negative electric charges on its surface, causing it to repel neighboring particles, just as magnetic poles repel each other. Since this prevents these charged particles from colliding to form larger "flocs," they do not settle very rapidly. Coagulation is the destabilization of these colloids by neutralizing the forces that keep them apart. This is generally accomplished by adding chemical coagulants such as aluminum salts, iron salts, or polyelectrolytes and applying mixing energy. The floc–building step is termed flocculation. Precipitation, clarification, sludge thickening and dewatering depend upon correct application of the theories of coagulation and flocculation for their success.

Chemical precipitation is a physical–chemical process in which a dissolved contaminant is transformed into an insoluble solid, facilitating its subsequent removal from the liquid phase by sedimentation or filtration. The process usually involves adjustment of pH in order to shift the chemical equilibrium to a point that no longer favors solubility, addition of the chemical precipitant, and finally flocculation in which the precipitated particles agglommerate into larger particles. Usually, metals are precipitated from solution as either their hydroxides, sulfides, or carbonates. The solubilities of the specific metal(s) requiring treatment and the clean–up standards required will typically dictate the precipitation process to be employed. For instance, metal sulfides are generally much less soluble than hydroxides, thus better removal efficiencies are achievable.

Solids separation by means of media filtration encompasses pressure filters, belt filter presses, plate and frame filters, vacuum filters, ultrafiltration and reverse osmosis.

Adsorption is the physical adhesion of molecules or colloids to the surface of a solid; an adsorbent such as granular activated carbon, without chemical reaction. The process is particularly applicable for organics and to a lesser extent inorganics. In some respects, adsorption is similar to coagulation and flocculation. One distinction is that adsorption generally uses an adsorbent solid processed especially for water treatment; whereas in coagulation and flocculation, the adsorbent is produced in situ by the reaction of a chemical, such as alum, with water.

RECOVERY PROCESSES

Several reclamation processes have been demonstrated effective and are in common use within the hazardous waste industry.

Ion exchange is a process which reversibly exchanges ions in solution with ions retained on a reactive solid material called ion resin. A typical ion exchange system has a fixed bed of ion exchange resin, where the resin has either the ability to exchange positively charged ions (cation exchange) or negatively charged ions (anion exchange). Depending on the charge of the resin, anions or cations will be held by electrostatic forces to the charged sites. Generally, divalent and trivalent ions have a higher affinity for ion exchange than monovalent ions. Thus, toxic metal cations such as divalent cadmium and nickel, and anions like divalent chromate and selenate are effeciently-removed by ion exchange.

Reverse osmosis (RO), or "membrane chemical filtration," is a pressure driven membrane separation process. There is no destruction of the chemicals in the process; they are merely concentrated making reclamation possible. The feed is separated under pressure into a purified "permeate" stream and a concentrate stream by selective passage of water through the microscopic pores of the semipermeable membrane. RO is a low energy process. There is no phase change required for separation of the dissolved materials and therefore no latent heat of vaporization, fusion, or sublimation is required to effect separation. RO requires only pressure energy which is normally supplied through a pump run by a simple electric motor. RO systems have been implemented for reclaiming nickel, chromium and aluminum.

For a limited number of applications, acid regeneration techniques may be worthy of consideration. These techniques have been employed in the iron and steel industry for the past twenty years and include evaporation, crystallization, roasting and solvent extraction. The purpose of acid regeneration is to concentrate the acid (i.e., hydrochloric, sulfuric, nitric or hydrofluoric), and remove any impurities to permit its reuse. Recently, a new process has been developed for this purpose. The Acid Purification Unit (APU) uses synthetic resins to adsorb strong acids from solutions and reject metal salts of these acids. This system can be scaled for small volume applications. A major drawback of acid regeneration systems is that they cannot separate mixed acids and can be somewhat expensive to construct and operate. However, commercial acid regeneration facilities do exist and should be considered if a large volume of acidic waste requires treatment.

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CHARACTERIZING THE WASTE STREAM

"Having a Sense of Where You Are"

SOLIDS CONTENT

- Suspended or dissolved
- Volatile or fixed
- Settleable

FIELD PARAMETERS

- Temperature
- pH
- Turbidity
- Conductivity
- Oxidation-reduction potential

IMPORTANT SITE CHARACTERISTICS

- Permeability
- Other inorganics (iron, magnesium)
- Organics present
  - chelating properties
  - by-products of incomplete oxidation
  - chemical demand
  - rate of reaction or reagent requiremnts

OTHER CONSIDERATIONS

- Site characterization
  - above ground
  - in-situ
- Life cycle design
  - staged process
  - equipment design

SPECIFIC METALS

- Species
- Analytical Method (DL)
- Which metals?

SPECIATION

	Occurrence in natural setting	
	Common	Rare
• Arsenic species	As^{+3} As^{+5}	As^{0} As^{-3}
• Chromium species	Cr^{+3} Cr^{+6}	Cr^{+2}
• Selenium species	Se^{+4} Se^{+6}	Se^{-2}

FIELD/LABORATORY TESTING

- Titration curves
- Jar testing
- Filtration studies
- Isotherm studies

APPLYING "THE PROCESS" TO INORGANICS IN THE AQUEOUS PHASE

NEUTRALIZATION

Function: Render acid or caustic waste non-corrosive by pH adjustment.

TYPICAL NEUTRALIZING AGENTS

H_2SO_4	$Ca(OH)_2$, CaO
HCl	NaOH
HNO_3	$NaHCO_3$ Na_2CO_3 $Mg(OH)_2$

CHEMICAL PRECIPITATION

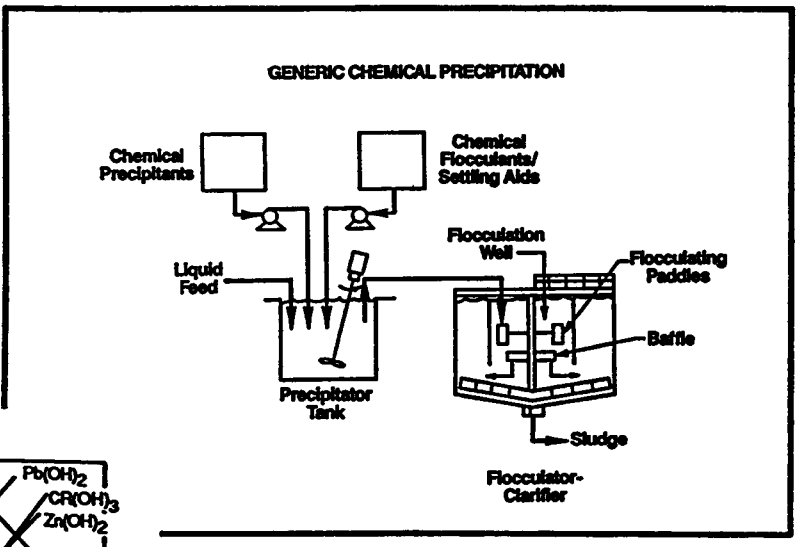
Function: Remove dissolved metals from aqueous waste and chemical conversion to insoluble form

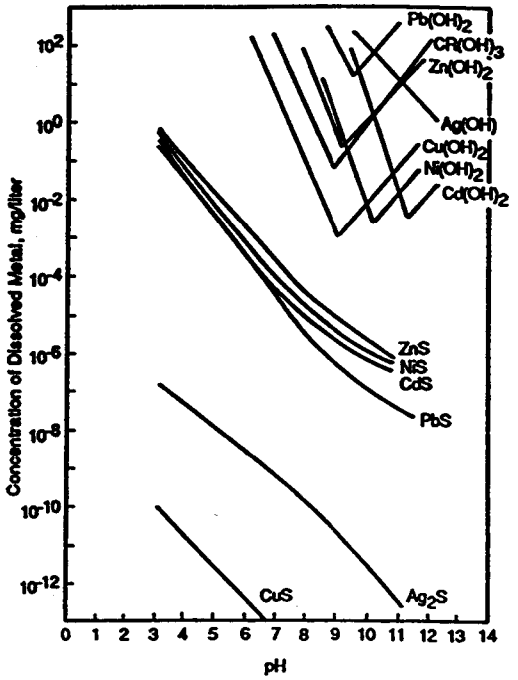
Combination of coagulation, flocculation, sedimentation and filtration processes

CHEMICAL PRECIPITATION

Removal of heavy metals primarily as hydroxides, sulfides, and carbonates

(Cr^{+3}, As^{+5}, Hg^{0}, Se^{+4})





COMPARISON OF PRECIPITATION REAGENTS

Lime	least expensive, generates highest sludge volume
Caustic and Carbonates	more expensive than lime, generates smaller amount of sludge, applicable for metals where their minimum solubility within a pH range is not sufficient to meet clean up criteria
Sulfides	effective treatment for solutions with lower metal concentrations
Sodium borohydride	expensive reagent, produces small sludge volumes which can be reclaimed

CHEMICAL PRECIPITATION
Limitations

- Mixed metals - optimum pH
- Chelating/complexing agents

CHEMICAL PRECIPITATION
Residuals

- Metal sludge
- Treated effluent
  - elevated pH
  - excess sulfide

OXIDATION/REDUCTION FOR INORGANICS

Oxidation:

Increase the oxidation state of a substance by the removal of electrons or the addition of oxygen

OXIDATION/REDUCTION FOR INORGANICS

Reduction:

Decrease the oxidation state by transferring reactive electron from reducing agent to the contaminant

APPLICATION

Oxidation

- CN Bearing Wastes
- Arsenic

CHEMICAL OXIDATION

Technology Status

- Widely used for CN oxidation
- Gaining acceptance for aqueous treatment of trace organics
- Limited application for in-situ treatment

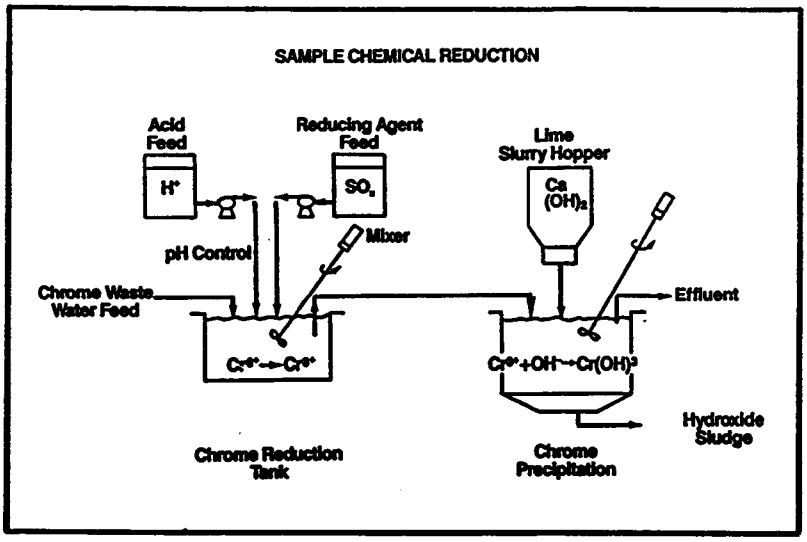
CHEMICAL REDUCTION

- Function:
  - -reduce oxidation state of metal
  - -render non-toxic/facilitate precipitation
- Applicability:
  - -Cr(VI)
  - -mercury
  - -organic lead compounds
  - -chelated metals
  - -reducing agents
    SO_2, $NaHSO_3$, Fe(II), $NaBH_4$

APPLICATION

Reduction

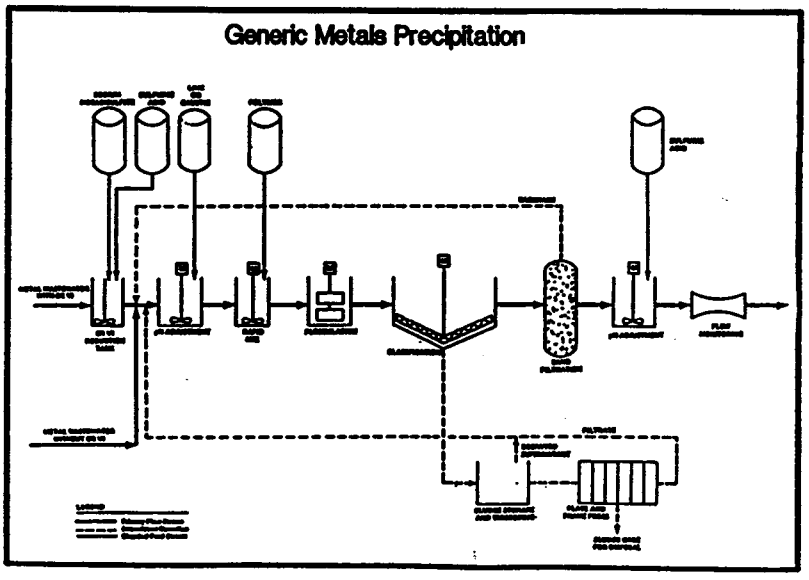
- Cr^{+6}
- Se^{+6}
- Certain Chelated Wastes



CHEMICAL REDUCTION

Limitations

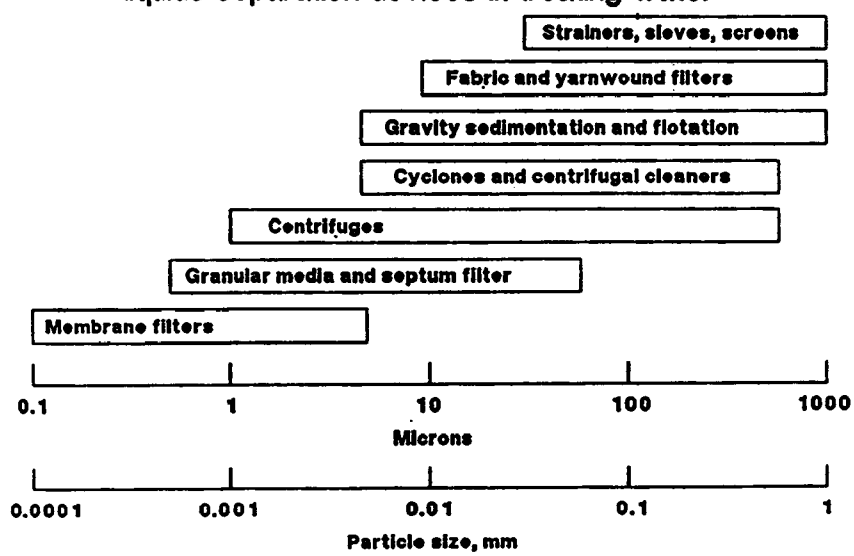
- Reducing agents are non-selective
- Quantity of residuals generated in subsequent processes is of concern
- Violent reactions are possible
- Air emissions
- Potential odors
- Difficult to apply to slurries, tars or sludges



SOLIDS/LIQUID SEPARATION

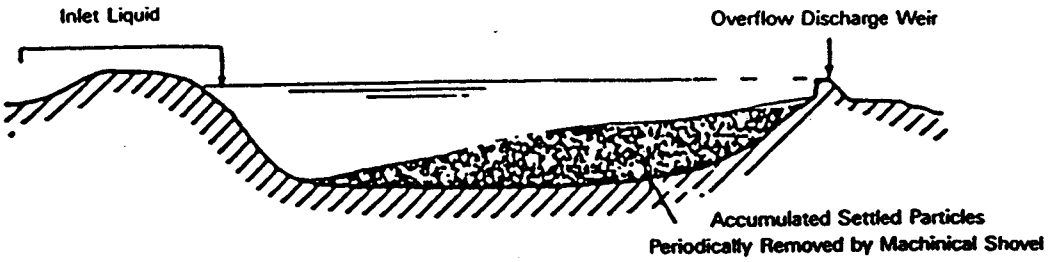
Removal of suspended solids from water by sedimentation, straining, flotation, and filtration

Approximate operating regions of solids/ liquids separation devices in treating water

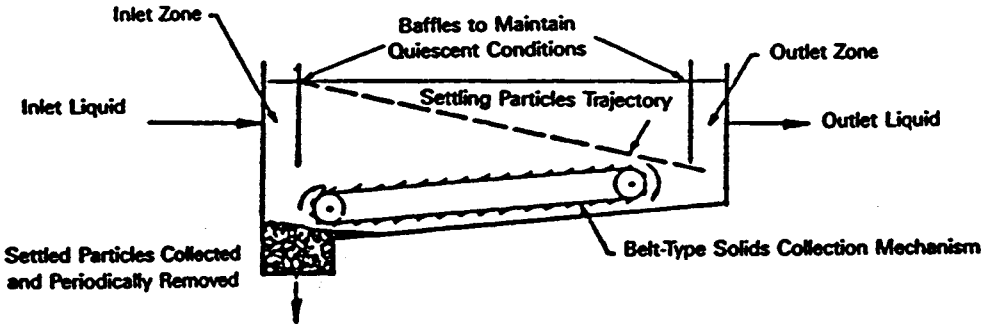


REPRESENTATIVE TYPES OF SEDIMENTATION

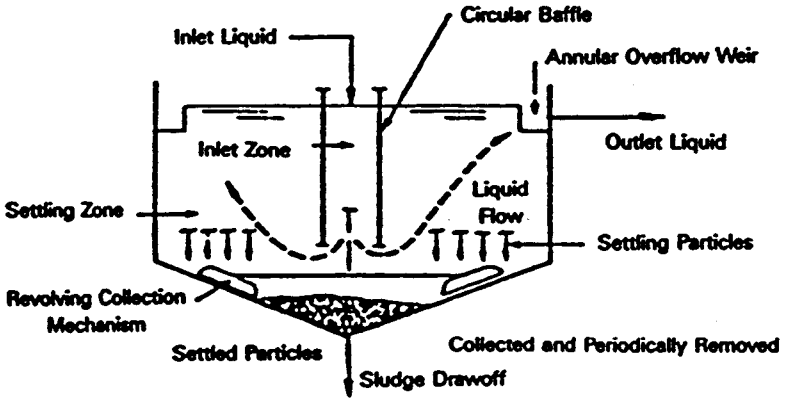
Setting Pond

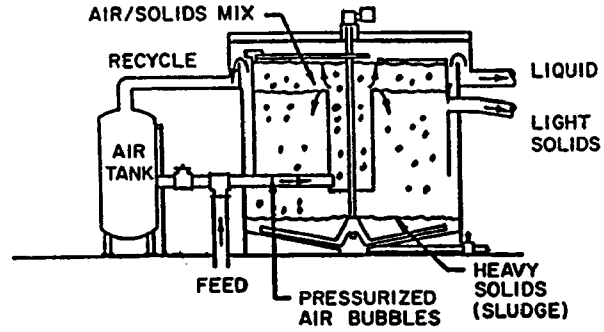


Sedimentation Basin



Circular Clarifier





SOURCE: PEABODY-WELLES, ROSCOE, IL.

RECYCLE FLOW DISSOLVED AIR FLOTATION SYSTEM

FACTORS IMPACTING SEDIMENTATION/FLOTATION

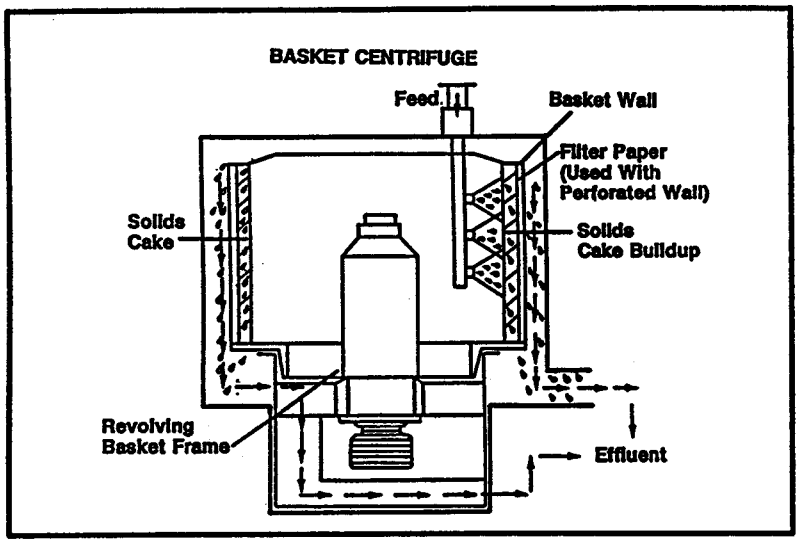
- Particle size
- Particle shape
- Density
- Liquid medium particle is settling through
- Water temperature

CENTRIFUGATION

Components of a fluid are separated based on their relative density by rapidly rotating the fluid within a vessel

CENTRIFUGATION (continued)

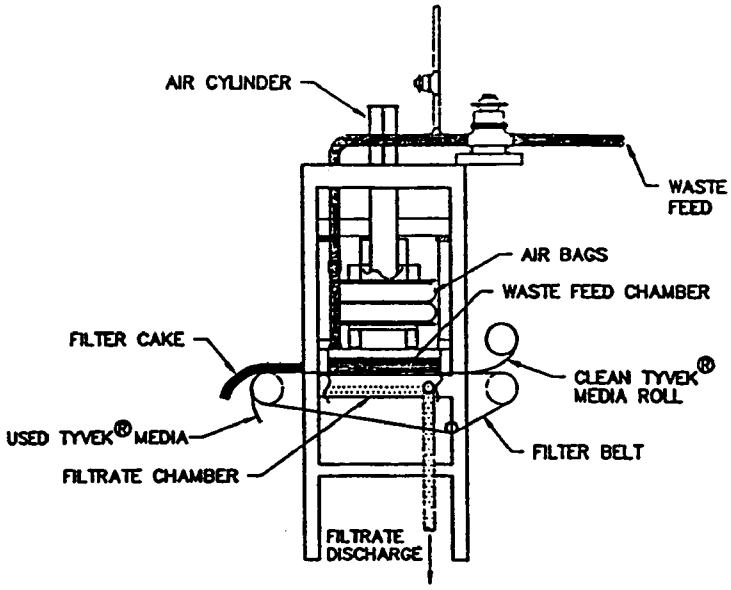
- Dense particles are deposited furthest from axis of rotation
- Centripetal forces are thousands of times stronger than gravitational



PRINCIPLE: MEDIA FILTRATION

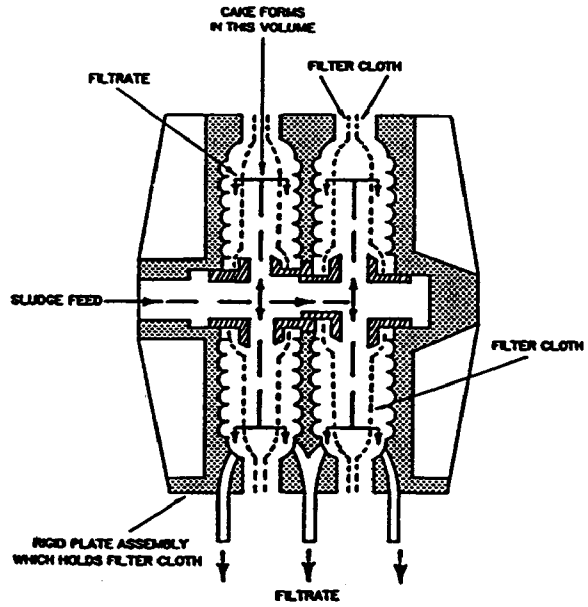
Function: Separation, Recovery, Volume Reduction, Pretreatment

- Processes
  - -pressure filtration
  - -belt filter press
  - -plate & frame filter press
  - -vacuum filtration
  - -ultrafiltration
  - -reverse osmosis
  - -dialysis



DuPont/Oberlin microfiltration system.

Currently Being Developed. (SITE)



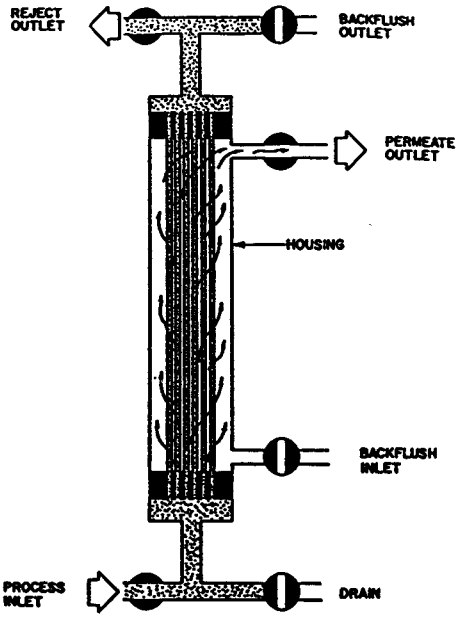
CROSS SECTION OF A FIXED VOLUME RECESSED PLATE FILTER PRESS ASSEMBLY

ULTRAFILTRATION

- Low pressure (10-150 psi) membrane process
- Separates high molecular weight dissolved materials and colloidal materials
- Semi-permeable membrane (0.1 to 1.0 um thick)

ULTRAFILTRATION (continued)

- Requires pretreatment to remove suspended solids and free oil
- Commonly used to remove emulsified oils, metals, and proteins



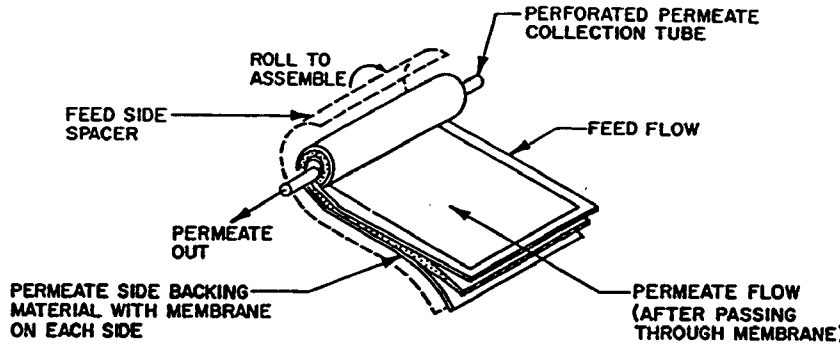
CAPILLARY UF MODULE

REVERSE OSMOSIS
(Hyperfiltration)

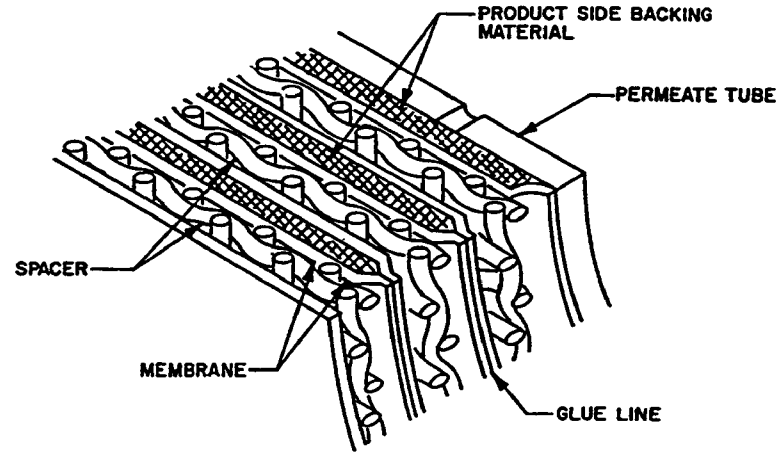
- High pressure (150-400 psi) membrane separation process
- Driving force is pressure differential across membrane
- Commercial units historically used for recovering Ni plating baths
- Process is applicable for dissolved heavy metals and certain dissolved organics

REVERSE OSMOSIS
(continued)

- Can remove even low molecular weight ionic species
- Rejection is most often a function of the semipermeable membrane
- Limitation - influents containing film formers
- Pretreatment should include removal of oxidizing materials, particulates, oils, grease and other film formers



UNRAVELLED MEMBRANE



DETAIL OF MEMBRANE SANDWICH

DETAILS OF SPIRAL WOUND MODULE

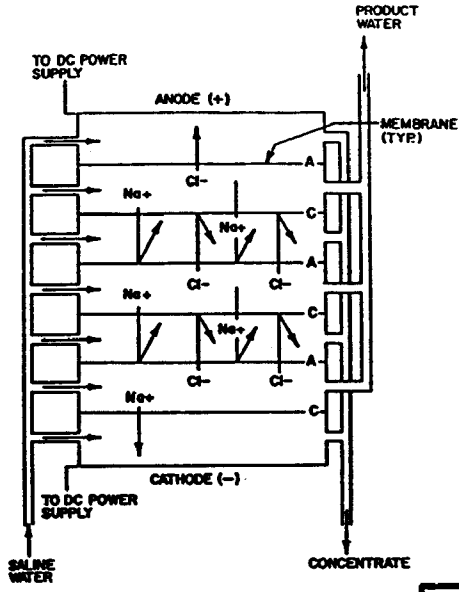
DIFFERENCES BETWEEN REVERSE OSMOSIS AND ULTRAFILTRATION

Item	Reverse Osmosis	Ultrafiltration
Size of solute retained	Molecular weights generally less than 500	Molecular weights generally over 1000
	High salt retention	Nil salt retention
Osmotic pressures of feed solutions	Important, can range to over 1000 psig	Negligible
Operating pressures	Greater than 400 psig, up to 2000 psig	10 to 100 psig
Nature of membrane retention	Diffusive transport barrier; possibly molecular screening	Molecular screening
Chemical nature of membrane	Important in affecting transport properties	Unimportant in affecting transport properties so long as proper pore size and pore distribution are obtained
Typical membrane flux levels	2 to 5 gal/day-ft^2	20 to 200 gal/day-ft^2

Source EPA 1978

Relative Performance Criteria of RO Membrane Material

	CA	PA	TFC
Operating Temp., F	33-104	33-95	33-115
pH Range	4-7	2-12	2-12
Salt Rejection	Good	Good	Better
Organics Rejection	Good	Better	Better
Biological Stability	Fair	Good	Good
Chlorine Stability	Fair	Poor	Poor
Water Flux Rate	Good	Better	Better
Spiral Wound Config.	Yes	No	Yes
Hollow-Fine-Fiber Config.	Yes	Yes	No



THE ED PROCESS

PRINCIPLE: ADSORPTION/ION EXCHANGE

Function: Separation, Recovery, Volume Reduction/Concentration, Pretreatment

- Processes
  - -carbon adsorption
  - -resin adsorption
  - -ion exchange

ION EXCHANGE

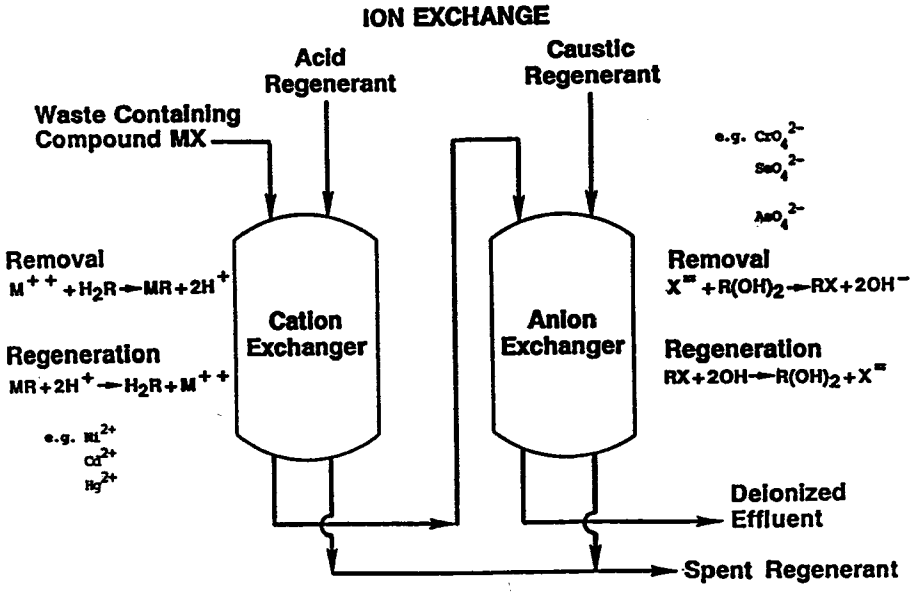
Definition: Process that removes heavy metals from wastewater by using synthetic resins that exchange a less harmful ion for a heavy metal ion in solution

ADVANTAGES

- Reversible
- Can treat to very low levels
- Recent development of chelating resins
- Can treat metal-chelated wastes

DISADVANTAGES

- Cost
- Concentrate requires disposal
- Limitations for wastes with TDS > 1000 ppm or TS > 50 mg/l
- Non-selective



ELECTROLYTIC PROCESSES

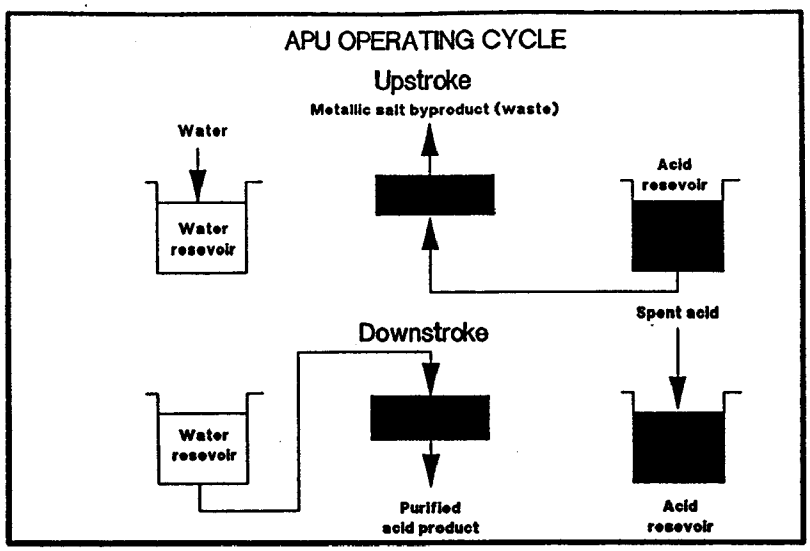
- Cathodes and anodes are immersed in tank with waste, and a DC field is imposed on the system
- Used to plate out dissolved metals, oxidize cyanide, or reduce chromium for wastewaters

ELECTROLYTIC PROCESSES (continued)

- Particularly applicable for high CN (approximately 10%) waste
- Limitations are the form of the waste, non-selective nature of process, and long process time

ACID REGENERATION

Concentrates hydrochloric, sulfuric, nitric, and hydrofluoric acids to permit reuse



CONSTRAINTS

- Mixed acids cannot be separated
- Organic contamination may not be removed from acid fraction
- Expensive processes
  - consider off site existing facilities

OTHER METHODS FOR INORGANIC CONTAMINANT REMOVAL

- Adsorption on biomass
- Assimilation by plants
  - constructed wetlands
  - sphagnum moss for acid mine drainage

WASTE EXCHANGE

- State and area programs where waste generators can make their waste streams available for sale to reclaimers and other processors

TECHNOLOGY APPLICATIONS

	Separation	Recovery	Treatment
Neutralization			X
Precipitation			
Lime			X
Carbonate		X	X
Sulfides		X	X
Na borohydride		X	X
Oxidation/reduction	X	X	X
Sedimentation	X		
Centrifugation	X		
Flotation	X		
Media Filtration			
Pressure filtration	X		
Vacuum filtration	X		
Belt filter press	X		
Plate & frame filter press	X		
Ultrafiltration	X		
Reverse osmosis	X	X	
Dialysis	X	X	
Electrolysis		X	X
Acid regeneration		X	
Ion exchange		X	X
Adsorption		X	X

U.S. Waste Exchanges

CALIFORNIA WASTE EXCHANGE
Robert McCormick
Department of Health Services
Toxic Substances Control Division
714 P Street
Sacramento, CA 95814
(916) 324–1807

GREAT LAKES REGIONAL WASTE EXCHANGE
William Stough
470 Market St., S.W.
Suite 100A
Grand Rapids, MI 49503
(616) 451–8992

INDIANA WASTE EXCHANGE
Shelley Whitcomb
Environmental Quality Control
1220 Waterway Boulevard
P.O. Box 1220
Indianapolis, IN 46206
(317) 634–2142

INDUSTRIAL MATERIAL EXCHANGE SERVICE
Margo Siekerka
P.O. Box 19276
Springfield, IL 62794–9276
(217) 782–0450

INDUSTRIAL MATERIALS RECYCLING PROGRAM
Marion Mudar
New York State Environmental Facilities Corporation
50 Wolf Road
Albany, NY 12205
(518) 457–4138

INDUSTRIAL WASTE INFORMATION EXCHANGE
William E. Payne
New Jersey Chamber of Commerce
5 Commerce Street
Newark, NJ 07102
(201) 623–7070

MONTANA INDUSTRIAL WASTE EXCHANGE
Don Ingles
Montana Chamber of Commerce
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Helena, MT 59624
(406) 442–2405

NORTHEAST INDUSTRIAL WASTE EXCHANGE
Lewis M. Cutler
90 Presidential Plaza
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Syracuse, NY 13202
(315) 422–6572

SOUTHEAST WASTE EXCHANGE
Mary McDaniel
Urban Institute
UNCC Station
Charlotte, NC 28223
(704) 547–2307

SOUTHERN WASTE INFORMATION EXCHANGE
Roy Herndon
P.O. Box 6487
Florida State University
Institute of Science & Public Affairs
Tallahassee, FL 32313
(904) 644–5516

SEPARATION OF ORGANIC CONTAMINANTS FROM SOILS AND SLUDGES

Abstract 6-1

Slides 6-5

SEPARARATION OF ORGANIC CONTAMINANTS FROM SOILS AND SLUDGES

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Chapman, Inc.
Freehold, New Jersey

James H. Nash
Chapman, Inc.
Freehold, New Jersey

Selection of remedial actions involves several risk management decisions. Uncertainties with respect to performance, reliability, and cost of treatment alternatives underscore the need for well-planned, well-conducted, and well-documented treatability studies. Treatability studies provide valuable site-specific data necessary to support Superfund remedial actions. They serve two primary purposes: (1) to aid in the selection of the remedy, and (2) to aid in the implementation of the selected remedy. Treatability studies conducted during the remedial investigation/feasibility study (RI/FS) phase indicate whether a given technology can meet the expected cleanup goals for the site, whereas treatability studies conducted during the remedial design/remedial action (RD/RA) phase establish the design and operating parameters of optimization of technology performance. Although the purpose and scope differ, they complement one another (i.e., information obtained in support of remedy selection may also be used to support the remedy design).

Based on the EPA's research program on Best Demonstrated Available Technology (BDAT) a total of 466 different chemical contaminants were identified at 888 Superfund Sites (see Table 1, on page 6-8). Organics and VOC's lead all categories of contaminants as summarized in Table 2, on page 6-8.

The treatment of organic contaminants in soils, sludges and sediments can be accomplished by physical separation/volume reduction of contaminated and clean particulate fractions. Soils washing is a physical/chemical separation technology whereby excavated contaminated soil is first mixed with aqueous based wash fluid(s) and then separated from them. Research has found that a large percentage of soil contamination is usually associated with or bound to very small (silt and clay) soil particles. Therefore, a physical separation of the large soil particles (sand and gravel) from the silt and clay and humic material can effectively concentrate the contaminants largely in the silt and clay and humic fraction of the soil mass. Thus, for those soils with a large fraction of sand and gravel (40%), soils washing technology will significantly reduce the volume of contaminated soil which will require subsequent treatment.

In the soils washing process, contaminants may become solubilized or highly contaminated fines may become suspended in the wash fluid and are separated from the clean coarse soil fraction. Chemical agents such as surfactants, extractants, or chelants can be added to the washwater to increase the efficiency of contaminant removal. Acidic or alkaline solutions may be added to mobilize, neutralize, or destroy the contaminants, thereby increasing the efficiency of contaminant removal (see Cleaning Excavated Soil Using Extraction Agents: A State-of-the-Art Review, EPA/600/2-89/034, 1989). The use of solvent extraction technologies has been making significant progress in the areas of waste site remediation.

Solvent extraction techniques being demonstrated under the SITE program are shown in Table 3 on page 6–32.

The application of in–situ treatment technologies has many advantages if site conditions are favorable for this remedial application. General in–situ technologies can be categorized into the following categories:

- Soils Flushing
- Solidification/Stabilization
- Degradation
- Control of Volatile Materials
- Chemical and Physical Separation Technologies

REFERENCES

Everson, Francine, Overview of Soil Washing Technologies for Site Remediation. June 1989, EPA, Edison, New Jersey.

A Compendium of Superfund Field Operations Methods, EPA/540/P–87/001, December 1987.

Characterization of Hazardous Waste Sites – A Methods Manual: Volume II Available Sampling Methods, Second Edition, EPA/600/4–84/076, 1984.

Cleaning Excavated Soil Using Extraction Agents: State–of–the–Art Review, Raghavan, R., D.H. Dietz E. Coles, Enviresponse, Inc., EPA/600/2–89/034 Livingston, New Jersey.

Data Quality Objectives for Remedial Response Activities: Development Processes, EPA/540/G–87/003, March 1987.

Data Quality Objectives for Remedial Response Activities: Example Scenario RI/FS Activities at a Site with Contaminated Soils and Groundwater, EPA/540/G–87/004, March 1987.

Development and Use of EPA's Synthetic Soil Matrix (SSM/SARM). U.S. EPA Release Control Branch, February 1989.

Guidelines for the Use of Chemicals in Removing Hazardous Substances Discharges, EPA/600/2–81/205, September 1981.

Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media, EPA/730/2089/042, February 1989.

Mobile System for Extracting Spilled Hazardous Material from Excavated Soils, EPA/600/2–83/100.

Sediment Sampling Quality Assurance User's Guide, EPA/600/4–85/048, July 1985.

Soil Sampling Quality Assurance User's Guide, EPA/600/4–84/043, May 1984.

Technological Approaches to the Cleanup of Radiologically Contaminated Superfund Sites, EPA/1540/2–88/002, August 1988.

Technology Screening Guide for Treatment of CERCLA Soils and Sludges, EPA/540/2-88/004, September 1988.

U.S. Environmental Protection Agency, Systems to Accelerate In Situ Stabilization of Waste Deposits, EPA/540/2-86/002, Cincinnati, Ohio 1986.

Murdoch, L., B. Patterson, G. Losonsky, and W. Harrar. 1988. Innovative Technologies of Delivery or Recovery: A Review of Current Research and a Strategy for Maximizing Future Investigations. Report for Contract No. 68-03-3379. U.S. EPA Risk Reduction Engineering Laboratory, Cincinnati, Ohio.

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U.S. Environmental Protection Agency, Review of In-Place Treatment Technologies for Contaminated Surface Soils - Volume 1: Technical Evaluation, EPA-540/2-84-003a, Cincinnati, Ohio 1984.

U.S. Environmental Protection Agency, Handbook: Remedial Action at Waste Disposal Sites (Revised), Hazardous Waste Engineering Research Laboratory, Cincinnati, OH and Office of Emergency and Remedial Response, Washington, D.C., EPA/625/6-85/006, 1985.

U.S. Environmental Protection Agency, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Office of Emergency and Remedial Response, Washington, D.C., EPA/540/G-89-004, 1988.

PRESENTATION OVERVIEW

- Gaining a perspective of the problem
- Fundamental unit operations
- Processes requiring excavation
- In-situ processes

ESTIMATED NUMBER OF U.S. HAZARDOUS WASTE SITES

CERCLA	22,000	Total (971 ON NPL)
RCRA	3,000	TSDs (Active in 1985)
	25,000	Total
GENERATORS	10,000	Without TSDs

RCRA SITES (14,098 GENERATORS IN 1981)

REGION	%	
1	10	68%
2	12	
3	10	
4	13	
5	23	
6	9	32%
7	5	
8	2	
9	14	
10	2	
	100	

NOTE: Generators Resurveyed in 1987 by RTI. - Data Not Yet Available

Types of Generators (1981)

Fabricated Metal Products (SIC 34)	19%
Chemical & Allied Products (SIC 28)	17%
Electrical Equipment (SIC 36)	11%
Other Metal-Related Products (SIC 33, 35, 37)	16%
All Other	
	100%

Source: EPA 530/SW-84-005, April 1984. Established statistics for RCRA TSD'S and generators as of 1981

ESTIMATED NUMBER OF ACTIVE RCRA FACILITIES (TSDs)

	1981		1985		% Change
Total No. Active RCRA TSDs	4818		2971		-38%
Region					
1	354	71%	234	76%	
2	603		386		
3	518		298		
4	695		484		
5	1,237		864		
6	611	29%	430	24%	
7	204		156		
8	114		89		
9	360		304		
10	122		84		
Total No. Landfills	199		98		-51%
Total Volume of Waste Handled (MMT)	264		272		+3%

Observations:
- Most Sites East of Mississippi
- Nearly 2,000 Sites Have Closed or Dropped Out (Some May be SF Sites Now)
- Half the Landfills No Longer Operate
- Waste Volumes Same or Slightly Increased Overall

SUPERFUND SITES

Total Listed		22,000 - 24,000
NPL		1175 (11/88)*
Rods		437 Total
1982-85	123	
1986	84	
1987	75	
1988	155 (EST.)	
	437	

* EPA - OSWER

NPL SITES BY LOCATION

REGION	NO.	
1	60	74% East of Mississippi
2	176	
3	135	
4	116	
5	234	
6	54	26% West of Mississippi
7	46	
8	40	
9	74	
10	36	
	971 (as of 8/88)	

(Source: Inside EPA Superfund Report 8/3/88)

ROD SUPERFUND SITES MEDIA AFFECTED

	No. Reported	Estimated Percent
Groundwater	190 (virtually all)	100%
Soil	147	75%
Sediments/ Stream Beds	46	25%
Sludge	12	5%

Source: EPA Hazardous Site Control Division 8/31/87

EXAMPLES OF LAND USES POTENTIALLY ASSOCIATED WITH TOXIC/HAZARDOUS WASTE

Agricultural Operations
Agricultural Spraying Service Companies - Lawn Firms, Pest Control
Airports
Asphalt Plants
Auto Repair
Battery Companies
Bottling Companies
Cement Processing Operations
Chemical Companies
Dry Cleaners
Fence Companies
Firing Ranges/Test Sites
Gas Stations/Tank Farms/Heating Oil Businesses
Highway Spill Sites
Hospitals
Incinerator Sites
Industrial Parks
Junk Yards/Scrap Yards
Labor Camps—State Highway Department Operations
Landfills
Metal Fabricators
Mining Sites—Sand and Gravel Pits
Ordnance Operations
Paint Stores, Warehouses, etc.
Penitentiaries
Plastics Companies
Plating Operations
Processing Plants/Heavy Industrial Sites
Railroad ROW, Maintenance Yards, and Other Related Uses (derailment sites)
Recycling Companies
Refining Operations
Rendering Companies
Research Laboratories
Semiconductor/Computer High Technology Plants
Sewage Treatment Plants
Surplus Military Property
Tanneries
Tire and Rubber Plants
Trucking Terminals
Utility Companies—power plants, electrical equipment storage yards, etc.
Waste Lagoons
Welding Products Companies
Wood Processing and Preserving Operations

(Source: U.S. Environmental Protection Agency CERCLIS Data Base)

466 SUBSTANCES FOUND AT 888 PROPOSED AND FINAL NPL SITES, OCT 1986

	CHEMICAL	OCCURENCE (NO. OF SITES)	% OCCURENCES
1	Trichloroethylene	311	35
2	Lead	286	32
3	Toluene	243	27
4	Chromium	220	25
5	Benzene	208	23
6	Chloroform	179	20
7	PCBs	159	18
8	1,1,1-Trichloroethane	151	17
9	Perchloroethylene	149	17
10	Zinc	142	16
11	Cadmium	141	16
11	Arsenic	141	16
12	Phenol	121	14
13	Xylene	113	13
14	Ethylbenzene	111	12
15	Copper	106	12
16	1,2-Dichloroethylene	104	12
17	Methylene Chloride	91	10
18	1,1-Dichloroethane	85	10
19	1,1-Dichloroethylene	79	9
20	Mercury	78	9
21	Cyanide	73	8
22	Vinyl Chloride	70	8
23	Nickel	65	7
24	1,2-Dichloroethane	64	7
24	Chlorobenzene	64	7
25	Carbon Tetrachloride	61	7
26	Pentachlorophenol	53	6

A total of 466 different substances have been found at 888 sites.
(Source CDM, J. Knap, March 1987)

MAJOR CONTAMINANTS FOUND AT NPL SITES WITH RODS

CONTAMINANT	NO. SITES REPORTED
Acids	17
Arsenic	25
Asbestos	2
Chrome	27
Dioxins	6
Heavy Metals	79
Inorganics	50
Oils	24
Organics/VOCs	122
PERC	23
PAHs	20
PCBs	41
Phenols	22
Pesticides	22
Radioactive	5
Solvents	35
TCE	51
Toluene	33

(Total number of RODs searched unreported; estimate 150-200)
(Source: EPA Hazardous Site Control Division 8/31/87)

TYPICAL SUPERFUND SOIL AND SLUDGE CONTAMINATION LEVELS
FOR SELECTED CONTAMINANTS

VOLATILES	AVERAGE PPM	MAXIMUM PPM
Ethylbenzene	3,200	53,000
Xylene	8,400	150,000
1,2-Dichloroethane	580	6,700
Perchloroethylene	540	9,200
Acetone	6,800	55,000
Chlorobenzene	360	3,900
Styrene	120	1,100
SEMIVOLATILES		
Anthracene	4,800	100,000
PCP	700	7,200
Bis(2-Ethylhexyl)phthalate	1,900	22,000
INORGANICS		
Pb	3,100	61,000
Zn	5,000	67,000
Cd	180	3,000
As	90	950
Cu	2,100	52,000
Cr	370	3,000
Ni	200	1,900

Source of Information: CH_2M Hill ROD Database

1987-88 CERCLA SOIL STUDY

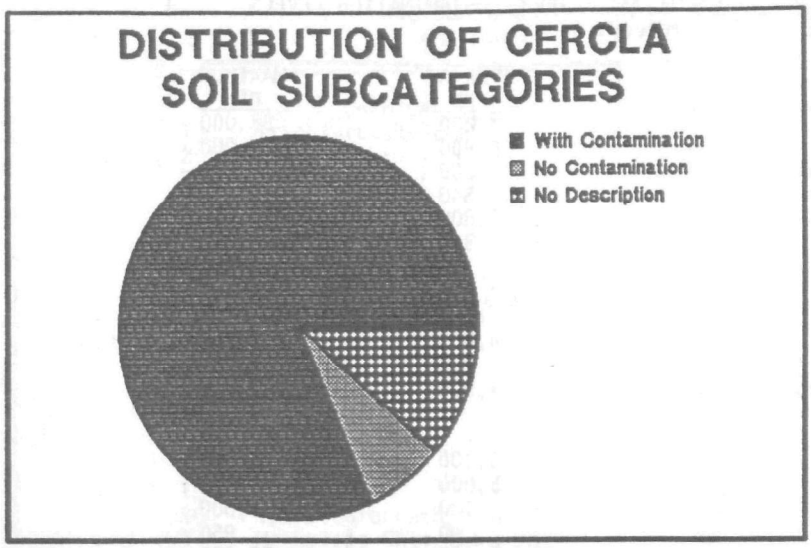
- REVIEWED 116 RODS - FOUND SOIL DESCRIPTIONS IN 95

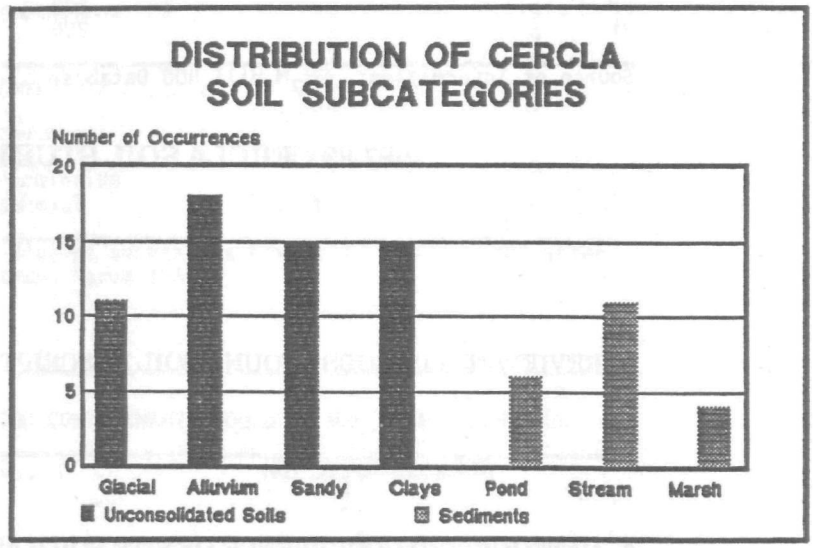
- CATEGORIZED OCCURRENCE OF SITE SOILS AS FOLLOWS: (EX-3)

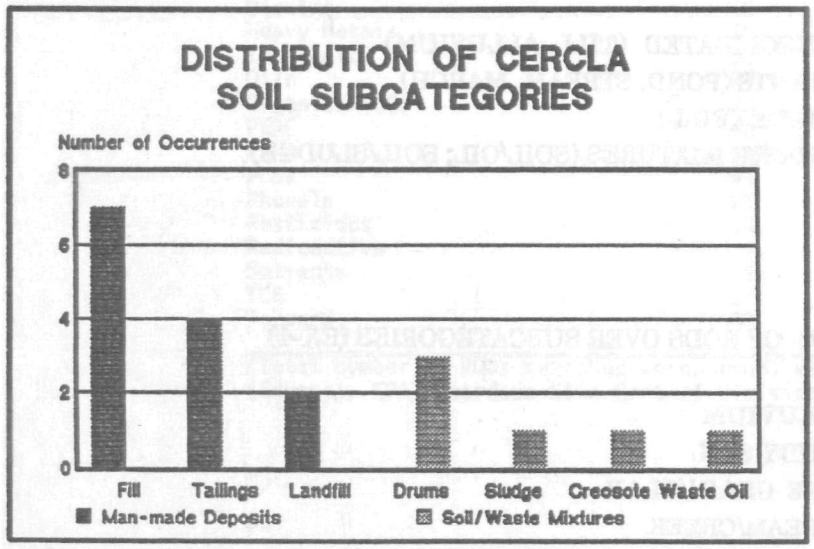
  65% UNCONSOLIDATED (TILL, ALLUVIUM)
  20% SEDIMENTS (POND, STREAM, MARCH)
  10% MANMADE (FILL)
  5% SOIL/WASTE MIXTURES (SOIL/OIL; SOIL/SLUDGE)

- DISTRIBUTION OF RODS OVER SUBCATEGORIES (EX-4)

  ~ 17% ALLUVIUM
  ~ 15% SANDY SOIL
  ~ 15% FINE GRAIN/CLAY
  ~ 12% STREAM/CREEK
  ~ 11% GLACIAL TILL
  ~ 30% OTHER


DISTRIBUTION OF CERCLA
SOIL SUBCATEGORIES
With Contamination
No Contamination
No Description


DISTRIBUTION OF CERCLA
SOIL SUBCATEGORIES
Number of Occurrences
20
15
10
5
0
Glacial
Alluvium
Sandy
Clays
Pond
Stream
Marsh
Unconsolidated Soils
Sediments


DISTRIBUTION OF CERCLA
SOIL SUBCATEGORIES
Number of Occurrences
8
6
4
2
0
Fill
Tailings
Landfill
Drums
Sludge
Creosote
Waste Oil
Man-made Deposits
Soil/Waste Mixtures

TARGET CONTAMINANT CONCENTRATIONS FOR SSM, MG/KG

Analyte	SSM-I (High organic, low metal)	SSM-II (Low organic, low metal)	SSM-III (Low organic, high metal)	SSM-IV (High organic, high metal)
Volatiles				
Acetone	6,800	680	680	6,800
Chlorobenzene	400	40	40	400
1,2-Dichloroethane	600	60	60	600
Ethylbenzene	3,200	320	320	3,200
Styrene	1,000	100	100	1,000
Tetrachloroethylene	600	60	60	600
Xylene	8,200	820	820	8,200
Semivolatiles				
Anthracene	6,500	650	650	6,500
Bis(2-ethylhexyl) phthalate	2,500	250	250	2,500
Pentachlorophenol	1,000	100	100	1,000
Inorganics				
Arsenic (as As2O3)	10	10	500	500
Cadmium (as 3CdSO4 . 8H2O)	20	20	1,000	1,000
Chromium (as Cr(NO3)3 . 9H2O)	30	30	1,500	1,500
Copper (as CuSO4 . 5H2O)	190	190	9,500	9,500
Lead (as PbSO4 . PbO)	280	280	14,000	14,000
Nickel (as Ni(NO3)2 . 6H2O)	20	20	1,000	1,000
Zinc (as ZnO)	450	450	22,500	22,500

ORD Edison
"Synthetic Soils Mixture" SSM
Spiked Volatiles
Franklin Edison Edison NJ

PHYSICAL TREATMENT

Separation by:

- Gravity
- Phase changes
- Dissolution
- Adsorptivity/ionic characteristics

PHYSICAL TREATMENT DATA NEEDS

Data Need	Purpose
Absolute density	Density separation
Bulk density	Storage volume required
Grain size distribution	Size modification/ separation
Friability	Size reduction
Solubility (in water, oils, etc.)	Dissolution

GRAVITY SEPARATION

- Sedimentation
- Centrifugation
- Flocculation
- Oil/water separation
- Dissolved air flotation
- Heavy media separation

DISSOLUTION

- Soils washing/flushing
- Chelation
- Liquid/liquid extraction
- Supercritical solvent extraction

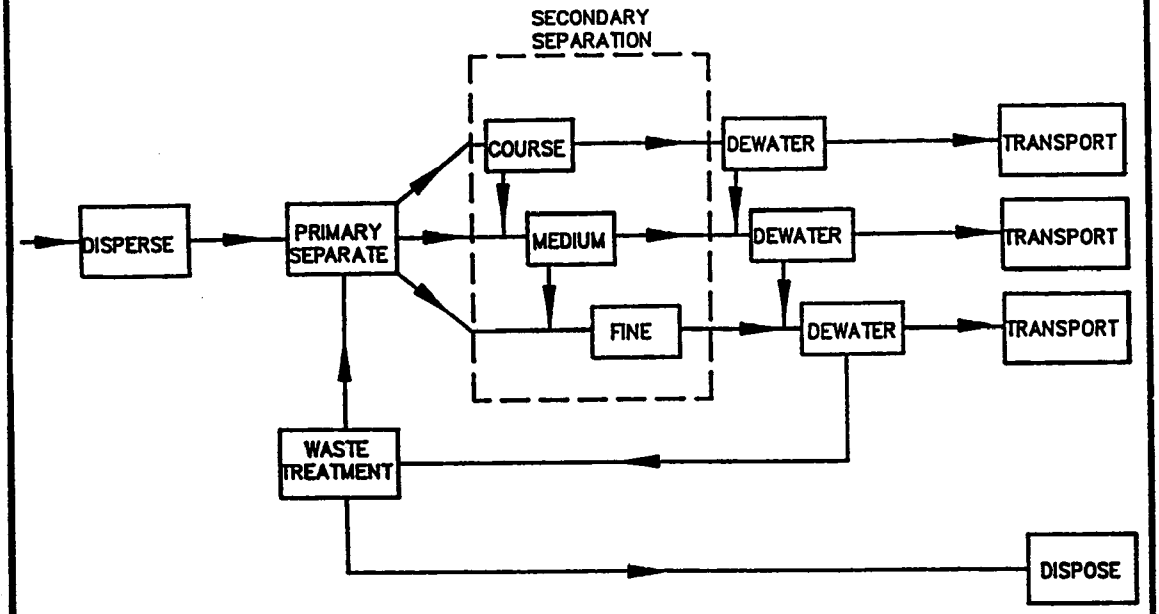
SOIL WASHING FLUIDS

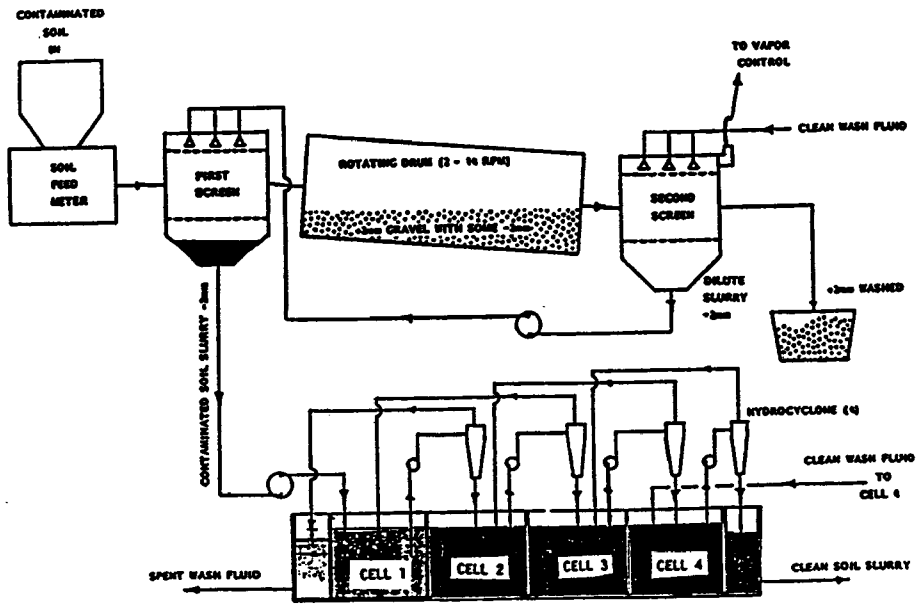
- Water only
- Water plus additives
  - -acids (e.g., sulfuric acid)
  - -bases (e.g., sodium hydroxide)
  - -oxidants (e.g., hydrogen peroxide)
  - -reductants (e.g., sodium bisulfite)
  - -surfactants (e.g., Tween)
  - -chelates (e.g., EDTA)
- Organic solvents
  - -alcohols (e.g. isopropanol)
  - -alkanes (e.g. hexane)
  - -halogenated alkanes (e.g. Freon)

SUSCEPTIBILITY OF ORGANICS TO SOLUBILIZATION BY SURFACTANTS

Chemical Class	Example
Alkanes	Pentane
	Octane
Alcohols	Octanol
Aromatics	Benzene
	Butylbenzene
	Naphthalene
Phenols	Dimethylphenol
Halogenated Aromatics	Bromobenzene
	Dichlorobenzene

SOIL WASHING SYSTEM
(Conceptual process flow diagram)



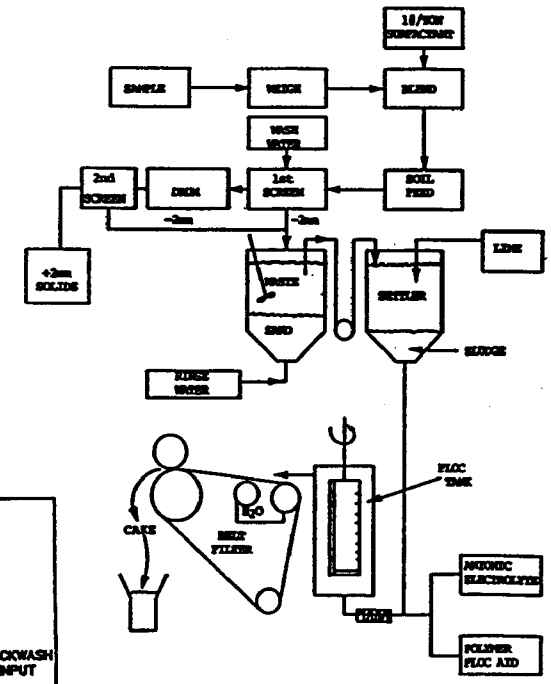


Mobile Soils Washing System

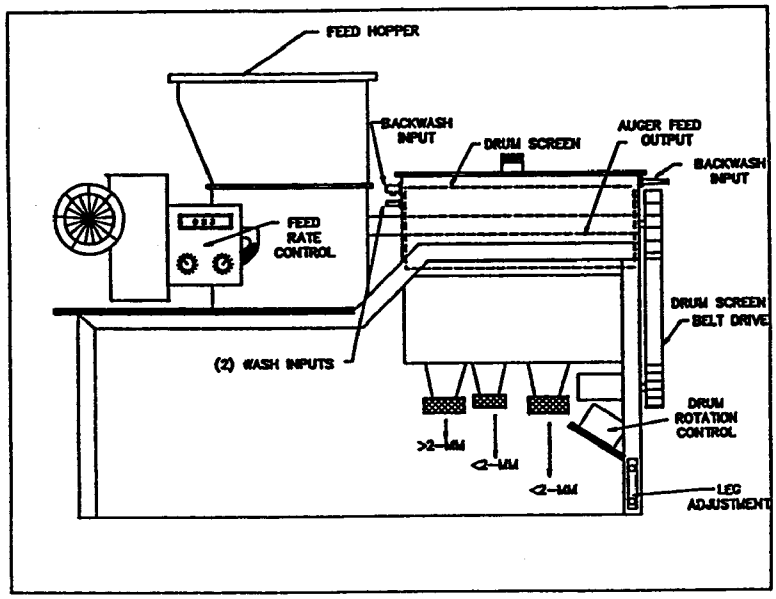
LAKEHURST, NJ NAVAL AIR ENGINEERING CENTER

Heavy Oil Contamination

	O&G mg/kg	Size % of sample	Contaminant % of Total
Total Sample	36,000	100	100.0
› 2 mm	60	5	0.1
2 mm to 0.06 mm	400	80	0.8
‹ 0.06 mm	240,000	15	99.1

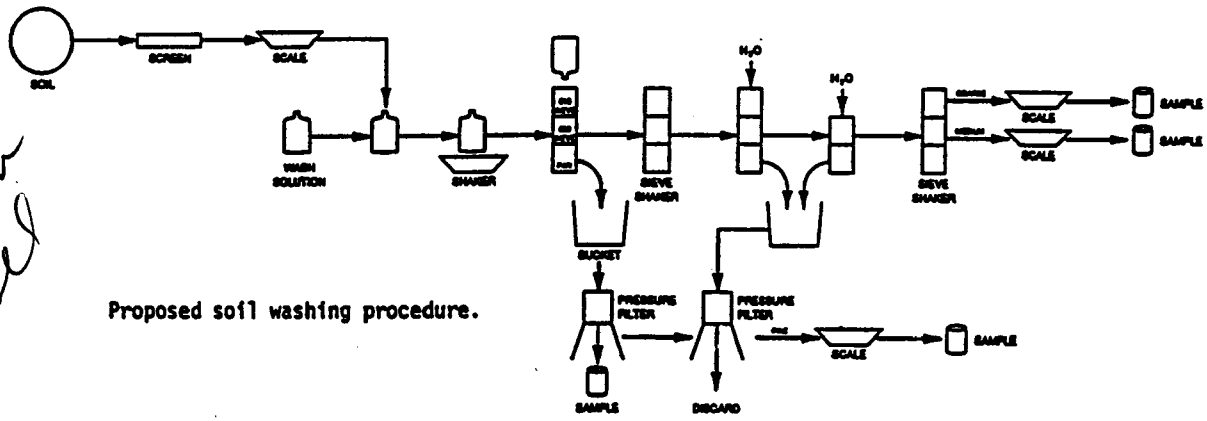


Pilot soil washing process at NAEC, Lakehurst - July - August 1988.



Lakehurst, NAEC Soil Washing Data

Description	Quantity, Rate
1. Soil Feed Rate	50 - 100 pounds/hr
initial oil & grease	38,000 mg/kg
0.25-2-mm oil & grease	375mg/kg
2. Wash Water Rate	1-2 gal/min
	(4.5 liters/pound of soil)
3. Wash Water pH	4.7
4. Wash Water Total Solids	2.97%
5. Sludge, settled total solids	15.5%
6. Belt Filter Press Cake total solids	47%
7. Belt Filter Press Cake Ash content	30%
8. Belt Filter Press suspended solids	20 mg/liter
9. Percent Removal Efficiency	99%



Proposed soil washing procedure.

Extra clean #6 Diesel

USEPA SYNTHETIC SOIL MATRIX PARTICLE SIZE DISTRIBUTION (USDA)

		USDA(%)	USCS(%)
Gravel		--	--
Sand	Total	60.0	58.0
	V. Coarse	16.0	
	Coarse	8.8	
	Medium	11.7	
	Fine	23.5	
Silt		19.0	15.2
Clay		21.0	26.8

Soil washing effectiveness (greater than 2-mm size fraction), overall percentage reduction by contaminant group.[a]

	Soil I (high organics, low metals)		Soil II (low organics, low metals)			Soil III (low organics, high metals)		Soil IV (high organics, high metals)		
	Water	Surfactant	Water	Surfactant	Chelant	Water	Chelant	Water	Surfactant	Chelant
Volatiles	>99.9	>99.8	99.9	99.9	>99.9	>99.9	99.9	>99.9	99.9	>99.9
Semivolatiles	98.9	>99.8	93.9	93.5	90.1	>94.8	96.4	97.8	>98.3	97.8
Inorganics	92.2	91.5	>96.7	95.7	95.9	98.0	98.4	97.1	98.4	98.1

[a] Total waste analysis.

Soil washing effectiveness (250-μm to 2-mm size fraction), overall percentage reduction by contaminant group.[a]

	Soil I		Soil II			Soil III		Soil IV		
	Water	Surfactant	Water	Surfactant	Chelant	Water	Chelant	Water	Surfactant	Chelant
Volatiles	99.8	99.8	>99.9	>99.8	>99.9	>99.3	99.0	>99.7	>99.7	>99.7
Semivolatiles	56.2	65.6	52.7	47.3	67.5	0	0	0	29.4	32.3
Metals	81.6	80.7	>82.7	91.6	85.1	96.4	98.4	90.7	91.8	90.3

[a] Total waste analysis.

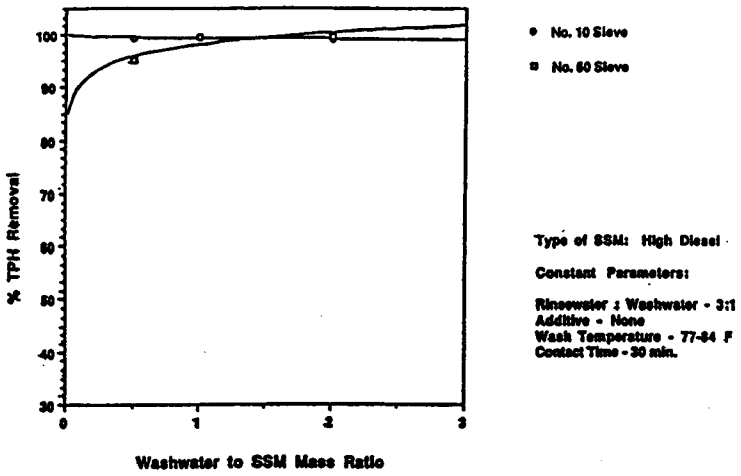
Soil washing effectiveness (less than 250-μm size fraction), overall percentage reduction by contaminant group.[a]

	Soil I		Soil II			Soil III		Soil IV		
	Water	Surfactant	Water	Surfactant	Chelant	Water	Chelant	Water	Surfactant	Chelant
Volatiles	66.2	88.0	>99.8	>99.4	99.6	86.7	>93.2	>69.6	95.0	81.8
Semivolatiles	59.7	43.2	0	0	0	0	0	0	0	0
Metals	0	0	0	0	21.9	0	78.2	0	7.3	82.2

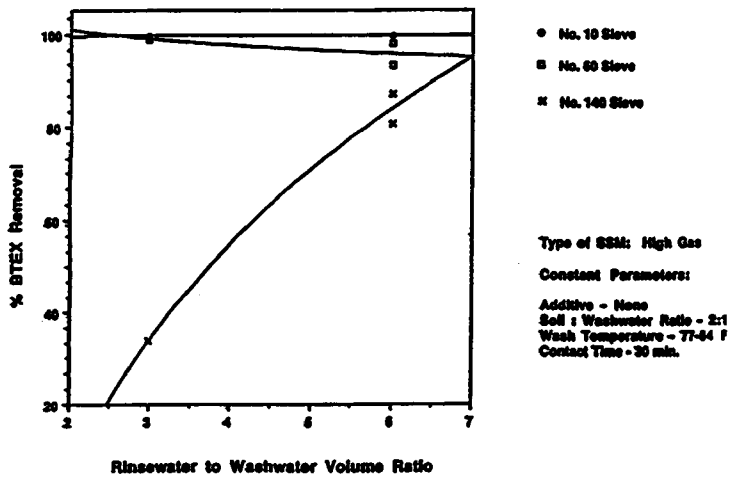
[a] Total waste analysis.

Best Best extraction sludge Test.

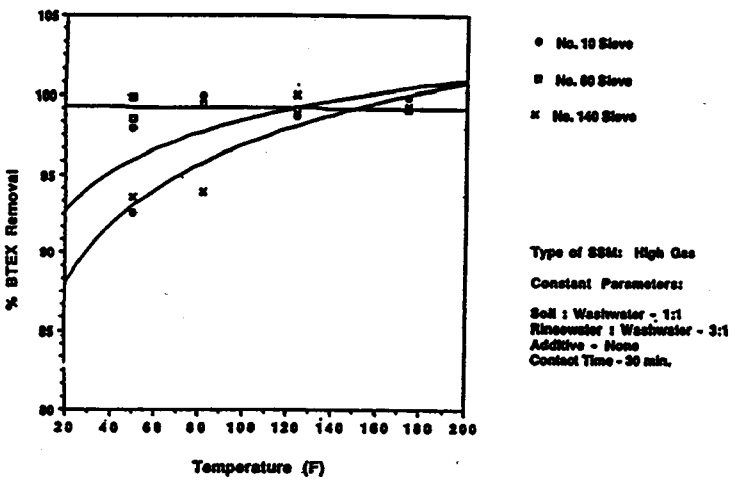
Washwater to Soil Ratio Effect on Percent TPH Removal



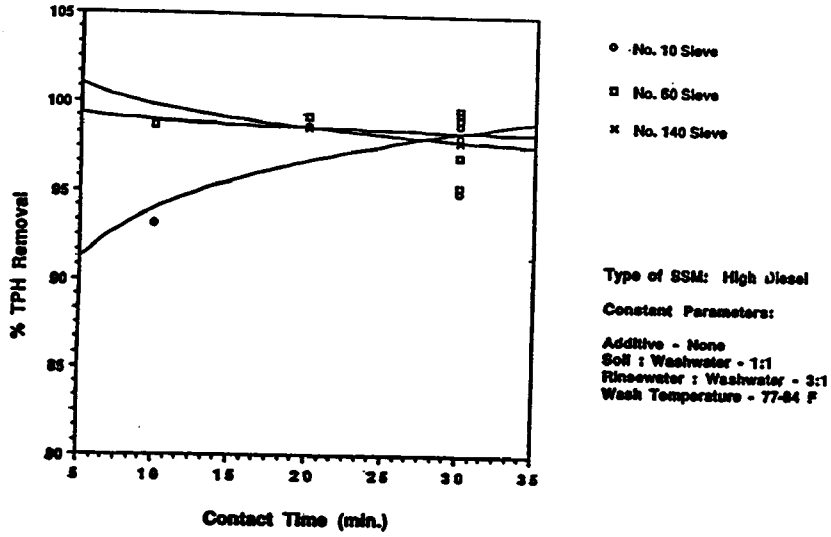
Rinsewater to Washwater Ratio Effect on Percent BTEX Removal



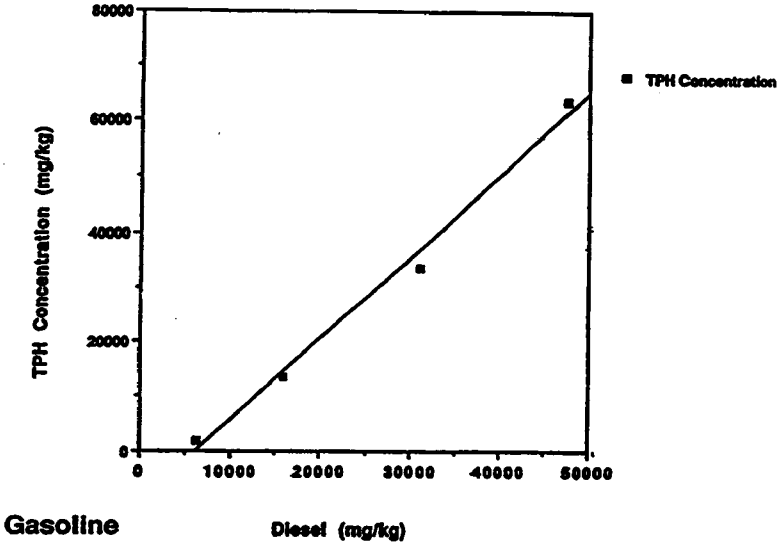
Temperature Effect on Percent BTEX Removal



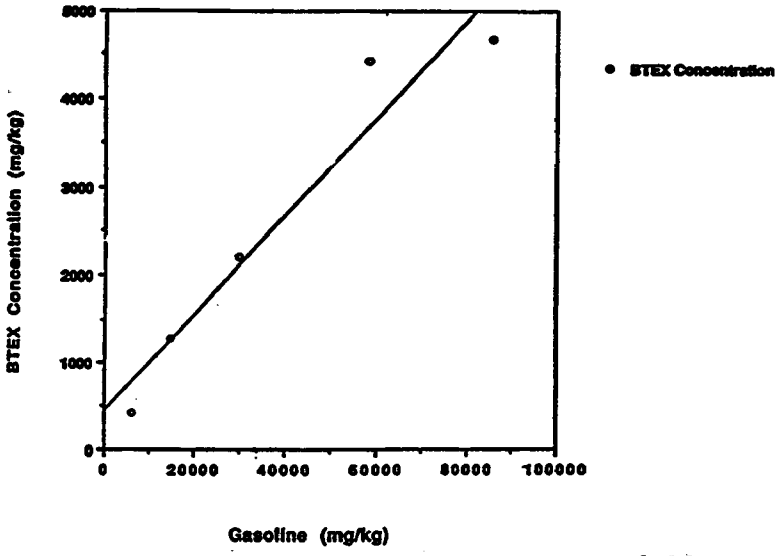
Contact Time Effect on Percent TPH Removal



Dose / Response Values for Diesel Fuel



Dose / Response Values for Gasoline



TOTAL PETROLEUM HYDROCARBON SOIL WASHING APPLICATIONS

SITE	INITIAL CONC. (mg/kg)	FINAL CONC.			PERCENT REMOVAL EFFICIENCIES		
		10-MESH	60-MESH	140-MESH	10-MESH	60-MESH	140-MESH
Grove City, OH, LUST - Gas	243.1 BTEX	196.8	124.6	123.3	19	49	49
Grove City, OH, LUST - Gas	243.1 BTEX	81.3	122.1	N/A	67	50	--
Mahwah, NJ, LUST - Gas	23.8 BTEX	0.6	4.7	20.5	97	80	14
Mahwah, NJ, LUST - Gas	23.8 BTEX	19.9	2.5	N/A	16	89	--
Princeton, NJ LUST - No.2 Oil	1375 TPH	320	300	240	77	78	83
Princeton, NJ LUST - No.2 Oil	1375 TPH	250	1880	N/A	82	0	--
Holmdale, NJ LUST - No.1 Kerosene	215 TPH	<30	98	110	86	54	49
Holmdale, NJ LUST - No.1 Kerosene	215 TPH	<20	<20	65	91	91	70
Valdez, AL Beach Material	14,410 TPH	470	14,800	N/A	97	0	--

PROCESSES REQUIRING EXCAVATION/DREDGING

BASIC EXTRACTION SLUDGE TREATMENT (BEST)

Resources Conservation Company
Bellevue, Washington

APPROPRIATE WASTES

- Oily sludges
- High water-content organic wastes

TECHNOLOGY

- Treats oily sludge with triethylamine (TEA) solvent
- Separates oil from water & solids
- Produces incinerable oil
- Discharge water to POTWs
- Dry, pathogen-free solids

BASIC COMPONENTS

- Centrifuge
- Dryer
- Decanter
- Solvent still
- Water still

ADVANTAGES

- Produces dry solids
- Recovers oil or high-boiling chemicals
- Water discharge is disposable

LIMITATIONS

- Process limited to low-solids, oily sludge
- Hazardous components not destroyed
- Complex process

SOLVENT EXTRACTION WITH LIQUIFIED GAS

C.F. Systems Corporation
Waltham, Massachusetts

TECHNOLOGY

As a liquid approaches its critical point, it:

- Behaves like a liquid solvent dissolving large amounts of organic substances
- Behaves like a gas allowing high rates of extraction

MAIN COMPONENTS OF SYSTEM

- Extractor
  - -aqueous solutions (trays)
  - -solids and sludges (mixer)
- Separator

ADVANTAGES

- Waste minimization by volume reduction process
- Low operating cost
- Totally enclosed system

LIMITATIONS

- Highly water soluble, highly polar organics
- Very low concentration organics
- Heavy metals

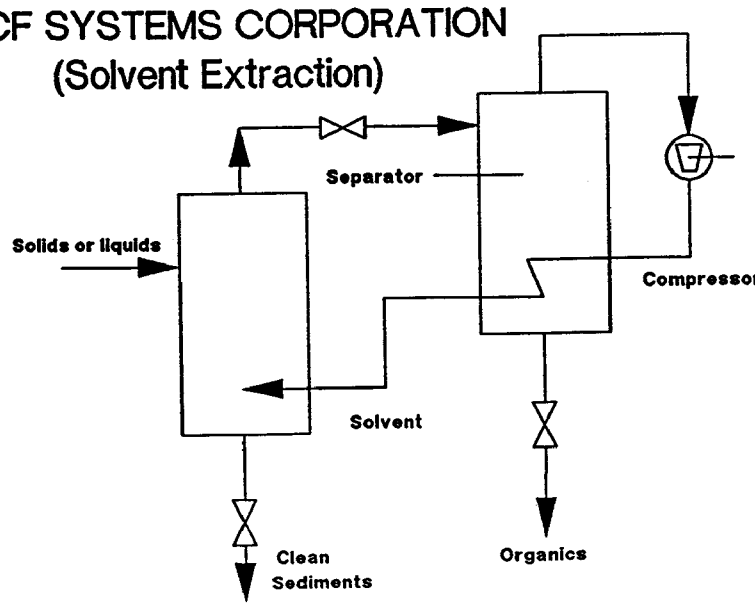
APPROPRIATE WASTES

- Waste streams containing 10-25 % organics
- Aqueous waste streams are treated in the aqueous process unit
- Pumpable waste streams are treated in the solids/sludge unit

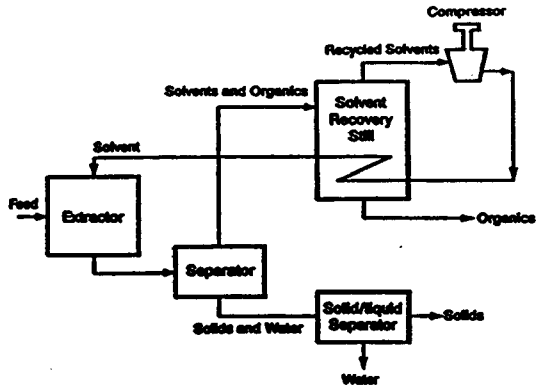
POTENTIAL APPLICATIONS

- Extraction/separation of organics from waste water
- Extraction/separation of organics from pit sludges
- Separation/recycling of valuable oils
- Incinerator pretreatment process

CF SYSTEMS CORPORATION
(Solvent Extraction)



PIT CLEAN-UP UNIT



BIOTROL SOIL TREATMENT SYSTEM (BSTS)

BASIC COMPONENTS

- Soils washing equipment
- Biological water treatment system
- Slurry bioreactor

ADVANTAGES

- Low cost
- Volume reduction
- Return to excavation
- Soluble organics are destroyed
- Process water treated and recycled
- Fine particle sludge is treated
- Process is flexible

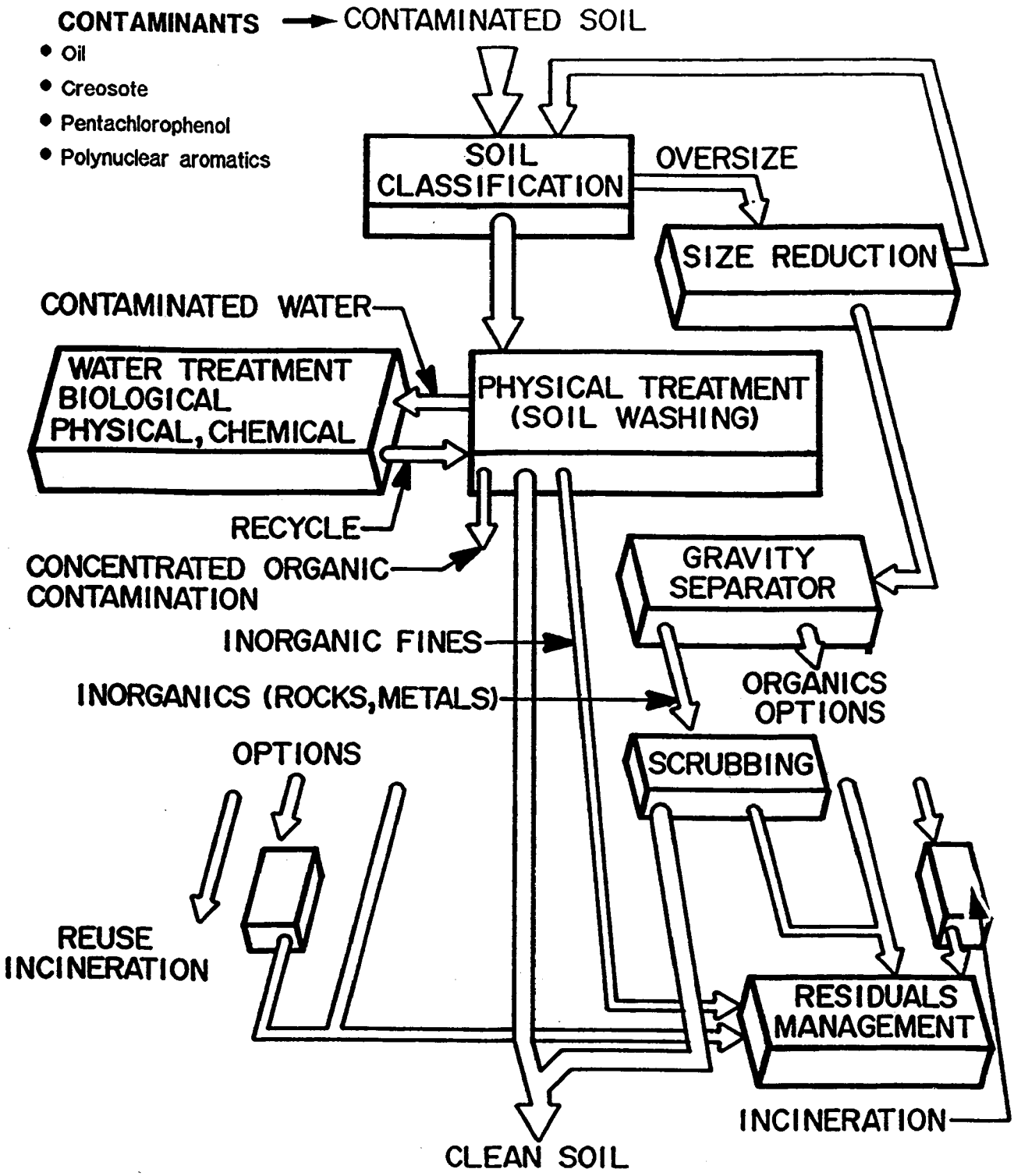
LIMITATIONS

- Debris removal required
- Metals removal
- Not demonstrated on a commercial scale

APPROPRIATE WASTES

- Soils from wood-treatment sites
- Petroleum hydrocarbon contaminated soils
- Pesticides contaminated soil

BIOTROL SOIL TREATMENT SYSTEM (BSTS)



PROCESS DIAGRAM FOR SOIL WASHING SYSTEM

PILOT SOIL WASHING EQUIPMENT

- 42' semi-trailer
- Soil feed rate up to 500 pounds per hour (dry weight)
- Soils initially screened and classified
- Countercurrent soil washing using water

PILOT SOIL WASHING EQUIPMENT (Continued)

- Contaminated water treated with aerobic biological treatment system
- Decontaminated water recycled to unit
- Sands and clays separated and treated
- Large debris treated separately

SITE SOIL CHARACTERISTICS

- Silty, fine to medium grained sands with intermediate and laterally discontinuous silt and sand lenses

PENTACHLOROPHENOL SOIL WASHING RESULTS

(All concentrations are in ppm)

Soil	# of Tests	Dry Feed (lbs/hr)	Influent Conc.	Treated Conc.	Percent Reduction
#1	4	282 (+/-77)	1,498 (+/-558)	80 (+/-37)	>94
#2	5	420 (+/-48)	160 (+/-26)	10 (+/-5)	>93
#3	5	443 (+/-51)	215 (+/-11)	24 (+/-4)	>88

ESTIMATED TREATMENT COSTS

- $100 per cubic yard
- Final cost depends upon:
  - -volume of soil to be treated
  - -specific contaminants present
  - -composition of soils
  - -required effluent concentrations

OPERATIONAL EXPENSES

- Supplies/reagents
- Energy
- Operating personnel
- Disposal of end-products

ECONOMICS

- Capital equipment
- Design/engineering
- Installation expenses
- Operational expenses

PRETREATMENT FACTORS

- Nonaqueous phase neat material removal
  - specific gravity <1
  - specific gravity >1
- pH
- Nutrients
- Toxicity
  - organic
  - inorganic
- Nuisance substances
  - iron
  - suspended solids

POST TREATMENT FACTORS

- Solids removal and disposal
- Effluent organics
  - persistent compounds
  - metabolic by-products
- Air emissions

OTHER SOIL, SEDIMENT AND SLUDGE EXTRACTIVE TREATMENT TECHNOLOGIES UNDER U.S. EPA SITE PROGRAM

Technology	Developer
Chemical Oxidation/ Cyanide Destruction	Exxon Chemicals, Inc.
Liquid/Solid Contact Digestion	MoTec, Inc.
Soil Washing, Catalytic/ Ozone Oxidation	Ozonics Recycling Corporation
Low Energy Solvent Extraction	Enviro-Sciences, Inc.
Soil Washing	Harmon Environmental Services, Inc. (formerly Envirite Field Services, Inc.)
Vapor Extraction System	American Toxic Disposal, Inc.
XTRAX™ Low-Temperature Thermal Desorption	Chemical Waste Management, Inc.
Carver-Greenfield Process for Extraction of Oily Waste	Dehydro-Tech Corporation
Contained Recovery of Oily Wastes (CROW)	Western Research Institute

IN-SITU PROCESSES

IN-SITU VOLATILIZATION

Terra Vac, Inc.

Dorado, Puerto Rico

TECHNOLOGY

- Highly volatile organics vacuumed from soil interstices from bore hole
- Recovered gas passed through activated carbon filters

ADVANTAGES

- Simple process
- Readily available equipment
- Not depth-limited

LIMITATIONS

- Only for highly-volatile organics
- Dense soils (clays) significantly slow diffusion
- Spent carbon canisters must be processed

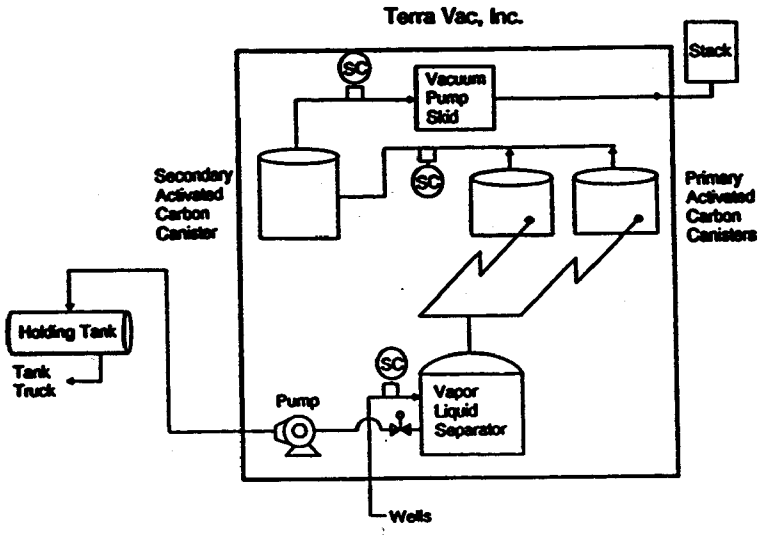
APPROPRIATE WASTES

Organics that are volatile at ambient temperatures

BASIC COMPONENTS

- Production well
- Monitoring wells
- High-vacuum pumps
- Carbon bed filters

In-Situ Vacuum Extraction



Schematic diagram of equipment layout.

SOLUTION MINING

Function: To inject or apply a flushing solution in order to displace a substance and allow the collection of the contaminated leachate.

SOLUTION MINING

Applicability

- Heavy metals
- Hydrophilic organics
- Hydrophobic organics
- Sandy soils with < 10% clay
- Soils with < 5% TOC

TYPICAL EXTRACTION AGENTS

- Water
- Acids - HCl, H_2SO_4, HNO_3, Acetic acid
  Dihydrogen phosphate
- Bases-Na_2CO_3, NaOH
- Surface active agents
- Complexing agents-citric acid, EDTA
- Organic solvents
  - -Water soluble
    (e.g., acetone, ethanol, IPA)
  - -Water insoluble
    (e.g., hexane)
- Combination of above

SOLUTION MINING
Design Considerations

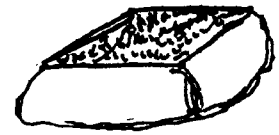
- Pollutant and concentration
- Organic content of soil
- Soil acidity (or alkalinity)
- Soil permeability

SOLUTION MINING
Design Considerations (Continued)

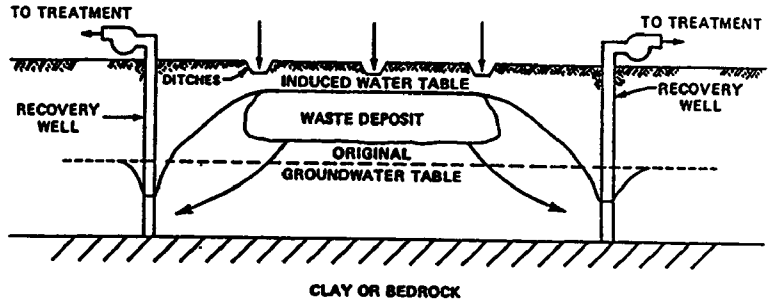
- Properties of extracting solvent
- Proper design of injection and withdrawal wells
- Pretreatment (e.g., oxidation)
- Results of shaker tests and column testing programs

SOLUTION MINING
Limitations

- Permeability of soil
- High organic content in soil
- Presence of interfering cations
- Unfavorable coefficient for extraction



DISTRIBUTION OF SOLUTION THROUGH DITCHES



IN-SITU STEAM STRIPPING

- Toxic Treatment (USA) Inc. "The Detoxifier"
- Drilling Tower
- Vapor Collection Shroud
- "Closed Loop" Treatment System
- 30 Square Foot Treatment Block, To 30 Feet Deep
- Tractor Mounted Drilling Tower And Separate Process Train (16' x 48')

IN-SITU STEAM STRIPPING

- Requires Flat (4 Degree Slope), Graded Site
- No Subsurface Debris, Concrete, Etc.
- Can Inject Solids, Liquids, Slurries, Gas Claimed Applicable To In-Situ
  - Air/Steam Stripping
  - Chemical Treatment (Neutralization, Oxidation)
  - Solidification/Stabilization

IN-SITU STEAM STRIPPING

- On-Going Treatment By "The Detoxifier" At San Pedro Terminal Site (Los Angeles)
- 8000 Cubic Yards (1.2 Acres, Up to 6 Feet Deep) Of Soil Contaminated With Chlorinated And Non-Chlorinated Volatiles
- Treatment Targets: <100 ppm Total HC
  <5 ppm Benzene

IN-SITU STEAM STRIPPING

"The Detoxifier" Treatment Of 4700 Cubic Yards Of Unsaturated Soil Contaminated With Gasoline/Diesel

- Steam And Potassium Permanganate Oxidation Of Highly Contaminated Soil
- Total Petroleum Hydrocarbons (ppm)

	Initial	Final
Low	1,000	100-250
Mean	2,200	190
Max.	36,000	2,200

IN-SITU STEAM STRIPPING

(Continued:)

- Average Processing Rate (In-Ground Only) 15 Cubic Yards/Hour
- Problems
  - Breakthrough Of Hydrocarbons Stripped From Most Contaminated Soil (GAC Overload) Reinjected Into Soil
  - Couldn't Strip Less Volatile Diesel Fuel Components

ON-SITE AND IN-SITU THERMAL TREATMENT METHODS

- Reduce Toxicity And Volume
- Conventional And Innovative Technologies
- All (Except Circulating Bed) Require Offgas Controls
- Wastes Handled: Most Organics & Organic-Contaminated Soils

IN-SITU THERMAL STRIPPING USING RADIO FREQUENCY (RF) HEATING

- Developed To Enhance Oil Recovery From Tar Sands
- Electromagnetic (RF) Energy Absorption Heats Soils To 220 To 400 Degrees Celsius
- Electrodes On Surface Or In Boreholes - Depends On required Penetration Depth And Temperature
- Soil/Ground Water Leads To Vaporization Or Steam Stripping/Steam Distillation Of Volatile Organics
- Heating May Be Used To Accelerate In-Situ Chemical Decontamination Processes (e.g., KPEG)

IN-SITU RF HEATING SYSTEM

- Electrode Array
  - Surface If Waste Depth <1 Meter, Temperature <130 Degrees Celsius
  - Boreholes If Waste Depth >1 Meter, Temperature >130 Degrees Celsius
- Power Generation
  - 1 MW For 10,000 SQ. FT By 8 FT Deep Treatment Zone

IN-SITU RF HEATING

- Maximum Penentration Depth 20 Ft - Limited By
  - Power Requirements
  - Heat Dissipation
  - Ability Of Volatiles To Escape
- Will Work Best In Damp Permeable Soils
- Estimated Cost $50/Ton (Not Including Disposal Of Recovered Waste)
- Pilot Scale Testing (8'x8'x6') At Volk Air National Guard Base, Wisconsin, In 1987-88

IN-SITU RF HEATING SYSTEM

(Continued:)

- Off-Gas Containment
  - Vapor Collection Hood
- Gas/Condensate Treatment
  - Condenser
  - Redistillation Unit (?)
  - Carbon Adsorption (Air And Liquid Phase)
  - Afterburner (?)

TECHNOLOGY APPLICATIONS

Technology	Separation	Recovery	Treatment
Soil washing	X	X	
BEST	X	X	X
C.F. Systems	X	X	
Biotrol	X		X
Terra Vac	X	X	
Solution mining	X	X	
Steam stripping	X	X	
RF heating	X	X	X

SEPARATION AND TREATMENT OF ORGANICS IN LIQUIDS

Abstract 7-2

Slides 7-6

SEPARATION AND TREATMENT OF ORGANIC CONTAMINANTS IN LIQUIDS

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INTRODUCTION

In assessing management options for liquid waste streams contaminated with organics, the treatment process selected should have as its goal the reduction of hazardous volume, and if possible, the elimination of the hazardous properties of the material. A number of separate, yet interdependent steps are necessary in the formulation and selection of remedial alternative technologies. Two of the first steps in accomplishing this goal are a characterization of the waste stream, followed by the definition of the clean–up goals. The challenge then becomes the selection of applicable unit technologies to treat these wastes in a cost–effective manner, while ensuring regulatory compliance. Recognizing the wide variety of hazardous waste remediation scenarios, treatment options for managing liquid wastes contaminated with organics can be categorized as pretreatment, treatment, or reclamation.

PRETREATMENT

Most liquid organic waste streams require some sort of pretreatment before they are introduced to the final or primary treatment process. Generally, some sort of phase separation may be required to remove solid materials (that can adversely affect process efficiency) or remove the organic contaminants from the liquid phase. Frequently, phase separation permits a significant volume reduction, particularly if the hazardous component is present to a significant extent in only one of the phases. Furthermore, by concentrating the hazardous portion of the stream, sequential processing steps may be accomplished more readily. Phase separation processes usually are mechanical, inexpensive and simple, and can be applied to a broad spectrum of wastes and wastes components.

The basic concept of separation processes is to get the solid phases or water to separate from the organic phase, through the use of gravitational, centrifugal, or hydrostatic forces. Emulsions are generally very difficult to separate. Heating, cooling, change of pH, salting out, centrifugation, API separators, and other techniques may all be tried, but there is no accurate way to predict its separation without treatability testing.

In addition to phase separation and/or modification of the waste properties through mixing or heating, some sort of treatment may be required to separate components. Component separation can be achieved physically by, for example, distillation of volatiles or use of solvent extraction processes, or chemically by neutralization, oxidation, or precipitation. Pretreatment options are numerous and must be tailored to both the waste stream and the process used for final treatment.

TREATMENT

Treatment of organic contaminants in a liquid phase is probably the most common management scenario confronting the hazardous waste profession. The reason is due to the fact that dilute aqueous streams with low concentrations of organics are neither amenable to recovery nor cost effective to treat by means of thermal destruction.

Furthermore, effluent limitations or clean-up objectives often approach detection limits, a situation where pretreatment by itself will not suffice. In assessing treatment options for a particular organic wastewater, the possibility of combining unit technologies must be completely evaluated both from a technical effectiveness and cost-analysis perspective. The physical/chemical processes most applicable for treating dilute organic waste streams are air stripping, stream stripping, liquid/liquid extraction, supercritical solvent extraction, adsorption (carbon and resin), chemical oxidation and dehalogenation.

Solvents may be removed from the solution by applying air or steam to the mixture. The organic solvent is driven to the vapor phase, depending primarily on the volatility of the compound and the temperature. It can then be condensed for reuse, combusted, adsorbed onto carbon for subsequent disposal. These technologies usually become less efficient as the concentration of solvent is reduced.

Liquid/liquid extraction (solvent extraction) is widely used in the chemical process industry but has not yet been extensively employed for treatment of hazardous wastes. It may possibly be utilized advantageously to separate components that can not be separated by processes based on differential volatilization. Extraction processes are applicable to both aqueous and organic matrices, although partition coefficients are greatest for aqueous/organic combinations.

Adsorption is highly applicable to most high weight molecular organics. Granular activated carbon (GAC) or various resins are used as the material in this treatment process. Constituents are adsorbed onto the surface via physical and chemical forces. The adsorption forces are comparatively weak and therefore the reverse process, desportion, is also possible. This reversible process allows the adsorbing surface to be regenerated. Adsorption is not generally used in the treatment of nonaqueous process streams. This is because the less polar the solvent stream, the less likely it will be that constituents are removed from a relatively nonpolar solvent to a nonpolar adsorption surface.

Chemical oxidation is a process which oxidizes ions or compounds to render them nonhazardous or to make them more amenable to subsequent removal or destruction processes. Species are oxidized by the addition of a chemical oxidizing agent which is itself reduced. Chemical oxidation is most useful as a polishing step for dilute, relatively clean aqueous wastes. Chemicals oxidants are relatively nonselective and may oxidize other compounds present prior to oxidizing the contaminants of concern. As a result, this process has limited application to wastewaters with large amounts of oxidizable components. Chemical oxidation processes include oxidation with hydrogen peroxide, potassium peroxide, or sodium hypochlorite; ozonation; alkaline chlorination, electrolytic oxidation, or a combination of these processes.

Dehalogenation processes use chemical reagents to remove halogens from halogenated molecules, to break apart chlorinated molecules, or to change the molecular structure of the molecule. Metallic sodium is typically the reagent used to strip the halogen away from the constituents to form a sodium salt. The majority of the dehalogenation research has been aimed at the detoxification of PCBs. This process is applicable to many other halogenated organic molecules such as chlorinated pesticides and dioxin compounds.

RECLAMATION

To some extent, most organics are considered soluble in water. When this solubility is exceeded, the excess organics can be recovered by simple settling and decanting of the insoluble fractions. Organics reclamation, particularly for solvents, may be considered a viable treatment alternative when the waste stream under examination contains significant quantities of recoverable materials. The three most commonly employed reclamation technologies for organics are steam distillation, separators, and fractionation columns.

Steam distillation is a process in which separation of two materials is achieved using their differences in boiling point. Steam passing through a coil volatilizes the "lighter" organic component, which then rises through the top of the vessel and is condensed in a phase separator. The two most common distillation systems are the steam–coil and the steam–stripper still.

The two types of separators used to recycle spent organics are scraped–surface separators and thin–film separators. The scraped surface separator is well suited for solvent streams with a high concentration of suspended solids and sludges, and can be effective in separating spent solvent by density. A power–driven shaft with attached paddles revolves inside a vertical vessel. This mechanism causes the incoming organic stream to be agitated. The heavy solid materials fall to the bottom of the vessel while the lighter materials are vaporized and drawn out of the top of the vessel. Heating is achieved by any number of methods, with stream being the most prevalent. The thin–film separator works on the same principal, however, the vertical slots are modified to spread a thin film of liquid material against the vessel wall where it is exposed to heat. The thin–film separator is best suited for reclaiming low–boiling–point solvents and is not applicable to spent solvent streams containing suspended solids or dissolved resinous material.

Fractional processes commonly employed for reclaiming spent solvents are bubble–tray columns and packed columns. Fractionation by bubble–tray columns normally requires several pretreatment steps in order to avoid solid material carry over and subsequent build–up on the trays which reduces the overall process efficiency. Settling tanks and thin–film separators are often employed to provide the pretreatment and ensure a near–pure liquid feed stream to the fractionation column. The packed–column fractionation system differs from the bubble–tray in that the column is packed with rings to create a maze for the passage of liquids and vapors, thus increasing the surface contact area and residence time.

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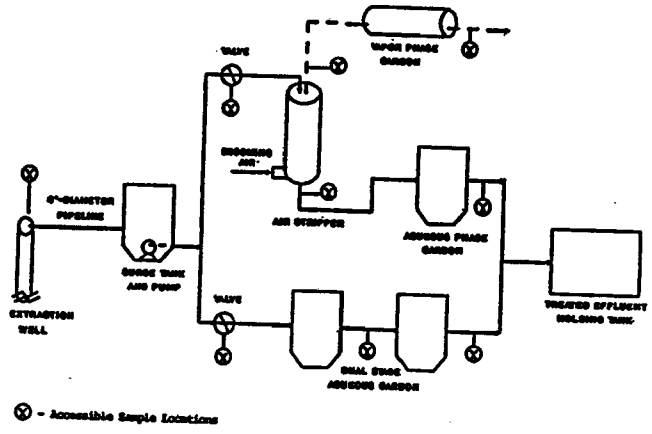
CHARACTERIZING THE WASTE STREAM

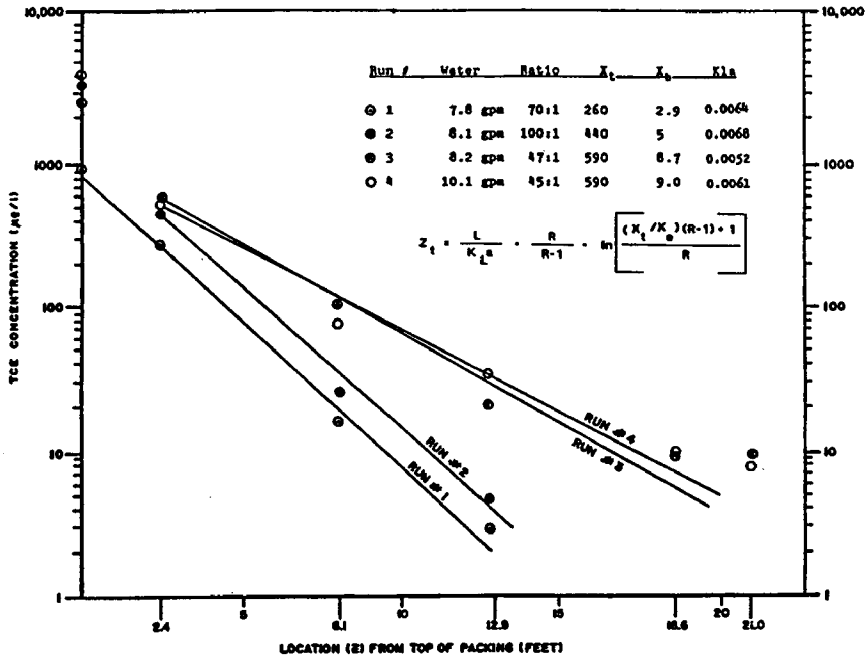
- Organic content parameters: COD, BOD, TOC, TOX
- Solids content: TS, TSS, TDS, TVS
- Specific organic compounds: which fractions, DL, analytical method
- In-situ parameters: temperature, pH, ORP, conductivity
- Other: viscosity

PILOT STUDIES

- Air stripping
- Adsorption isotherm studies
- Oxidation evaluations
- Evaluate impacts of metals, other pollutants

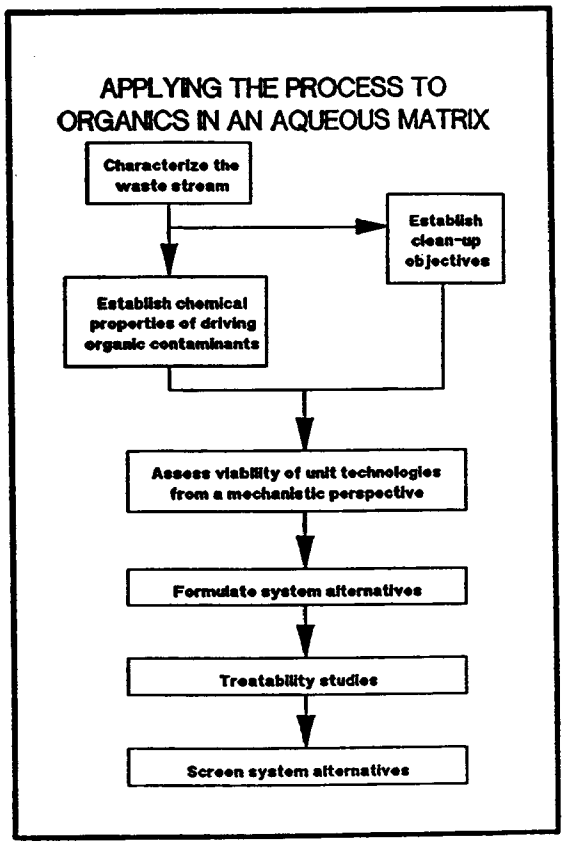


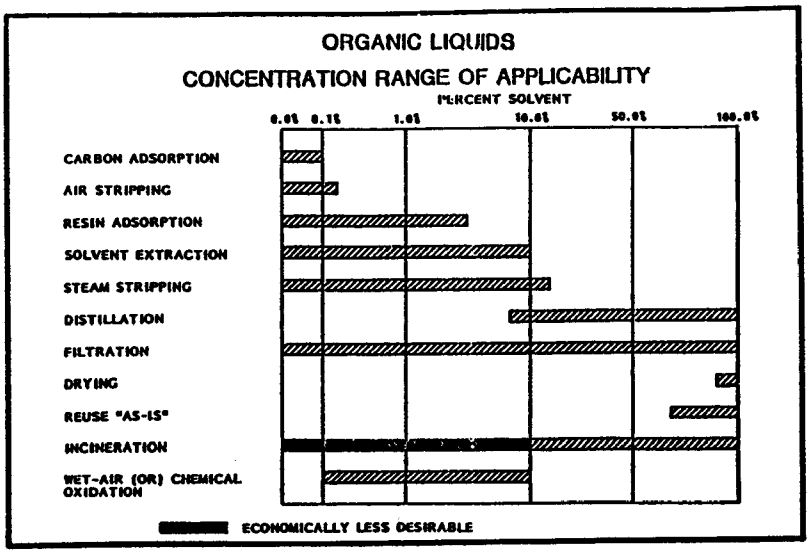
SAMPLE LOCATIONS DURING PILOT-SCALE TREATABILITY STUDY



TCE CONCENTRATION PROFILES FOR RUNS 1THROUGH 4

APPLYING THE PROCESS TO ORGANICS IN AN AQUEOUS MATRIX





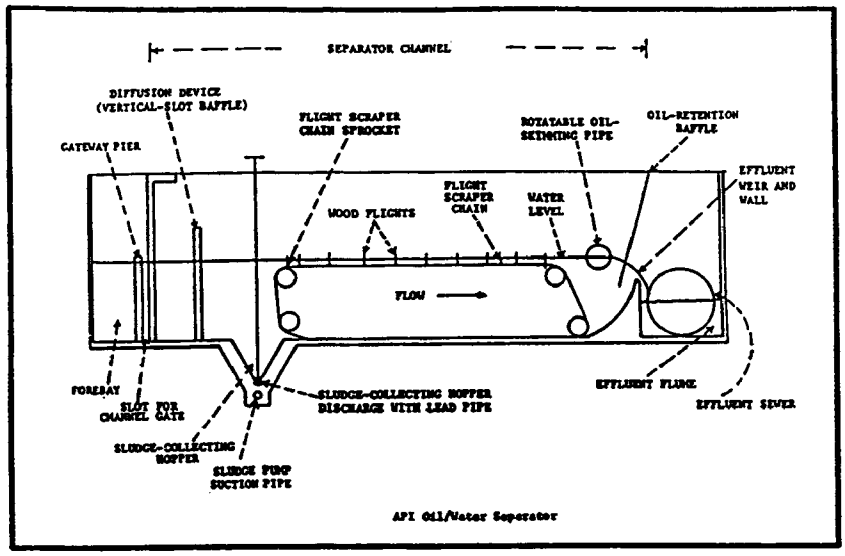
OIL/WATER SEPARATION

Quiescent gravity separation of two (or more) immiscible liquids having sufficiently different densities (such as oil and water)

Extensively used as a pretreatment step to subsequent unit processes

EFFECTIVENESS

- Depends on waste temperature, pH, flow rate
- Emulsion breaking with acids, metal salts, etc., may be necessary
- Centrifugation of skimmed oil may be appropriate



API Oil/Water Separator

AIR STRIPPING

Process of mixing air and contaminated water together to facilitate the removal of volatile contaminants from water

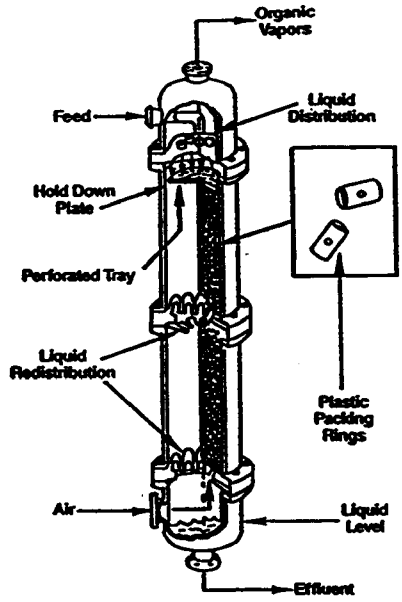
AIR STRIPPING

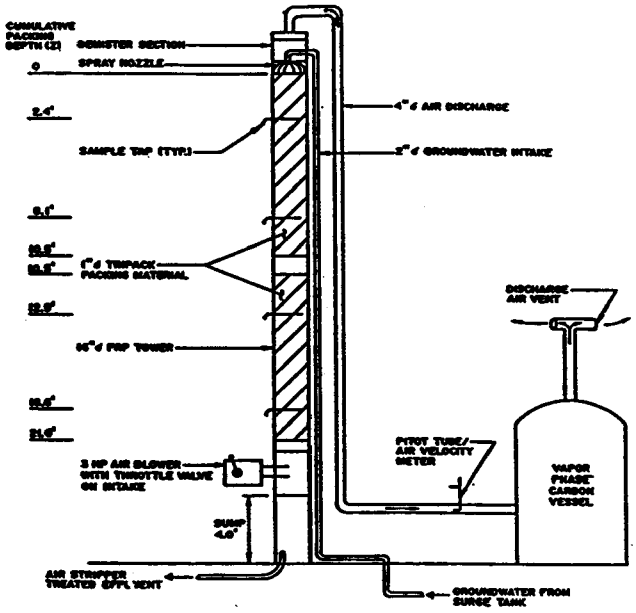
- Several tower configurations - most common is countercurrent packed tower
- Treatment efficiency: Henry's coefficient, A:W ratio, $K_L a$, temperature, pressure, surface area
- Objective: maximize air/water surface area contact

AIR STRIPPING

- Steady state process, i.e. % removal is independent of influent concentration
- Packed towers are susceptible to fouling and plugging
- Contaminated air stream may require treatment

AIR STRIPPING COLUMN— RING-PACKING TYPE





PILOT-SCALE AIR STRIPPING TOWER

—SME/EER—

AIR STRIPPING APPLICATION

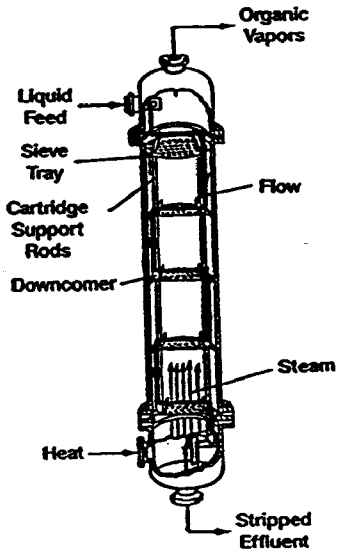
- Henry's coefficient values above 20 atmospheres
- Volatiles that are not soluble in water
- Pollutant concentrations <10-100 ppm
- No suspended solids, low hardness, low iron (<1.0 ppm)
- Warmer ambient environments assist process

STEAM STRIPPING PROCESS

Continuous fractional separation process carried out in a packed or tray tower

Residuals are contaminated steam, which is normally run through a condenser for recovering product, and stripped effluent

STEAM STRIPPING COLUMN—
PERFORATED TRAY TYPE



STEAM STRIPPING APPLICATION

- Chlorinated hydrocarbons
- Aromatics such as xylene
- Ketones such as acetone or MEK
- Alcohols such as methanol
- High boiling chlorinated aromatics such as pentachlorophenol
- Treats less volatile more soluble compounds than air stripping
- Can handle pollutant concentrations from <100ppb to >10%

LIQUID/LIQUID EXTRACTION

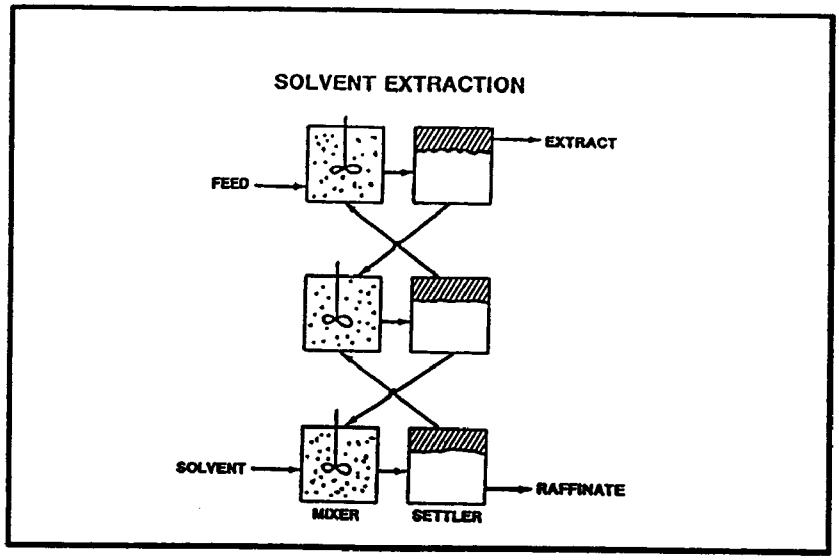
Separation of two intimately mixed or mutually soluble liquids by introduction of a third liquid which is a solvent for one (solute) and insoluble and immiscible with the second liquid

Solvent/solute stream (extract) is subsequently separated by distillation or chemical means

LIQUID/LIQUID EXTRACTION

Application

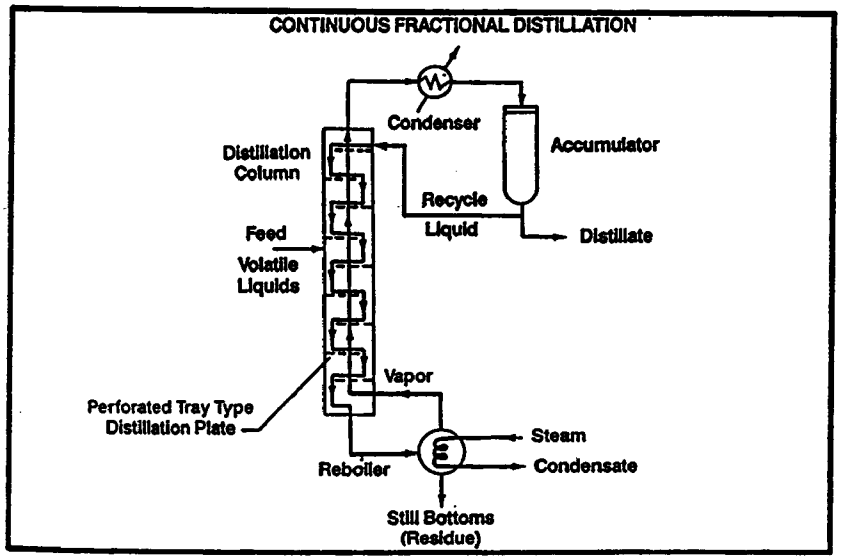
- Normally requires subsequent treatment for raffinate
- Used in various industries to remove organic contaminates from aqueous wastes
  - -petroleum refining
  - -organic chemicals
  - -pulp and paper
  - -iron and steel



SOLVENT EXTRACTION

Residuals

- Raffinate
  - treated effluent
  - contaminated with solvent
- Extract



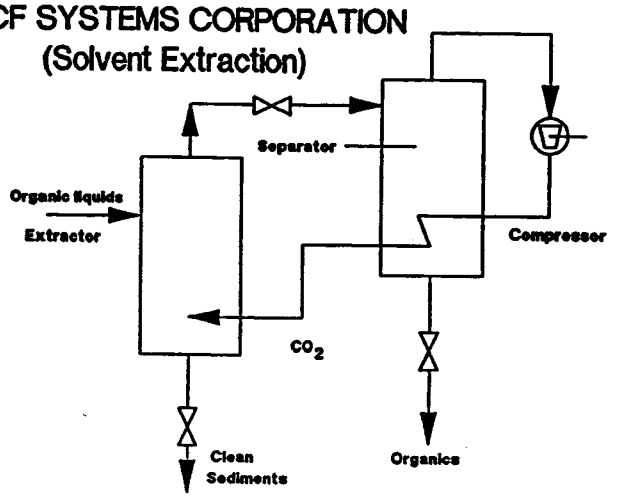
SUPERCRITICAL SOLVENT EXTRACTION

- Separation not a destruction process
- Critical temperature and pressure are used to enhance solvent properties of a fluid
- CO_2 or propane used as liquified gas for extracting contaminants

APPLICATION OF SUPERCRITICAL SOLVENT EXTRACTION

carbon tetrachloride	vinyl acetate	xylene
chloroform	PCBs	toluene
benzene	butyric acid	methyl acetate
naphthalene	dichloroethene	acetone
gasoline	oils and grease	butanol
phenol	heptane	propanol

CF SYSTEMS CORPORATION
(Solvent Extraction)



ADSORPTION PROCESSES

Separation technology used to remove dissolved organics and certain inorganics from a single-phase fluid stream

PRINCIPLE: ADSORPTION

Function: Separation, Recovery, Volume Reduction/Concentration, Pretreatment

- Processes
  - -carbon adsorption
  - -resin adsorption

GRANULAR ACTIVATED CARBON

- Unsteady state process (all or nothing)
- Carbon can be regenerated
- Applicable for mixed organics from aqueous
- Best suited for removing organics with:
  - -High molecular weights
  - -low water solubilities
  - -low polarity
  - -low degree of ionization
- TOC as high as 10,000 ppm treated

GAC LIMITATIONS

- Not effective for highly polar or soluble organics (i.e., alcohols & ketones)
- Not suited for oil and grease
- TSS should be < 10mg/l
- Effectiveness sensitive to proper installation, operation, and maintenance of system
- Operational costs

GAC PILOT TESTING

- Laboratory isotherm data
- Pilot column testing
- Accelerated column testing (ACT)

RESIN ADSORPTION

Adsorption and recovery of an organic substance from an aqueous waste by means of a synthetic resin fixed bed

Differs from GAC in that attraction between solute molecules and resin is less than GAC, thus promoting easier regeneration and recovery

RESIN ADSORPTION

- Requires low suspended solids (<10mg/l)
- pH dependent
- Strong oxidants cannot be present
- Process used more as a polishing step
- Very applicable for phenol removal
- Applicable for explosive materials

CHEMICAL OXIDATION

Function: Increase the oxidation state of a substance by the removal of electrons or the addition of oxygen.

CHEMICAL OXIDATION

Applicability

- CN bearing wastes
- Non-chlorinated pesticides
- Pretreatment for certain refractory organics
- Polishing step to oxidize trace organics

TYPICAL OXIDATION PROCESSES

- Oxidation by hydrogen peroxide
- Oxidation by potassium permanganate
- Ozonation
- Ozonation in conjunction with UV radiation
- Alkaline chlorination
- Oxidation by NaOCl
- Electrolytic oxidation
- Supercritical water oxidation

CHEMICAL OXIDATION

Design Considerations

- pH conditions
- Adequate mixing
- Heat of reaction
- Materials of construction
- Oxidation reduction potential
- Composition of by-products

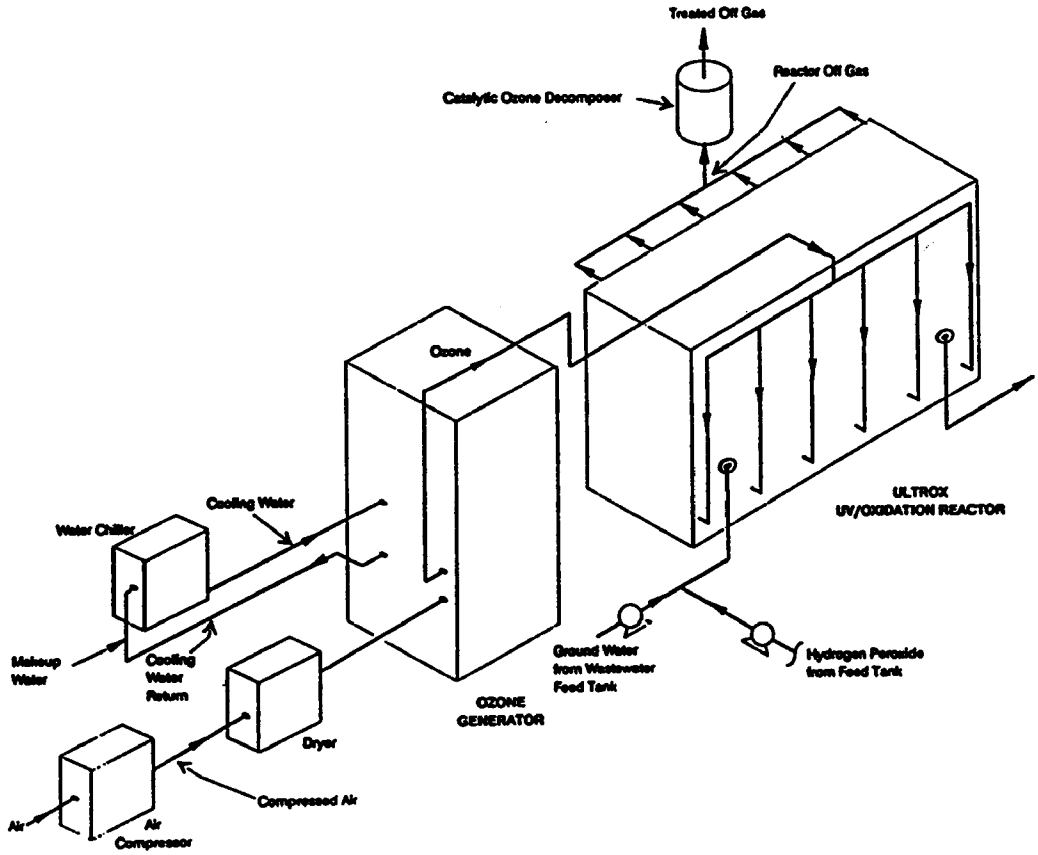
CHEMICAL OXIDATION

Limitations

- Non-selective process
- Certain transition metals (e.g., soluble iron)
- Slurries, tars, sludges
- Potential toxic by-products
- Long process time for certain applications

ULTROX UV/O3 PROCESS

- Alternative to carbon adsorption
- No residues generated
- Especially suited for chlorinated hydrocarbons
- Can treat organics from ppm range to less than detectable limits
- System is portable



Isometric View of Ultrox System

DEHALOGENATION

Function: Break apart or rearrange the structure of chlorinated molecules to form less hazardous compounds

DEHALOGENATION

Applicability

- PCBs
- Dioxins
- Other chlorinated hydrocarbons (solvents and pesticides)

TYPICAL DEHALOGENATION PROCESSES

- Alkali metals
- Metallic sodium and potassium in conjunction with proprietary reagents

SODIUM-BASED PROCESSES

- Suitable for oils containing <1000 ppm PCB
- Water sensitive
- Expensive
- Transformer decontamination

WASTE EXCHANGES

- State and area programs where waste generators can make their waste streams available for sale to reclaimers and other processes
- Privately owned companies who blend organics wastes for resale as fuels
- See inorganic section for waste exchange list

TECHNOLOGY APPLICATIONS

	Separation	Recovery	Treatment
Granular activated carbon	X		
Resin adsorption	X	X	
Oxidation			X
UV/Ozonation			X
Dehalogenation			X

TECHNOLOGY APPLICATIONS

	Pretreat-ment	Separation	Recovery
Oil/water separation	X	X	X
Air stripping	X	X	
Steam stripping		X	X
Liquid/liquid extraction		X	X
Supercritical solvent extraction		X	X

COLLECTION AND TREATMENT OF GASES

Abstract 8-2

Slides 8-5

COLLECTION AND TREATMENT OF GASES

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Air pollution problems at RCRA hazardous waste treatment, storage and disposal facilities (TSDFs) and at uncontrolled hazardous waste (CERCLA) sites may be the result of area fugitive emissions, process point source emissions and process fugitive emission. These emissions can be sources of both inorganic and organic hazardous air pollutants (HAPs).

Contaminated fugitive dusts from wind erosion, vehicular traffic, heavy equipment activity and material handling operations from processes such as incineration can be controlled by preventive techniques including wet suppression, stabilization, speed reduction, surface cleaning, wind breakers and good operating practices.

Control of organic vapor emissions from non–point sources such as landfills, spills and surface impoundment can be controlled by several means including pretreatment design and operating practices, in–situ controls and and posttreatment techniques. Gas control technologies at hazardous waste landfills include the use of multimedia caps and either active or passive gas collection systems. Active systems use gas vents and wells with vacuum pumps to collect the landfill gas for treatment. A passive system uses vapor barriers and collection systems that operate on diffusion and natural pressure. The vapor released from spills of volatile chemicals can be most effectively controlled by aqueous foam blankets, covers or mats. Available gas control options to reduce the rate of emissions from surface impoundments include complete enclosure, floating solid objects, shape modification, aerodynamic modification and floating oil layers and surfactants.

Control of organic vapor emission from equipment leaks such as pumps, valves and pressure relief valves can be accomplished by installing specific types of equipment that minimize leak and by implementing a leak detection and repair program. Closed vent systems can be installed to collect organic vapors for treatment by flaring, incineration, or vapor recovery.

Process point sources are generally controlled by add–on control devices for both particulate and organic vapor emissions. Selection of applicable control techniques for point source emissions is made on the basis of gas stream specific characteristics and desired control efficiency. Control devices which are applicable to particulate emission steming from point sources are cyclones, fabric filters, electrostatic precipitators, wet scrubbers and entrainment separators. Their applicability depends on the physical, chemical and electrical properties of the airborne particulate material.

Add–on type control technologies for the control of organic vapor emissions are adsorption, condensation, adsorption, flaring and incineration. Adsorption, condensation and adsorption are recovery technologies which are selected based on their removal efficiencies which in turn depend on the physical and chemical characteristics of the organic vapor. Flaring and incineration are combustion type technologies which are capable of high removal efficiencies for most types of organic vapors. Absorbers are generally impractical when used alone in organic vapor control applications because they cannot achieve low outlet concentrations required. Therefore, absorbers generally

are used with other control technologies such as incineration. Condensers used alone can control emission streams containing high VOC concentrations (> 5,000 ppmv) with a removal efficiency ranging from 50 to 90 percent. Removal efficiency above 90 percent are achievable if low temperature coolants are used. Frequently, condensers are use used as the preliminary technology prior to incinerators, adsorbers or absorbers. Carbon adsorbers can achieve removal efficiencies of 95–99 percent with a maximum inlet VOC concentration of 10,000 ppmv. Stream-assisted flares can achieve 98 percent destruction efficiency when controlling emission streams with heat contents greater than 300 BTU/scf.

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EMISSION SOURCES

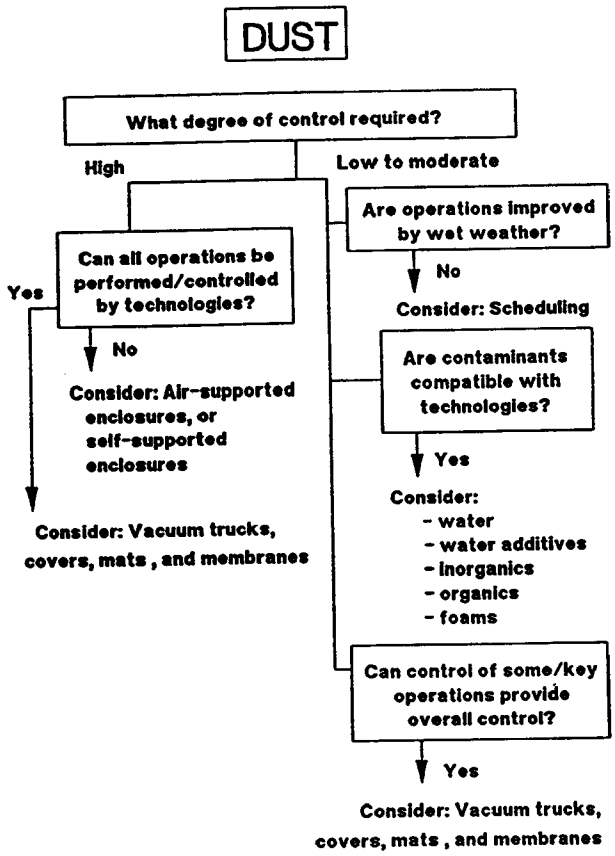
- Area fugitive sources
- Process fugitive sources
- Process point sources

AREA FUGITIVE EMISSIONS

- Particulates
- Organics

CONTAMINATED FUGITIVE DUSTS

- Wind erosion of wastes and contaminated soils
- Vehicular traffic
  -unpaved roads
- Heavy equipment activity
  -handling, excavating, loading
- Incineration of wastes during remediation



FUGITIVE DUST EMISSION SOURCES AND APPLICABLE CONTROL TECHNIQUES

Source	Wet suppression	Stabilization	Speed reduction	Surface cleaning/ transportation controls	Windbreaks	Good operating practices
Unpaved roads	X	X	X			
Construction activities	X			X		X
Dust from paved roads				X		
Off-road vehicles			X			
Overburden removal/ storage	X					X
Reclamation efforts		X				X
Inactive tailings piles		X			X	
Disturbed soil surfaces		X			X	X
Agricultural tilling					X	

CLASSIFICATION OF TESTED CHEMICAL SUPPRESSANTS

Dust suppressant category	Trade name
Salts	Peladow LiquiDow Dustgard
Lignosulfonates	Lignosite Trex
Surfactants	Biocat
Petroleum-based	Petro Tac Coherex Arco 2200 Arco 2400 Generic 2 (QS)
Mixtures	Arcote 220/Flambinder Soil Sement

CONTROL TECHNOLOGY APPLICATIONS FOR WASTE DISPOSAL SITES

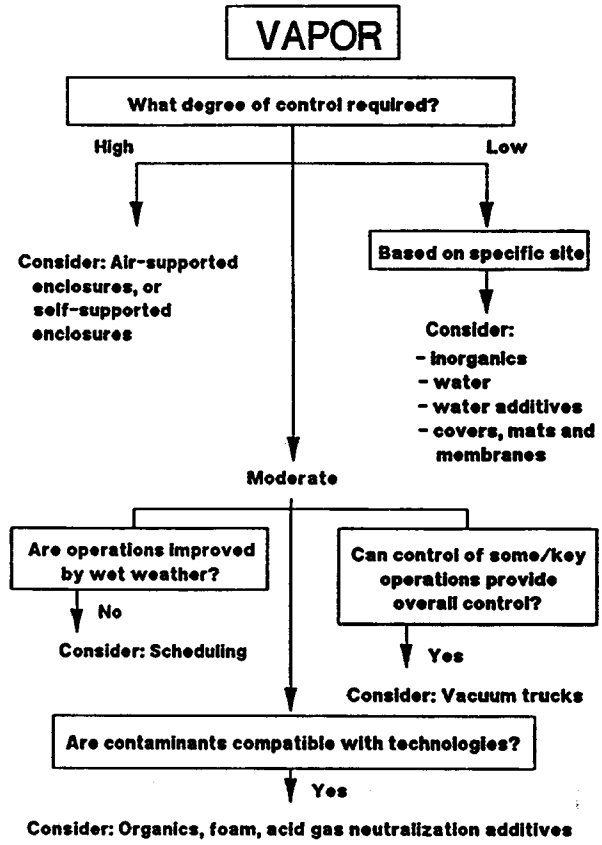
Emission Points	Control Procedure	Efficiency
Handling	Keep material wet	100%
	Cover or enclose hauling	No estimate
	Minimize free fall of material	No estimate
Dumping	Spray bar at dump area	50%
	Minimize free fall of material	No estimate
	Semi-enclose bin	No estimate
Wind Erosion	Cover with dirt or stable material	100%
	Chemically stabilize	80%
	Revegetate	25%-100%
	Rapidly reclaim newly filled areas	No estimate
Grading	Water	50%

CONTROL TECHNOLOGY APPLICATIONS FOR OPEN STORAGE PILES

Emission Points	Control Procedure	Efficiency
Loading onto Piles	Enclosure	70-99%
	Chemical wetting agents or foam	80-90%
	Adjustable chutes	75%
Movement of Pile	Enclosure	95-99%
	Chemical wetting agents	90%
	Watering	50%
	Traveling booms to distribute material	No estimate
Wind Erosion	Enclosure	95-99%
	Wind screens	Very low
	Chemical wetting agents or foam	90%
	Screening of material prior to storage; fines to processing	No estimate
Loadout	Water spraying	50%
	Gravity feed onto conveyor	80%
	Stacker/reclaimer	25-50%

Control Technology Applications for Roads

Emission Points	Control Procedure	Efficiency
Paved Streets	Street cleaning	No estimate
	Housecleaning programs to reduce deposition of material on streets	No estimate
	Vacuum street sweeping (daily) (2)	25% (17)
	Speed reduction	Variable
Unpaved Roads	Paving	85%
	Chemical stabilization	50%
	Watering	50%
	Speed reduction	Variable
Road Shoulders	Stabilization	80%



ORGANIC VAPOR NON-POINT SOURCES

- Landfills
- Spills
- Surface impoundments

TYPES OF CONTAMINANTS AND MODES OF TRANSPORT (U.S. EPA, SEPTEMBER 1988)

Contaminant/Type	Mode of Transport (Vapor or Dust)	Migration Concerns
Landfill Gases Methane Hydrogen sulfide	Vapor	Difficult to contain, highly mobile, ignitable at high concentrations, toxic at high to moderate concentrations, malodorous at low concentrations.
Inorganic Acid Vapors Hydrogen sulfide Hydrogen cyanide Hydrogen chloride Sulfuric acid	Vapor	Difficult to contain, highly mobile, corrosive, toxic at high to low concentrations, malodorous at low concentrations.
Volatile Organic Compounds A variety of chlorinated and nonchlorinated organic compounds ranging in volatility from methylene chloride to chlorobenzene.	Vapor	Typically contained in soil moisture or adsorbed onto soil organic fraction and is readily stripped from the soil when in contact with fresh air not already saturated with organics. A wide range of toxicity, carcinogenicity, and odor characteristics.
Semivolatile Organic Compounds A variety of chlorinated and nonchlorinated organic compounds ranging from dichlorobenzene to pyrene.	Vapor and Dust	Typically adsorbed onto soil organic fraction or present in separate liquid or solid phase. Transport to vapor phase generally lower. Transport via dust possible. A wide range of toxicity, carcinogenicity, and odor characteristics.
Polychlorinated biphenyls	Dust (to a lesser extent vapor)	Typically adsorbed onto soil organic fraction. Relatively low volatility results in lower vapor phase transport rate. Transport via dust possible. A highly regulated carcinogen.
Dioxins, Furans	Dust	Typically adsorbed onto soil organic wastes. Low volatility limits vapor phase transport. Transport possible via dust. Highly regulated, highly toxic classes of organic compounds.
Pesticides (Organic) 2,4-D 2,5-TP silver Lindane Pentachlorophenol	Dust (to a lesser extent vapor)	Typically adsorbed onto soil organic fraction or associated with organic wastes. Low volatility resulting in lower vapor phase transport. Transport via dust possible. Typically environmentally persistent with a range of toxicity and carcinogenicity characteristics.
Metal Dusts Lead/lead oxides	Dust (to a lesser extent vapor)	Typically low solubility results in little chemical binding to soil. Physically mixed with soil and/or battery casings. Transport via dust possible.
Dissolved/Adsorbed Metals Chromium Cadmium	Dust	Typically low to moderate solubility results in some migration at relatively low concentration and adsorption onto soils. Transport via dust possible, but metal fraction is low. Persistent and toxic.
Metal Vapors Mercury	Vapor	Mercury volatile in metallic form. Transport via vapor. Toxic.
Radiation	Dust and Vapor	May be present in gas (e.g., radon) or solid form. Exposure to radioactive dusts, particularly hazardous due to release of alpha particles and other ionizing radiation.

COST AND EFFECTIVENESS OF VARIOUS DUST SUPPRESSION FORMULATIONS ON A 50-FT X 50-FT EXPOSED TEST AREA[a]

Material Cost/Acre Dollars[b]	Type of Formulation	Application Concentration[c]	Application Rate	Effectiveness[d] @ 15 days	Effectiveness[d] @ 30 days
1642	Latex acrylic copolymer	3%	1.0 gal/yd^2	0	0
2661	Carboxylated styrene-butadiene copolymer	20%	0.6 gal/yd^2	Not given	5%
5481	Nonwoven geotextile	8 oz/yd^2	12-ft roll	44%	0
70	Lignosulfonate	17%	0.5 gal/yd^2	8%	0
548	Vinyl acetate resin	10%	0.2 gal/yd^2	0	0
309	Synthetic resin	3%	0.3 gal/yd^2	0	0
1009	Latex	7.2%	0.5 gal/yd^2	15%	0
959	Petroleum resin	25%	0.5 gal/yd^2	0	0
906	Straw mulch with emulsified asphalt	NA	NA	0	0
77	Vegetable gum	0.3%	1.4 gal/yd^2	36%	4%

a Adapted from Rosbury (June 1985).

b Material costs updated to August 1988 dollars by Chemical Week (CW) price service index of industrial chemical prices. Actual increases for specific chemicals may vary.

c Percent formulation in water.

d $$\text{Percent effectiveness} = 1 - \frac{\text{controlled ppm}}{\text{uncontrolled ppm}} \times 100.$$

REPRESENTATIVE SUMMARY OF DUST AND VAPOR SUPPRESSANT PRODUCTS

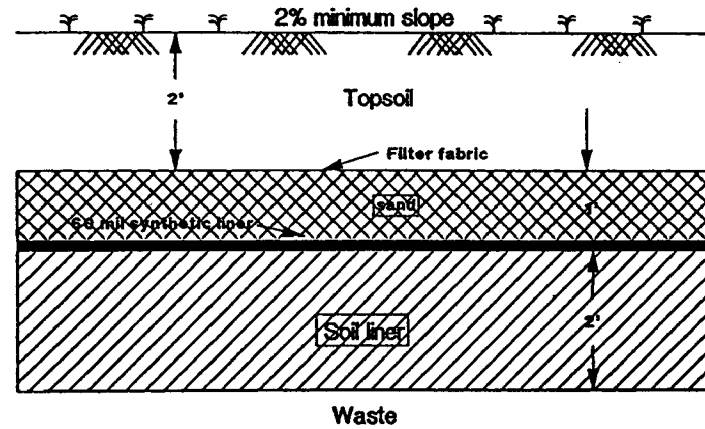
Product Type	Typical Material Cost ($/Acre)[a]	Form
Calcium lignosulfonates	67	Organic binder
Calcium chloride	230	Inorganic binder
Sodium silicate	340	Inorganic binder
Vinyl acetate resins	480	Water additive
Acrylic emulsions	840	Water additive
Ammonium lignosulfonates	620	Organic binder
Asphalt emulsion	1,180	Organic binder
Soil enzyme	1,400	In-Situ injectable
Wood fibers with plastic netting	1,700	Covers, mats, membranes
Polyurethane-Polyurea Foam	8,400	Foam
Sodium bentonite clay	16,500	Covers, mats, membranes
Sodium bentonite and geotextile fabric	26,100	Covers, mats, membranes

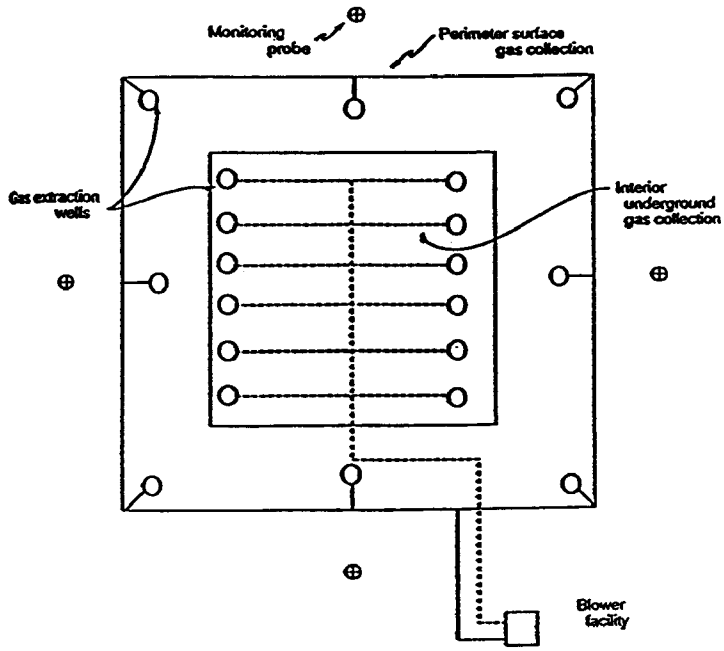
a Costs updated to August 1988 dollars by vendor information.

GAS CONTROLS FOR LANDFILLS

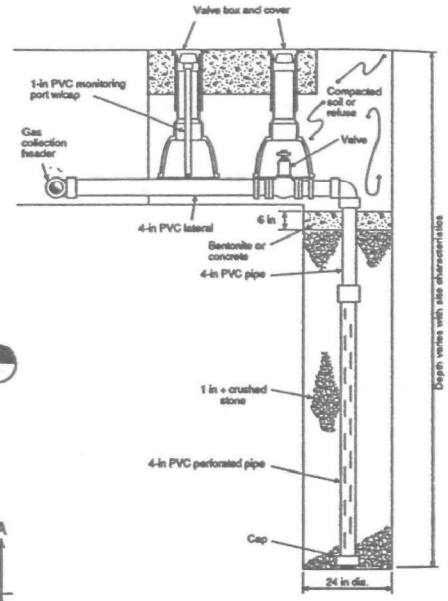
- Capping
- Active gas collection
- Passive gas collection

CROSS-SECTION ILLUSTRATING A MULTIMEDIA CAP DESIGN

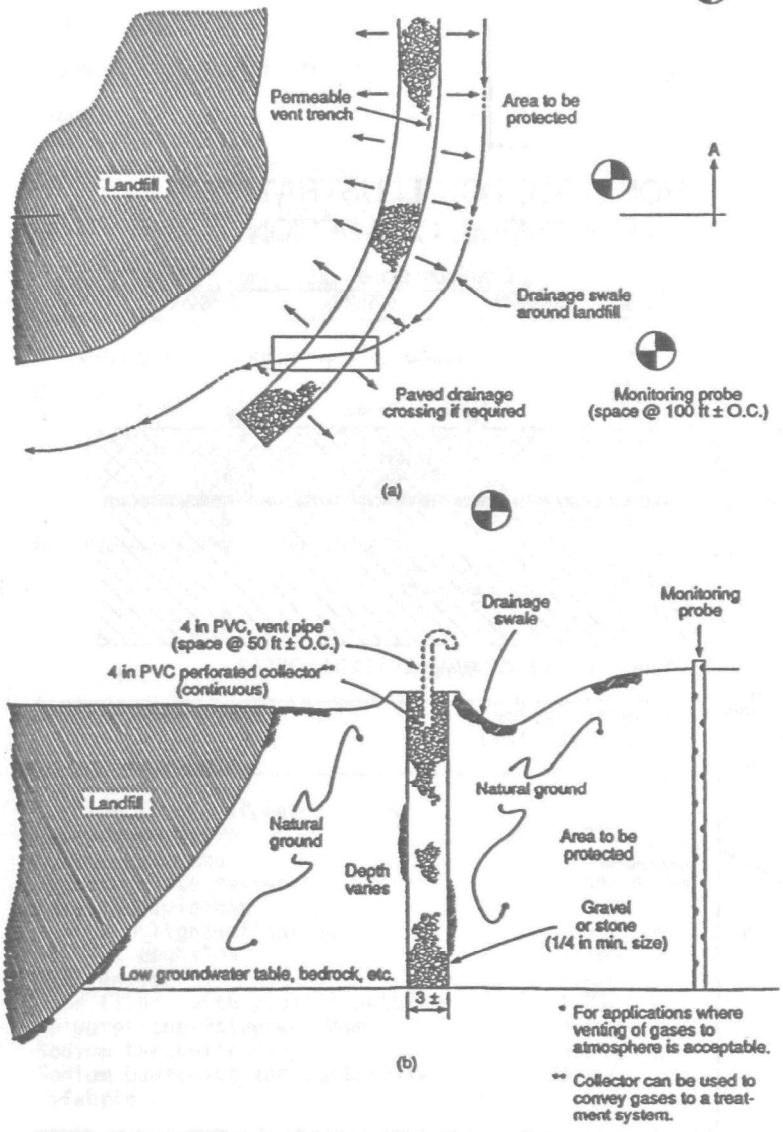




Active gas collection system at a closed landfill site.



Gas extraction well



Passive gas collection using a permeable trench
(a) Plan view; (b) section A-A

SPILL VAPOR CONTROL

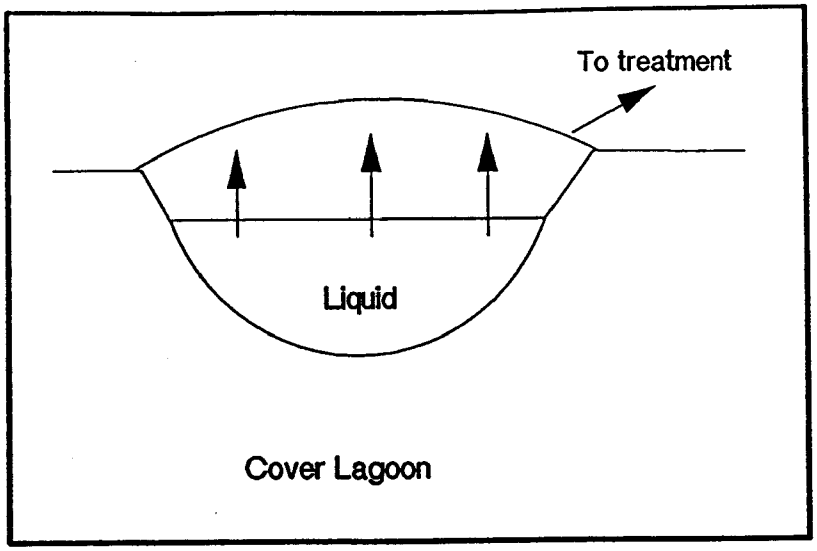
- Foams
- Spill cooling
- Immiscible liquid covers
- Direct neutralization

GAS CONTROL FROM SURFACE IMPOUNDMENTS

- Enclosure
- Floating solid objects
- Shape modification
- Aerodynamic modification
- Floating oil layer and surfactants

ENCLOSURES

- Air-supported structure
- Vapor collected and treated
- Susceptible to wind damage
- Vapors may be harmful to cover materials
- Control effectiveness about 100%



FLOATING SOLID OBJECTS

- Synthetic membrane covers
- Rafts
- Hollow plastic spheres

SYNTHETIC MEMBRANE COVERS

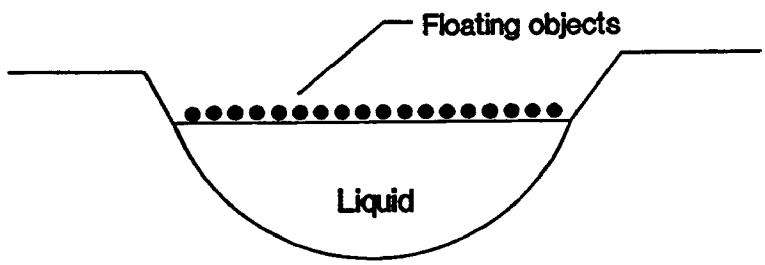
- Feasible if oxygen transfer not needed
- Outgassing of volatiles not expected
- Liner material permeable to some vapors
- Damage caused by weathering or waste contact
- Effectiveness can approach 100%

RAFTS

- Restrict the surface area exposed to air
- Reduces oxygen absorption
- Short life - damage due to contact with waste
- Effectiveness about 90%

FLOATING HOLLOW SPHERES

- Made from polypropylene with projections to prevent rotation
- Spheres restrict oxygen absorption
- Reduces emissions
- Effectiveness - 80 to 90%
- May be blown away in high winds



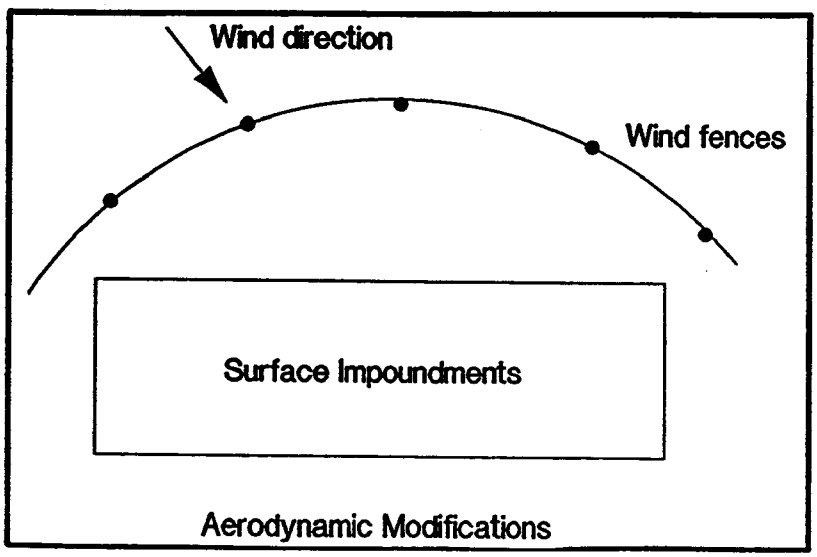
Floating Objects
to reduce evaporation

SHAPE MODIFICATION

- Berm height - reduces wind emissions
- Liquid depth - greater depth and less surface area reduces emissions
- Length, width and orientation normal wind direction to narrow width produces least emissions

AERODYNAMICS MODIFICATION

- Wind barriers effective in reducing emissions under wind-enhanced conditions
- Porous wind fence material for dust control superior to solid fences
- Wind fences achieve emission reduction of up to 80%
- Oxygen absorption similarly affected



Aerodynamic Modifications

AERODYNAMIC MODIFICATION

(Continued)

- 4 to 10 feet high
- Reduction of wind velocity expected for distance of 1 to 5 fence height downstream
- Composed of polyester or other high strength material

FLOATING OIL LAYERS AND SURFACTANTS

- Immiscible liquid floating on surface found effective in reducing air emissions about 90% under little wind conditions
- Under windy conditions, covering blown aside, emission reduction of 50 to 80% expected

PROCESS FUGITIVE EMISSIONS

VOC EMISSION CONTROL TECHNIQUES

Control technique	Percent efficiency	TSHO application
Enclosure	--	Container storage Container cleaning Loading operations
Vapor absorption	90+	Storage tanks Enclosed TSHO's
Vapor condensation	60 (surface condenser) 99 (two-state condenser)	Storage tanks Enclosed TSHO's
Carbon adsorption	90+ (nonregenerable) 95+ (regenerable)	Storage tanks Enclosed TSHO's
Flares	98	Storage tanks Enclosed TSHO's (concentrated streams)
Refrigeration	93-97	Truck, rail car, ship, and barge loading
	98	Storage tanks
Vapor recovery	90-98	Truck, rail car, ship, and barge loading
Vapor balancing system	99	Truck, rail car, ship, and barge loading Storage tanks
Submerged loading	65	Truck, rail car, ship, barge, and drum loading
Internal floating roof tank	90-95 (a function of turnovers)	Fixed-roof tanks
High-pressure tank	85	Storage tanks
Leak detection and repair[a]	33 (valves) 44 (pumps)	Pumping and piping of waste
Spill response	50	All spills

[a]Weighted averages are applied.

Summary of Control Effectiveness for Controlling Organic Area Fugitive Emission Sources

Emission Source	Control Technique Equipment Modification	Control Effectiveness (%)
Pumps	Monthly leak detection and repair	61
	Seafless pumps	100
	Dual mechanical seals	100
	Closed vent system[a]	100
Valves		
- Gas	Monthly leak detection and repair	73
	Diaphragm valves	100
- Light liquid	Monthly leak detection and repair	46
	Diaphragm valves	100
Pressure Relief Valves	Rupture disk	100
	Closed vent system[a]	100
Open-ended Lines	Caps, plugs, blinds	100
Compressors	Mechanical seals with vented degassing reservoirs	100
	Closed vent system[a]	100
Sampling Connections	Closed purge sampling	100

[a]Closed vent systems are used to collect and transfer the fugitive emissions to add-on control devices such as flares, incinerators, or vapor recovery systems.

Comparison of Fugitive Emissions from Equipment Types

Equipment type	Process fluid	Emission factor, kg/h	Percent of total VOC fugitive emissions
Valve	Gas/vapor	0.0056	47
	Light liquid	0.0071	
	Heavy liquid	0.00023	
Pump	Light liquid	0.0494	16
	Heavy liquid	0.0214	
Compressor	—	0.228	4
Pressure-relief valve	Gas/vapor	0.1040	9
Sampling connection	—	0.0150	3
Open-ended line	—	0.0017	6
Flange	—	0.00083	15
			100

PROCESS POINT SOURCES

- Particulates
- Organics

PARTICULATE CONTROL TECHNOLOGIES FOR CONTAINED EMISSIONS

- Cyclones
- Filters
- Electrostatic precipitators
- Wet scrubbers
- Entrainment separators

DATA NEEDS FOR PARTICULATE EMISSION CONTROL SYSTEMS

Emission Stream Properties

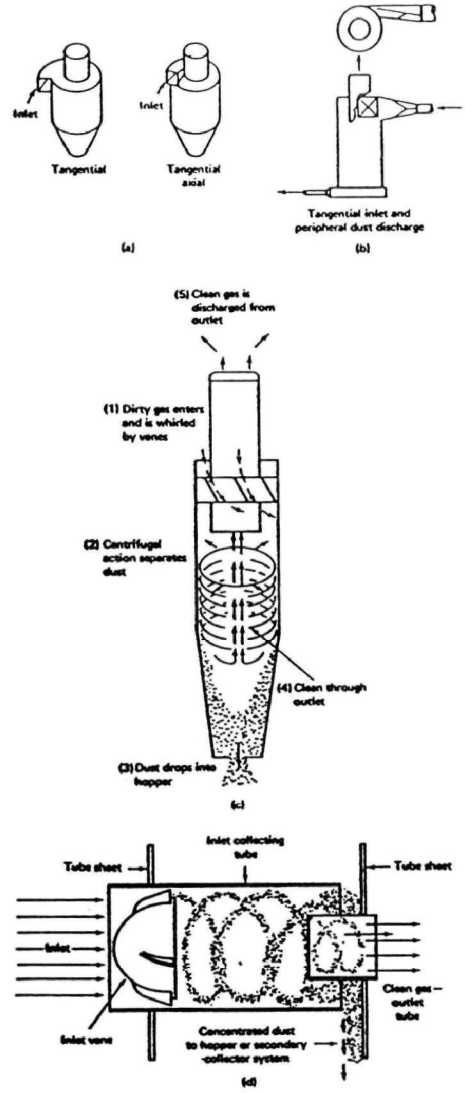
HAP content
Particulate content
Moisture content
Sulfur trioxide content
Flow rate
Temperature
Particle mean diameter
Drift velocity

Substance	Typical Particulate Size: Normal Maximum Size, microns	Typical Particulate Size: Normal Minimum Size, microns
Water vapor mists	500	40
Pulverized coal	250	25
Dust	200	20
Foundry shakeout dust	200	1
Cement dust	150	10
Fly Ash	110	3
Plant pollens	60	20
Fog (nature)	40	1.5
Plant spores	30	10
Bacteria	15	1
Insecticide dust	10	0.4
Paint pigment spray	4	0.1
Smog	2	0.001
Tobacco smoke	1	0.01
Oil smoke	1	0.03
Zinc oxide fume	0.3	0.01
Coal smoke	0.2	0.01
Viruses	0.05	0.003

DATA NEEDS FOR INORGANIC VAPOR EMISSION CONTROL SYSTEMS

Emission Stream Properties	HAP Properties
HAP content	Molecular weight
Moisture content	Vapor pressure
Halogen/metal content	Solubility
Flow rate	Adsorptive properties
Temperature	
Pressure	

Cyclones



CYCLONE COLLECTORS

Advantages

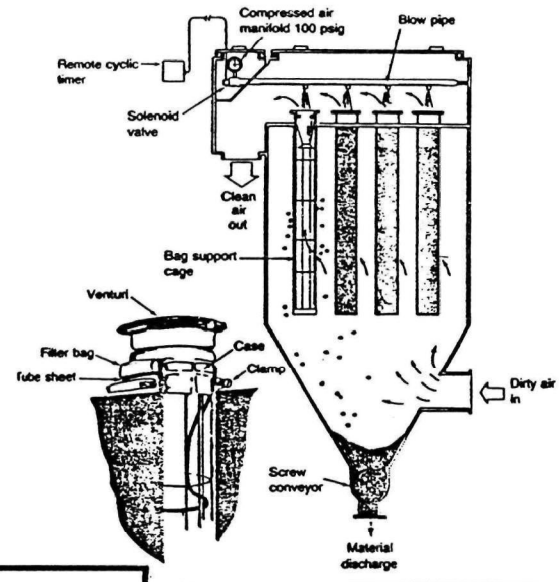
- Low cost of construction
- Relatively simple equipment with few maintenance problems
- Relatively low operating pressure drops in the range of approximately 2 to 6 in. water column
- Temperature and pressure limitations imposed only by the materials used
- Dry collection and disposal
- Relatively small space requirements

CYCLONE COLLECTORS

Disadvantages

- Relatively low overall particulate collection efficiencies, especially on particulates below 10 microns in size
- Inability to handle tacky materials

Schematic diagram of a pulse-jet baghouse.



BAGHOUSE

Advantages

- Very efficient at removing fine particulate matter from a gaseous stream; control efficiency can exceed 99% for most applications
- Lower pressure drop than venturi scrubber when controlling fine particulates; i.e. 2" to 6" water compared with greater than 40" water

(1 of 2)

BAGHOUSE
Advantages

- Can collect electrically resistive particles
- With mechanical shaking or reverse air cleaning, control efficiency is generally independent of inlet loading
- Simple to operate

(2 of 2)

BAGHOUSE
Disadvantages

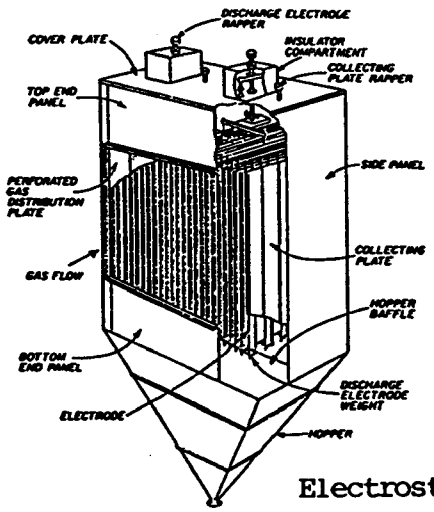
- Cannot control high temperature stream (>550 F) without a precooler
- Cannot effectively control stream with high moisture content
- Highly erosive particles can damage the filter

(1 of 2)

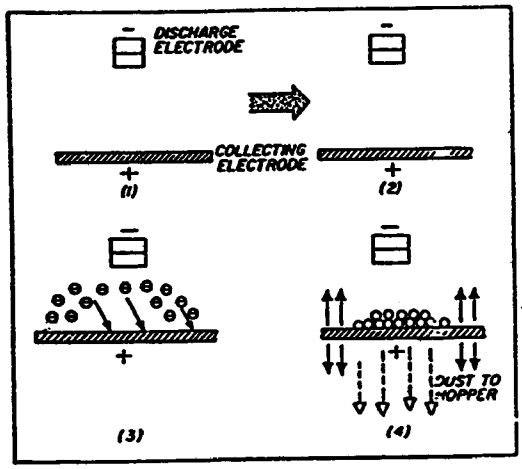
BAGHOUSE
Disadvantages

- Mechanical collectors generally required upstream if significant amounts of large particulates (> 20 um) are present
- Needs special or selected fabrics to control corrosive streams
- Least efficient with particles between 0.1 um to 0.3 um diameter

(2 of 2)



Electrostatic precipitator



Sequence of events in an electrostatic precipitator.

1. Generating a strong electrical field between electrodes.
2. Passing suspended particles to be collected through the field whereupon they are electrically charged by means of ionization.
3. Charged particles are then transported to a collecting surface, by means of the force exerted on them by the electric field.
4. Electrically charged particles precipitated on collecting surface are neutralized & removed by shaking the collecting electrode.

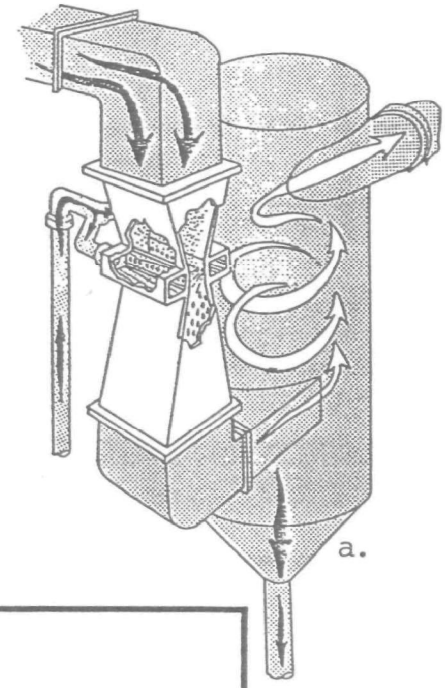
ELECTROSTATIC PRECIPITATOR (ESP)
Advantages

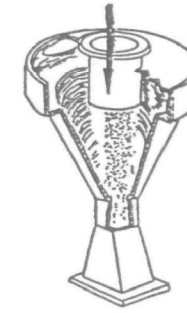
- Can control very small (<0.1 micron) particles
- Efficiency up to 99+%
- Low operating costs with very low pressure drop (0.5" water)
- Can collect corrosive or tar mists
- Power requirements for continuous operation are low
- Wet ESPs can collect gaseous pollutants

ELECTROSTATIC PRECIPITATORS (ESP)
Disadvantages

- High initial capital investment
- Not readily adaptable to changing conditions
- Conditioning agent may be necessary to control resistive particles
- More sensitive to particle loading than other devices
- Space requirements may be greater than that for a fabric filter or venturi scrubber

VENTURI SCRUBBER MAY FEED LIQUID THROUGH ETS a OVER A WEIR b OR SWIRL THEM ON A SHELF c





VENTURI
Advantages

- Low initial investment
- Takes up relatively little space
- Can control sticky, flammable, or corrosive matter with few problems
- Can simultaneously collect particulates and gaseous matter

(1 of 2)

VENTURI

Advantages

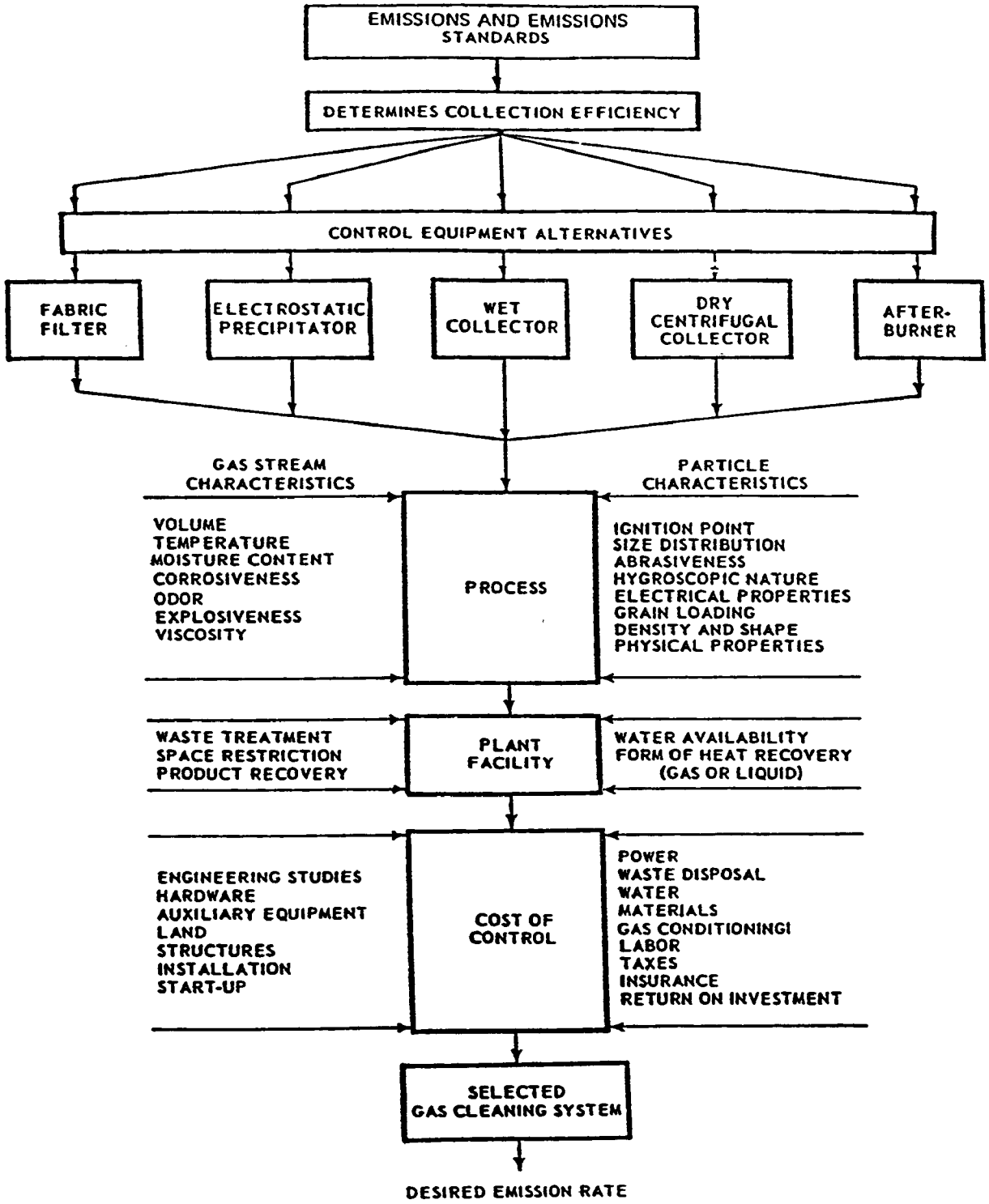
- Control efficiency is independent of particle resistivity
- Simple to operate, few moving parts
- Efficiency up to 99+%

(2 of 2)

VENTURI

Disadvantages

- High operating cost due to high pressure drop (40" water or greater), particularly for smaller (<1 micron) particles
- Has wastewater and cleaning/disposal costs
- Least efficient with particles less than 0.5 micron diameter



Criteria for selection of gas cleaning equipment.

Characteristics of Air Pollution Control Equipment.

Name of Device: General	Name of Device: Specific Type	Description	Air Contaminants	Optimum Size Particles (μm)	Optimum Concentration (gr/cu ft)	Temperature Limitations (°F)	Utility Requirements (HP, Water, KW, BTU)	Face Velocity: FPM	Face Velocity: Location	Air Resistance WG (inches)	Efficiency % by Weight	Space	Description of Collected Pollutant	Application	Limitations
Industrial Filters	Cloth bag	Bags made of synthetic or natural fiber fabrics	Dust, Fumes, Smoke, Mist	>0.5	>0.1	0-180-600		1-30	Fabric	>4	>99	Large reverse type pulse type moderate	Dust discharged into hoppers when dislodged from bags	Dry collection possible Decrease of performance is noticeable Collection of small particles possible High efficiencies possible	Sensitivity to filtering velocity High-temperature gases must be cooled to 200°F to 550°F Affected by relative humidity (condensation) Susceptibility of fabric to chemical attack
	Cloth envelope	Envelopes made of natural or synthetic fibers, fabrics over screen cages		>0.5	>0.1	0-180-600		1-30	Fabric	>4	>99	Large	Dust discharged into hopper when dislodged from fabric face		
Electrostatic Precipitators (High Voltage)	Single stage (plate)	Ionizing (-) wires between parallel collecting (+) plates		>0.5	>0.1	0-650	0.2-0.6kw/1000 cfm	180-600	Plates	<1	>99	Large	Dry dust on plates - dislodged into hopper	99% efficiency obtainable Very small particles can be collected Particles may be collected wet or dry Pressure drop and power requirement are small compared to other high-efficiency collectors Maintenance is nominal unless corrosive or adhesive materials are handled Few moving parts	Relatively high initial cost Precipitators are sensitive to variable dust loadings or flow rates Resistivity causes some materials to be economically uncollectable Precautions are required to safeguard personnel from high voltage Collection efficiencies can deteriorate gradually and imperceptibly
	Single stage (pipe)	Ionizing (-) wires inside concentric collecting (+) pipes		>0.5	>0.1	0-1200	0.2-0.6kw/1000 cfm	180-600	Pipes	<1	>99		Dry dust on pipe - dislodged into hopper		
Dry Inertial Collectors	Settling chamber	Straight chamber expansion (without baffles)		>50	>5	0-700		60-600	Chamber	<0.1	<50	Large	Dry dust or liquid into hopper	Low pressure loss, simplicity of design and maintenance	Much space required Low collection efficiency Much head room required
	Baffle chamber	Straight chamber expansion (with baffles)		>30	>5	0-700		1000-2000	Inlet	<0.5	<50	Large	Dry dust or liquid into hopper		
	Skimming chamber	Scroll shaped chamber w/peripheral slots		<20	>1	0-700		2000-4000	Inlet	<1.0	<70	Moderate	Dry dust or liquid into hopper	Little floor space required Dry continuous disposal of collected dusts	Low collection efficiency of small particles Sensitive to variable dust loadings and flow rates
	Cyclone	Chamber with spiral flow		>10	>1	0-700		2000-4000	Inlet	<2.0	<80	Moderate	Dry dust or liquid into hopper	Low to moderate pressure loss	
	Multiple cyclone	Small cyclones in parallel		>5	>1	0-700		2000-4000	Inlet	4.6	<90	Moderate	Dry dust or liquid into hopper	Handles large particles	
	Impingement	Alternate stages of baffles and nozzles		>10	>1	0-700		3000-6000	Nozzles	4.6	<80	Small	Dry dust or liquid into hopper	Handles high dust loadings	
	Dynamic			>10	>1	0-700	½hp/1000 cfm	2000-4000	Inlet	-8 developed	<80	Moderate	Dry dust or liquid into hopper	Temperature independent	

(Continued)

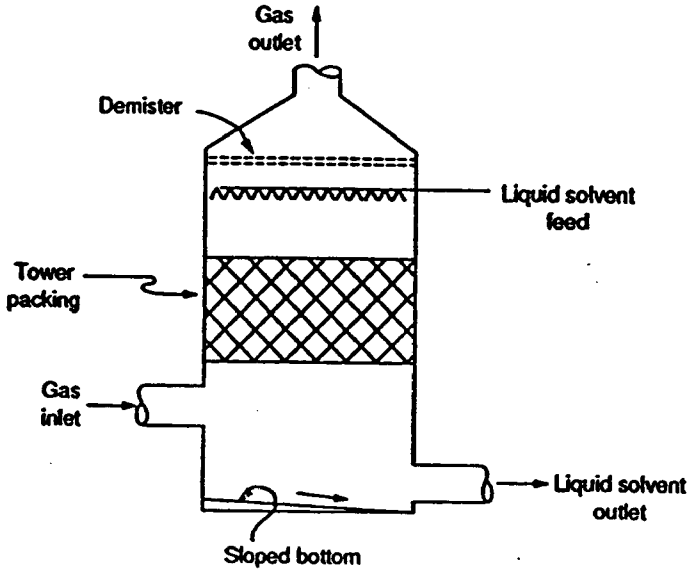
Name of Device: General	Name of Device: Specific Type	Description	Air Contaminants: Dust, Fumes, Smoke, Mist	Air Contaminants: Gases, Vapors, Mist	Optimum Size Particles (μm)	Optimum Concentration (gr/cu ft)	Temperature Limitations (°F)	Utility Requirements (HP, Water, KW, BTU)	Face Velocity: FPM	Face Velocity: Location	Air Resistance WG (inches)	Efficiency (% by Weight)	Space	Description of Collected Pollutant	Application	Limitations
Scrubbers	Cyclone	Cyclone collector same as dry inertial type with coarse sprays			>10	>1	40-700	2-10 gpm/1000 cfm	1500-3000	Inlet	1.5-3	<90	Large	Slurry sludge with water	Simultaneous gas absorption and particle removal Ability to cool and clean high-temperature, moisture-laden gases	Corrosion, erosion problems Added cost of wastewater treatment and reclamation
	Impingement	Impingement collector w/wetted baffles			>2-10	>1	40-700	3-8 gpm/1000 cfm 2-4 hp/1000 cfm	4000-6000	Nozzles	2/stage	<95	Large	Slurry sludge with water		Low efficient on submicron particles
	Submerged	Dynamic collector w/coarse sprays			>1	>1	40-700	1 gpm/1000 cfm	2000-4000	Inlet	3-6	<95	Small	Slurry sludge with water	Corrosive gases and mists can be recovered and neutralized	Contamination of effluent stream by liquid entrainment
	Fog	Cyclone collector w/fine tangential sprays			<2	>0.1	40-700	3-8 gpm/1000 cfm 350 psig sprays	3000-4000	Inlet	>2.0	<99	Moderate	Slurry sludge with water	Reduced dust explosion risk Efficiency can be varied	
	Pebble bed	Tower w/countercurrently wetted coarse packing			>5	>0.1		3-6 gpm/1000 cfm	500-1000	Bed	>4.0	<90	Large	Slurry sludge with water		Freezing problems in cold weather
	Multidynamic	Power driven normal and reverse flow fan stages w/coarse sprays			<0.5	>0.1	40-700	10-30 gpm/1000 cfm	2000-3000	Inlet	2-4	<99	Small	Slurry sludge with water		Reduction in buoyancy and plume rise
	Venturi	Venturi w/coarse sprays at throat			<2	>0.1	40-700	3-6 gpm/1000 cfm	12000-24000	Throat	>10	<99	Small	Slurry sludge with water		Water vapor contributes to visible plume under some atmospheric conditions
	Crossflow	Packed bed; liquid and gas flows at 90°			>5	>0.1	40-250		1500-3000	Bed	*	<95	Small	Slurry sludge with water	Gas and particulate removal	
	Jet	Water activated jet pump			>2	>0.1	40-700	50-100 gpm/1000 cfm	2000-3000	Inlet	~8 developed	<90	Small	Slurry sludge with water		
	Electrostatic	Charged water spray			0.1-10	>0.1	40-700	1-10 gpm/1000 cfm	500-1000	Inlet	<1	90-99	Large	Slurry sludge with water		
Afterburners	Direct	Combustion chamber with supplemental fuel firing			Any	Combustible Only	2000	1.1 Btu/cfm°ΔT	500-1000	Chamber	<1	<95	Moderate	Innocuous flue gas out stack	High removal efficiency of submicron odor-causing particulate matter Simultaneous disposal of combustible gaseous and particulate matter Direct disposal of nontoxic gases and wastes to the atmosphere after combustion Possible heat recovery Relatively small space requirement Low maintenance	High operational cost Fire hazard Removes only combustibles Catalysts subject to poisoning Catalysts require reactivation
	Catalytic	Combustion chamber with catalyst with supplemental fuel firing			Any	Combustible Only	1500		500-1000	Chamber	>1	<95	Moderate	Innocuous flue gas out stack		
Gas Absorbers	Spray tower	Vertical up-flow chamber with downward sprays			Molecular	>0.001	40-100	2-10 gpm/1000 cfm	120 (superficial)		<1	<95	Large	Solution in water		
	Packed tower	Tower with countercurrently wetted Raschig rings, berl saddles, etc. packing			Molecular	>0.001	40-100	3-6 gpm/1000 cfm	60 (superficial)		1.5-4 in. WG/ft of packing	>98	Compact	Solution in water		
	Fiber cell	One or more stages of co-currently wetted fiber cells			Molecular	>0.001	40-100	5-15 gpm/1000 cfm	200 (superficial)		<4	<95	Moderate	Solution in water		
Gas Adsorbers	Deep bed (1-3 ft)	Activated charcoal bed in regenerative recovery equipment			Molecular	>0.001	125		30-100	Bed	2-10	100	Large	Adsorbed on charcoal	Solvent recovery	
	Shallow bed (¼-4 in.)	Activated charcoal beds in cells or			Molecular	<0.001	125		30-120	Bed	0.5-2	95	Small	Discharged w/charcoal	Removal of toxic/odorous organics	

ORGANIC VAPOR PROCESS POINT SOURCE CONTROL TECHNOLOGIES

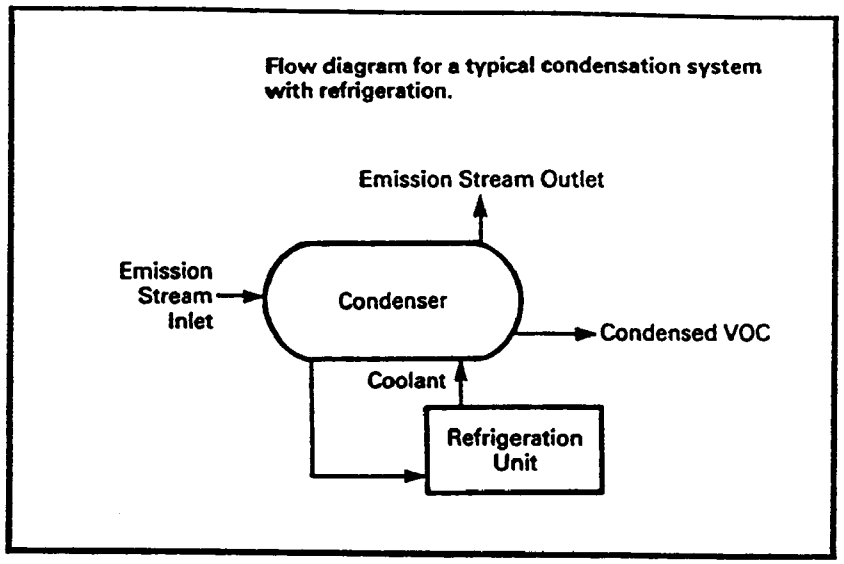
- Absorption
- Condensation
- Flaring
- Adsorption
- Incineration

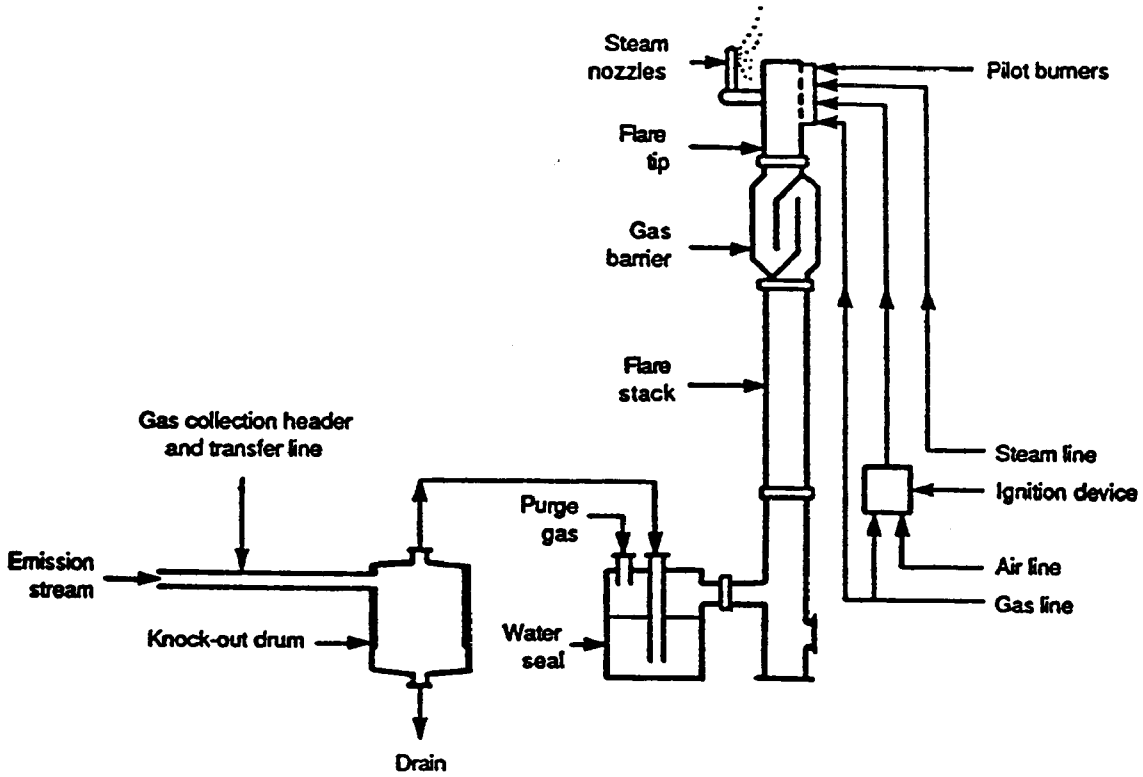
DATA NEEDS FOR ORGANIC VAPOR EMISSION CONTROL SYSTEMS

Emission Stream Properties	HAP Properties
HAP content	Molecular weight
Organic content	Vapor pressure
Heat content	Solubility
Oxygen content	Adsorptive properties
Moisture content	
Halogen/metal content	
Flow rate	
Temperature	
Pressure	

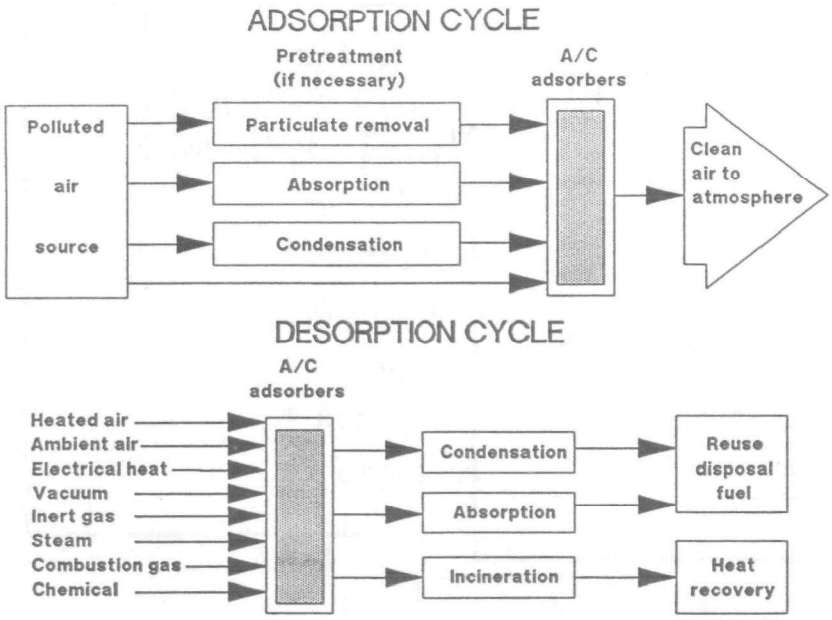


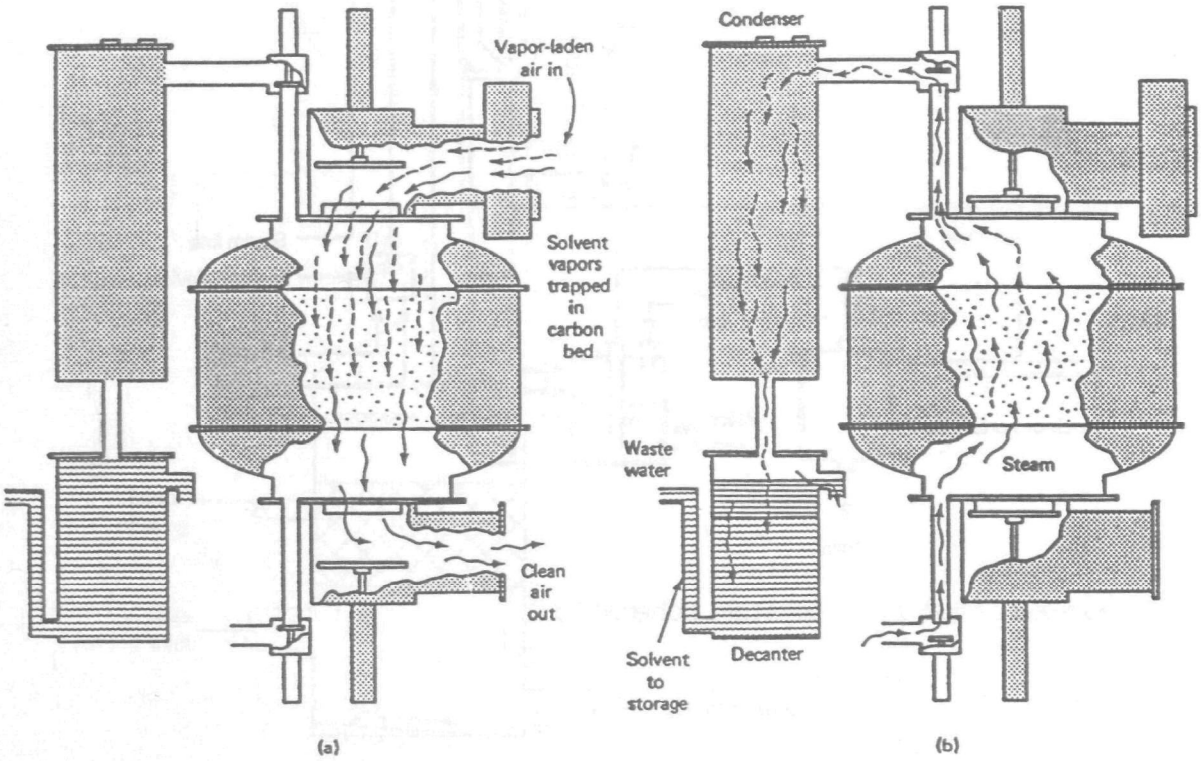
Countercurrent packed tower absorber.



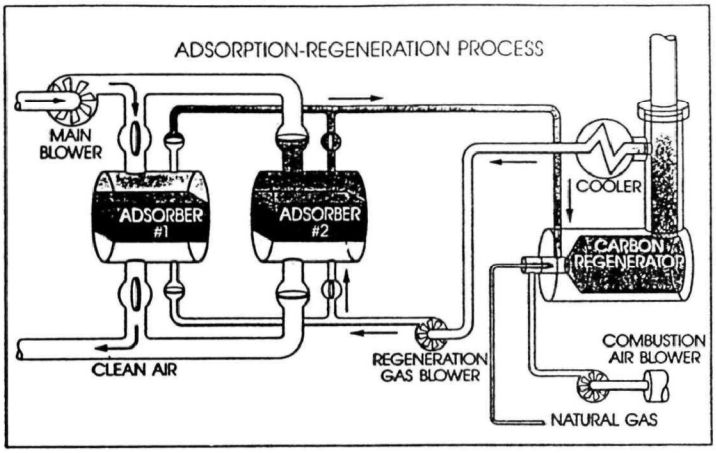


Steam-assisted flare system schematic





(a) Adsorption cycle; (b) desorption cycle.

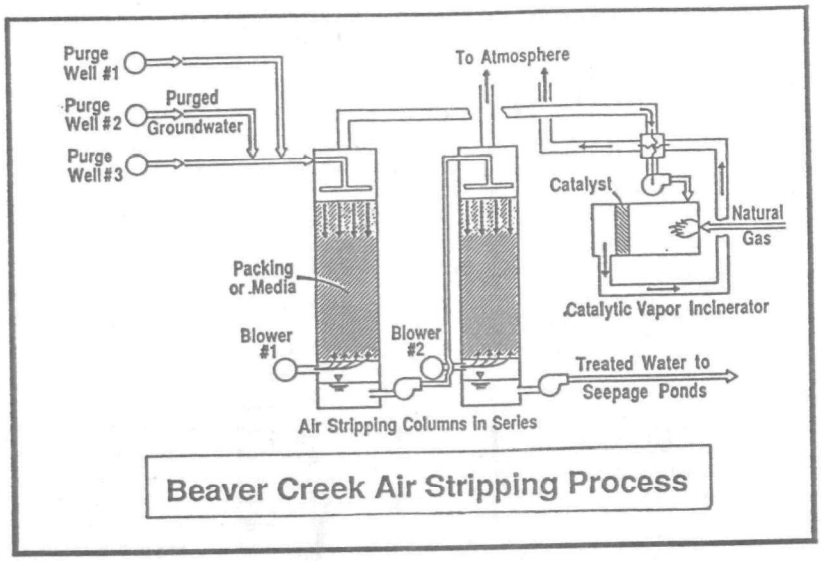


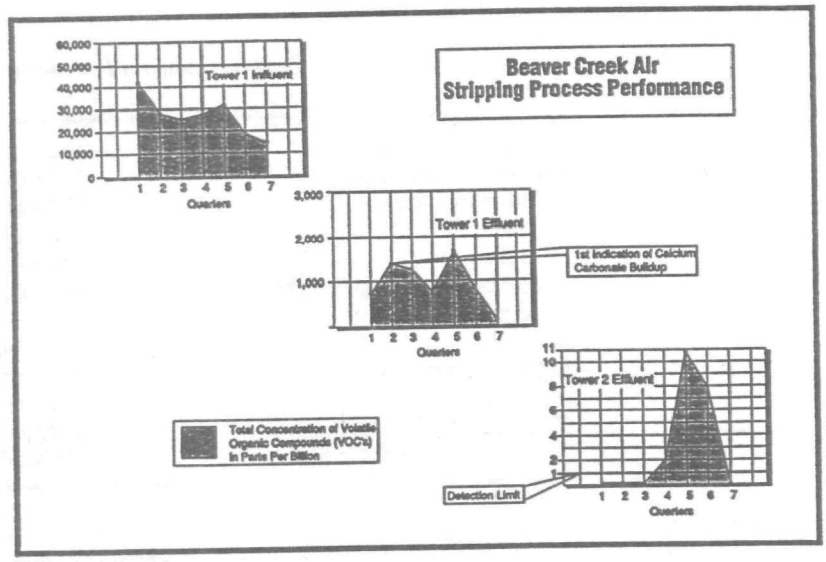
Classes of Organic Compounds Amenable to Adsorption on Activated Carbon

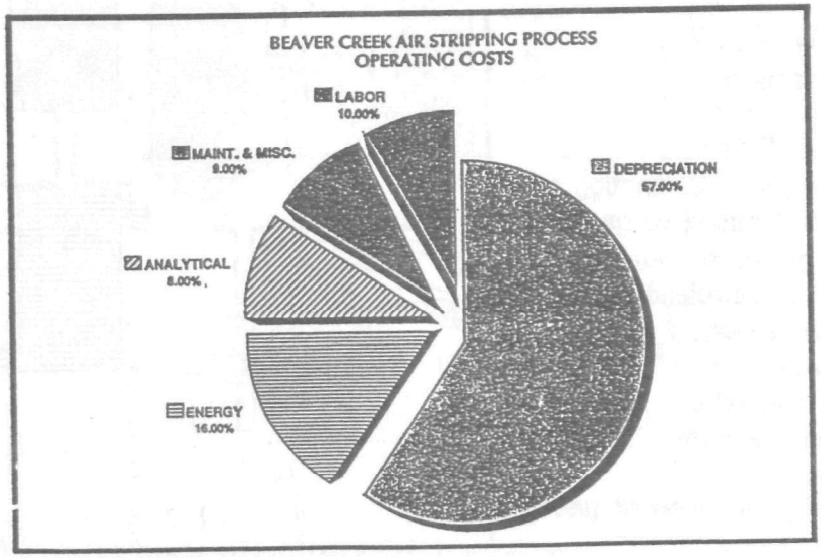
Aromatic solvents	Benzene, toluene, xylene
Polynuclear aromatics	Naphthalene, biphenyls
Chlorinated aromatics	Chlorobenzene, PCBs, Aldrin, Endrin. toxaphene, DDT
Phenolics	Phenol, cresol, resorcinol
High-molecular-weight aliphatic amines and aromatic amines	Aniline, toluene diamine
Surfactants	Alkyl benzene sulfonates
Soluble organic dyes	Methylene blue, textile dyes
Fuels	Gasoline, kerosene, oil
Chlorinated solvents	Carbon tetrachloride, perchloroethylene
Aliphatic and aromatic acids	Tar acids, benzoic acids

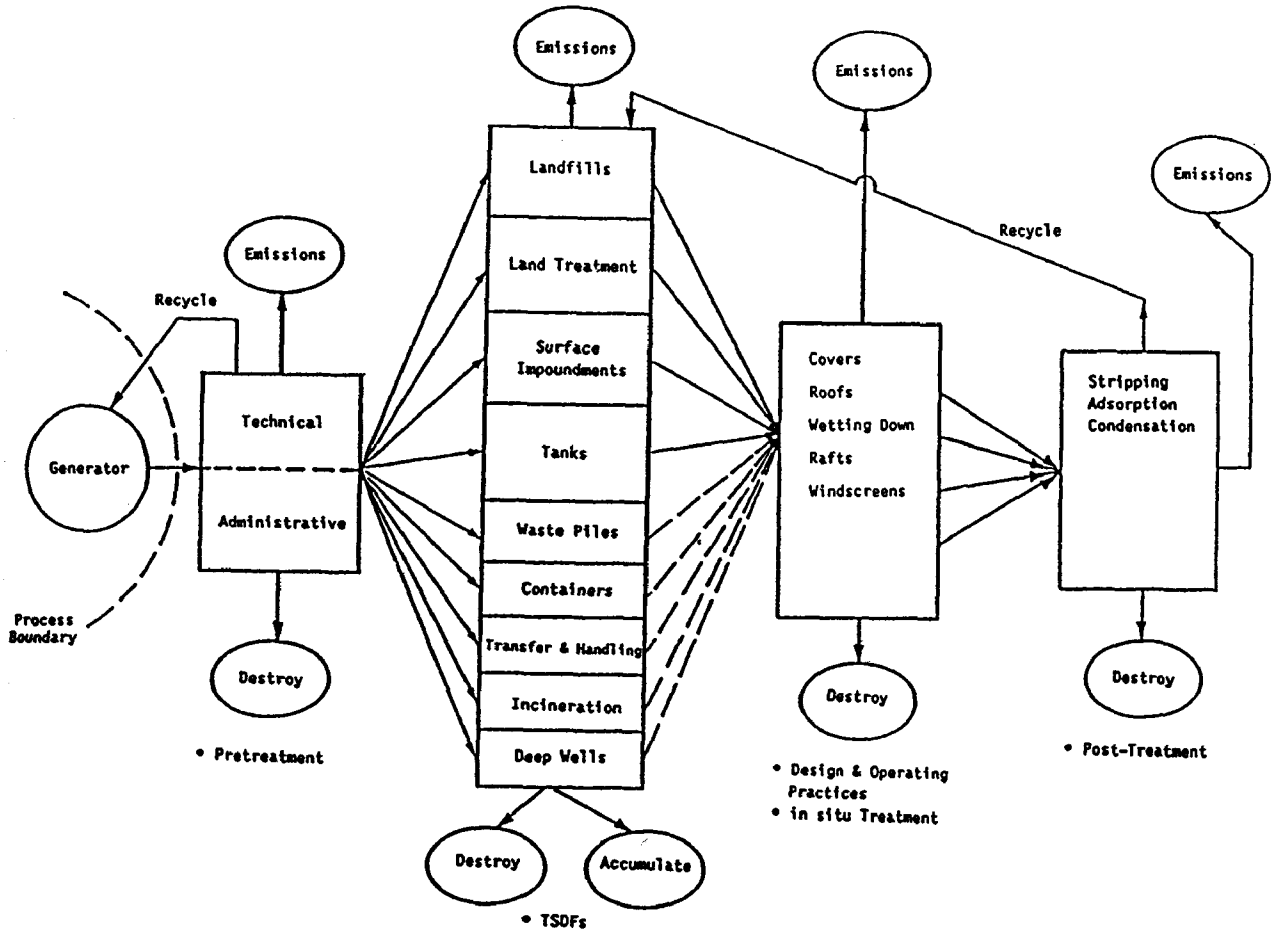
COMMON ADSORBENTS AND THEIR APPLICATIONS

Adsorbent	Application
Activated carbon	Solvent recovery, elimination of odors, purification of gases
Alumina	Drying of gases, air, and liquids
Bauxite	Treatment of petroleum fractions; drying of gases and liquids
Molecular sieves	Selective removal of contaminants from hydrocarbons
Silica gel	Drying and purification of gases


Purge Well #1
Purge Well #2
Purge Well #3
Purged Groundwater
To Atmosphere
Catalyst
Natural Gas
Packing or Media
Catalytic Vapor Incinerator
Blower #1
Blower #2
Treated Water to Seepage Ponds
Air Stripping Columns in Series
Beaver Creek Air Stripping Process


Beaver Creek Air Stripping Process Performance
Tower 1 Influent
Tower 1 Effluent
1st Indication of Calcium Carbonate Buildup
Tower 2 Effluent
Total Concentration of Volatile Organic Compounds (VOC's) in Parts Per Billion
Detection Limit
Quarters


BEAVER CREEK AIR STRIPPING PROCESS
OPERATING COSTS
LABOR 10.00%
MAINT. & MISC. 9.00%
DEPRECIATION 57.00%
ANALYTICAL 8.00%
ENERGY 16.00%



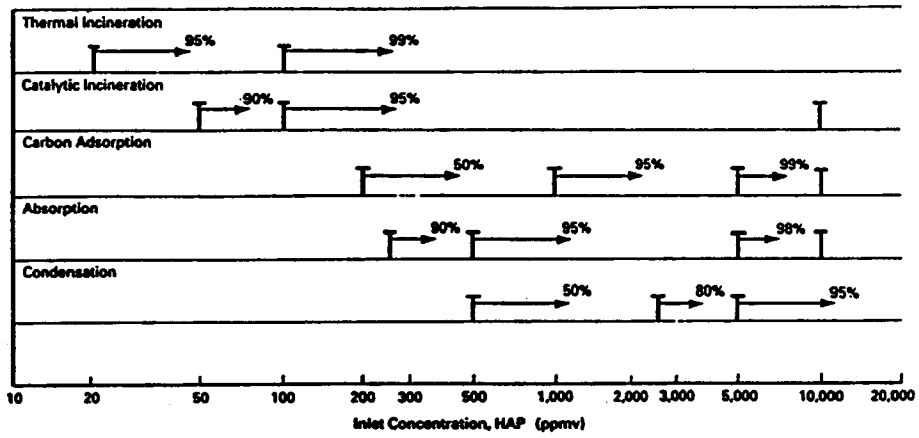
GENERALIZED FLOW OF VOLATILE EMISSIONS

Key Emission Stream and HAP Characteristics for Selecting Control Techniques for Organic Vapors from Point Sources

	Emission Stream Characteristics					HAP Characteristics			
Control Device	HAP/Organics Contents (ppmv)	Heat Content (Btu/scf)	Moisture Content (%)	Flow Rate (scfm)	Temp. (°F)	Molecular Weight (lb/lb-mole)	Solubility	Vapor Pressure (mm Hg)	Adsorptive Properties
Thermal Incinerator	>20; (<25% of LEL)			<100,000					
Catalytic Incinerator	50-10,000; (<25% of LEL)			<100,000					
Flare		>300		<2,000,000					
Boiler/ Process Heater		>150		Steady					
Carbon Adsorber	1,000-10,000 (<25% of LEL)		50%	300-100,000	100-200	45-130			Must be able to adsorb on/ desorb from available adsorbents
Absorber	250-10,000			1,000-100,000			Must be readily soluble in water or other solvents		
Condenser	>5,000			<2,000				>10 (at room temperature)	

Source: Purcell, 1988

Percent reduction ranges for add-on control devices.



Source: Purcell, 1988

Control technologies available for each remedial option.

Remedial operation	Contaminant	Control technology
Incineration	Hydrocarbons	Afterburner, operational (in-furnace) methods
	Particulate	Venturi scrubber, electrostatic precipitator, ionizing wet scrubber, fabric filter (baghouse)
	Acid Gases	Spray dryers, ionizing wet scrubber, venturi scrubber
	NO_x	Catalytic reduction, operational (in-furnace) methods
	Fugitives	Inspection/maintenance
Groundwater stripping	Hydrocarbons	Condensation Carbon adsorption (disposable) Carbon adsorption (regenerable) Incineration
In-situ venting	Hydrocarbons	Condensation Carbon adsorption (disposable) Carbon adsorption (regenerable) Incineration
Soils handling		
Excavation	Particulates, hydrocarbons	Water sprays of active areas Dust suppressants Surfactants Foam coverings
Transportation	Particulates, hydrocarbons	Water sprays of active areas Dust suppressants Surfactants Road carpets Road oiling Speed reduction Coverings for loads
Dumping	Particulates, hydrocarbons	Water sprays of active areas Water spray curtains over bed during dumping Dust suppressants Surfactants
Storage	Particulates, hydrocarbons	Windscreens and other enclosures Orientation of pile Slope of pile Foam covering and other coverings Dust suppressants
Grading	Particulates, hydrocarbons	Light water sprays Surfactants
Stabilization/ Solidification	Particulates, hydrocarbons	Enclosure of mixing area/apparatus Storage pile controls for raw materials Enclosure of binder preparation area Suction hood (in-situ treatment)

Source: Air & Waste Management Association, 1990.

DATABASES SUPPORTING TECHNOLOGY SELECTIONS

Abstract 9-2

Slides 9-4

DATABASES SUPPORTING TECHNOLOGY SELECTIONS

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Dayton, OH

The EPA has developed a number of databases on remedial actions and the data required to evaluate remedial alternatives. These databases provide information on past activities, treatment alternatives utilized, and costs. In addition, they may provide such supporting information on chemical toxicities and other pertinent characteristics of the contaminants. The major function of these databases is to facilitate the information dissemination associated with hazardous waste site cleanup. The following discussion identifies some of the more fully developed databases available and the type of information contained therein as well as the computer capabilities needed to access them. Names and telephone numbers are provided for additional information and assistance on each database identified.

The OSWER Electronic Bulletin Board System (BBS) provides up-to-date information on technical developments and conferences. The BBS was created by the Office of Solid Waste and Emergency Response as a tool for communicating ideas and disseminating information. In addition to its message capabilities, BBS is a gateway for many Office of Solid Waste (OSW) electronic databases. Few restrictions are set on the types of information exchanged. The BBS is available to U.S. EPA, their contractors, and state and local personnel.

The BBS provides easy access, through personal computers, to over 250 technology and program case studies, a calendar of training events and seminars, a directory of experts, a bibliography of 300 frequently referenced publications, and descriptions of federal and state programs. Users can order documents through BBS, which is electronically linked to the Center for Environmental Information (CERI).

The Alternative Treatment Technology Information Center (ATTIC) database contains information for the following areas:

- SITE Program
- Industry Studies and Data
- COLIS – Technical Information Exchange (TIX)
- State Agencies
- Cost of Remedial Action (CORA) Model
- RREL Water Treatability Database
- Hazardous Waste Collection Database
- Geophysics Advisor Expert System
- Technical Assistance Directory
- RSKERL Soil Transport and Fate Database
- NATO/International Studies
- Records of Decision (ROD)
- RCRA Delisting Actions
- Historical User File
- Treatability Studies
- USATHAMA IR Reports
- OSWER Bulletin Board
- Commercial Databases
- Regional Databases

Of these, the Record of Decision (ROD) database can be a good resource for the cleanup of hazardous waste sites by providing records of past remedial activities. The ROD database can be accessed through ATTIC.

Using keywords, the user can locate sites which exhibit similar characteristics; are contaminated with the same types of hazardous components; or, employ specific remedial alternatives. Further, RODs for NPL sites within a certain region or location can be identified.

The purpose of the Treatability Data Base/Superfund Treatability database is to compile data on the treatability of specific organic and inorganic compounds in all types of waters and wastewaters. The database currently contains more than 800 compounds, and more than 2500 sets of treatability data available for approximately 300 of those compounds. Again, access is available to the public and is operable on standard PC units.

The Computerized On-Line Information System (COLIS), developed by RREL, provides actual cost and performance information for past corrective actions. COLIS is currently composed of three files: Case Histories, Library Search, and Superfund Innovative Technology Evaluation (SITE) Applications Analysis Reports (AARs). The Case Histories file contains historical information obtained from corrective actions implemented at Superfund sites and on leaking underground storage tanks. The Library Search system is designed to provide access to special collections or research information pertaining to many RREL program (e.g., oil and hazardous materials, underground storage tanks, soils washing, incineration, and stormwater controls). The SITE AARs file provides actual cost and performance information. It presents results from three sites for which AARs have been prepared. Additional information will be added as AARs are completed. Information stored in this systems is textual in nature instead of numerical, which permits the user's interpretation. Plans for near-term development call for the implementation of both the Aqueous Treatability Data Base and the Soils & Debris Treatability Data Base. Access equipment includes standard PC devices.

Finally, databases such as the Integrated Risk Information System (IRIS), PHRED, and QSAR provide chemical-specific risk information on the relationship between exposure and health effects. This is useful in that it aids in hazard identifications and does-response assessments for applicable sites.

CONTACTS

BBS Jim Cummings, (202) 382-4686

ATTIC - Myles Morse - EPA ORD, (202) 475-7161

WERL - Treatability Data Base/Superfund Data Base
Kenneth Dostal - EPA RREL (513) 569-7503

COLIS - Hugh Masters - EPA, Edison, (201) 321-6678

IRIS Coordinator - (513) 569-7254

Dialog - (312) 726-9206

PHRED - (202) 382-2180

QSAR - (406) 994-4481

OBJECTIVES OF DATABASES

- Provide a compilation of information on past remedial activities
- Provide information on contaminants for risk assessment and treatability

AVAILABLE DATABASES

- BBS
- ATTIC
- ROD Database
- WERL Treatability Database
- COLIS
- IRIS
- Others

Electronic Bulletin Board System (BBS)

- A vehicle through which users can post and receive messages
- Equipment required includes PC, modem, and communications package

BBS
(continued)

- Currently has eight different components, including news, mail services, conferences, and publications on technical areas

BBS
(continued)

- Contains
  - -over 250 technology and program case studies
  - -calendar of training events and seminars
  - -bibliography of frequently referenced publications

BBS
(continued)

- Can be accessed by any person affiliated with government, trade association/industry, or academia
- For more information contact
  Jim Cummings
  (202)382-4686

ATTIC

Alternative Treatment Technology Information Center

- A compendium of information from many available databases
- Currently in process of reorganization, expansion, and modification

ATTIC

- Records of Decision (ROD)
- COLIS-Technical Information Exchange(TIX)
- Cost of Remedial Action (CORA) Model
- WERL Treatability Database
- RSKERL Soil Transport and Fate Database
- Historical User File
- Commercial Databases
- Others (e.g., DIALOG)

ATTIC

- Can be accessed through the RCRA/CERCLA Hotline or the BBS
- For more information contact
  Myles Morse
  (202)475-7161

ROD DATABASE

- Contains
  - -abstract
  - -text of ROD
- Search on keywords
- Equipment required:
  - -P.C. (DOS 3.3)
  - -modem
  - -communication software (Crosstalk)

ROD DATABASE

Information Can Be Accessed Based on:

- Contaminants
- Media contaminated
- Region or location
- Selected remedy
- ROD date

WERL Treatability Database/ Superfund Database

- Contains information on 800 compounds in water and wastewater, soon to include soils and debris
- Contains more than 2500 sets of treatability data for approximately 300 of these compounds
- Maintained by Risk Reduction Engineering Laboratory in Cincinnati

WERL

- The following hardware or software is needed:
  - -IBM PC or compatible
  - -PC/MS DOS, Version 2.0 or greater
  - -524 K RAM available
  - -10 cbi printer
  - -monochrome or color monitor

WERL (continued)

- For more information contact
  Kenneth Dostal
  (513)569-7503

COLIS

Computerized On-Line Information System

- Consolidates several databases developed by RREL in Cincinnati and Edison, NJ
- Information stored as text

COLIS

- Contains three files:
  1. Case Histories - contains historical information on prior corrective actions
  2. Library Search - provides access to information pertaining to RREL programs
  3. SITE Application Analyses Reports (AARs) -provides actual cost and performance information

COLIS (continued)

- Equipment required includes PC and modem
- Menu-type format with standard prompt commands
- For more information contact
  Hugh Masters
  (201)321-6678

IRIS

Integrated Risk Information System

- On-line database of chemical-specific risk information on relationship between chemical exposure and estimated human health effects
- Includes over 370 chemical risk summaries
- Updated monthly

IRIS

Integrated Risk Information System

- For more information contact
  IRIS Coordinator
  (513)569-7254

APPLICABILITY

- Supports first two steps of risk assessment process of
  - -hazard identification
  - -dose-response assessment
- Provides quantitative risk values and qualitative health effects information

LIMITATIONS

- Risk values cannot be used to predict incidence of disease or type of effects that chemical exposures may have on humans
- RfD is an estimate based on lifetime exposure
- Carcinogen assessments begin with a quantitative weight-of evidence judgement

OTHER DATABASES

- DIALOG
  - -contains pollution abstracts and world environmental information from 1971 to present
  - -contact (312)726-9206
- PHRED
  - -contains information on 364 chemicals
  - -contact Office of Emergency and Remedial Response, EPA (202)382-2180

OTHER DATABASES (continued)

- QSAR
  - -contains a series of exposure assessments for numerous chemicals
  - -contact (406)994-4481

BBS EXAMPLE OUTPUT

```
***********[ EPA Superfund/Solid Waste Technology Assistance BBS ]***********
!                          MAIN BOARD BULLETINS                              :
*****************************************************************************
 To download one of these bulletins, type "B BLTx A" (without the quotation
 marks), where "x" is the bulletin number.  Turn CApture off in CrossTalk.

  Number     Update     Description
     1       09-07-87   Using this bulletin board system.
     2       08-25-89   Participating in online specialty conferences
     3       01-30-90   Uploading and downloading files from the BBS.
     4       07-26-87   Sending messages to other bulletin board users.
     5       01-30-90   Archived (.ARC and .ZIP) files and how to unpack them.
     6       10-13-89   New ORD Publications --  Electronic ordering.
     7       02 26 90   Training and Tech Transfer Courses and Workshops
     8       08-15-87   25 Most Common Substances Found at Superfund Sites
     9       01-02-90   Monthly Statistics on Bulletin Board Usage
    10       12-18-87   How to Call the BBS via EPA's Regional Port Selectors
    11       12-14-89   Water quality models available on CEAM BBS (ERL-Athens)
    12       12-11-89   Honor roll of Certified Hackers & Century Club
    13       08-11-89   Hazardous Waste Library Collection Database Updating
                        Program and List of EPA Regional Libraries
    14       09-12-89   Jeff Morely's List of DC-area Public BBSs
(N)ext, More?
 Esc for ATtention, Home to SWitch    :     Capture Off        :   Local

                        Program and List of EPA Regional Libraries
    14       09-12-89   Jeff Morely's List of DC-area Public BBSs
    16       01-30-90   List of CLP IFB Organics Laboratories
    17       01-30-90   List of CLP IFB Inorganics Laboratories
    18       01-30-90   List of CLP IFB VOA-Only Laboratories
    19       01-30-90   List of CLP IFB Dioxin Laboratories
    20       01-30-90   Schedule of Upcoming CLP Conferences
    22       09-16-88   ATSDR Toxicological Profiles Published
    23       11-10-88   Guidance on Developing Expert Systems
    24       11-14-88   Foreword of Catalog of Superfund Directives
    28       02-16-89   Description of OPEN a DOOR Command on OSWER BBS
    29       03-21-89   Federal Register notices related to hazardous waste
    30       03-21-89   Draft comments on proposed NCP
    31       03-31-89   Information Guide to EPA's Office of Environmental,
                        Processes and Effects Research
    32       07-01-90   Superfund Technology Support Project
    33       06-05-89   Ground-Water Tech Assistance:  Regional Contacts
    34       06-05-89   Ground-Water Tech Assistance:  HQ and Lab Contacts
    35       06-05-89   Ground-Water Tech Assistance:  Tech Transfer Offices
    36       09-25-89   Hazardous Materials Information Exchange (HMIX) BBS
    37       10-31-89   RSKERL Annual Ground-Water Research Seminar
    38       01-25-90   Workshop:  Transporting Hazardous Materials
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:::::::::::::::::::::::::::::[ Conferences ]::::::::::::::::::::::::::::::::::::

   Conferences are open to all (except where indicated), but you must
   request membership the first time.  Leave a [C]omment for the SYSOP.

Conference
  Number     Description
----------   ---------------------------------------------------------------
     1       Environmental Services Division Conference --
                  Open to anyone interested in QA/QC, analytical chemistry,
                  field analyses, and laboratory audits.

     2       Ground-Water Workstation Conference --
                  Primarily of interest to the users of the 14 Hazardous
                  Waste Ground-Water Workstations.

     3       Waste Minimization Conference --
                  Contains state-by-state information, literature sources,
                  contacts, case studies.  Open to the public.

     4       Risk Conference --
                  A forum for the exchange of information on risk issues
(H)elp, More?
 Esc for ATtention, Home to SWitch    :      Capture Off        :   Local

                  relating to OSWER.  Non-EPA people *MUST* first obtain
                  permission from the Conference Moderator (Larry Zaragoza)
                  before requesting registration by the Sysop.

     5       Air/Superfund Conference --
                  Primarily of interest to RPMs and OSCs and Regional Air
                  Division technical staff who advise on Clean Air Act
                  requirements at Superfund sites.

     6       Incineration and Thermal Treatment Conference --
                  Exchange of information and ideas relating to thermal
                  treatment of hazardous wastes, permits, and technologies.

     7       Superfund Innovative Technology Evaluation (SITE) Conference --
                  Status and information on technology demonstrations.  Open
                  to all users regardless of affiliation.  All users automat-
                  ically registered in this conference.

     8       Removal Program Conference --
                  Open forum for Superfund Removal Program, mainly of interest
                  to OSCs and RPMs.

   Conference # to join (Enter)=none?
    Esc for ATtention, Home to SWitch    :      Capture Off        :   Local
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```
REGION        :6
SITE NAME     :
ROD ID        :
ROD DATE      :870327
  4,000 CUBIC YARDS OF HIGHLY CONTAMINATED SOILS WERE FOUND OVER THE FIRST
  THIRD OF A MILE OF FRONTIER PARK ROAD, AND 22,000 CUBIC YARDS OF
  MODERATELY CONTAMINATED SOILS WERE FOUND UP TO 2 MILES ALONG THE ROAD
**(TABLE 1). HIGHLY CONTAMINATED SOILS WERE DEFINED AS THOSE WITH GREATER
**THAN 100 PPM POLYAROMATIC HYDROCARBONS (PAH) OR VOLATILES, AND
**MODERATELY CONTAMINATED SOILS ARE THOSE BETWEEN 10-100 PPM PAHS OR
**VOLATILES. THESE CRITERIA ARE BASED ON A DIRECT CONTACT THREAT
  ESTABLISHED BY THE AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY.

                                  pah (text)
Order number                          -004-001
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  DUE TO THE VOLUME OF DATA GENERATED DURING THE SAMPLING EFFORT, TWO
  MARKER COMPOUNDS WERE CHOSEN TO REPRESENT CLASSES OF COMPOUNDS. BENZENE
  AND NAPHTHALENE WERE THE MOST PREVALENT CONTAMINANTS IN THE SAMPLES
**COLLECTED ALONG FRONTIER PARK ROAD. THEREFORE, BENZENE WAS USED TO
**INDICATE THE PRESENCE OF OTHER VOLATILE CONTAMINANTS FOUND AT THE SITE
**AND NAPHTHALENE WAS USED TO INDICATE THE PRESENCE OF OTHER BASE NEUTRAL
**CONTAMINANTS (PRIMARILY PAHS). IN GENERAL, THE BENZENE CONTAMINATION
  WAS FOUND UP TO A MAXIMUM CONCENTRATION OF 2100 PPM AND NAPHTHALENE UP
  TO A MAXIMUM CONCENTRATION OF 700 PPM IN THE ROADWAY.

  TRAFFIC SIGNIFICANTLY INCREASE THE POTENTIAL FOR CONTACT WITH
  CONTAMINANTS. BECAUSE THE ROAD PROVIDES THE ONLY ACCESS TO THEIR HOMES,
  THE ON-SITE RESIDENTS MAY POTENTIALLY BE EXPOSED SEVERAL TIMES DAILY.
**DURING DRY PERIODS, VEHICULAR TRAFFIC RAISES DUST PARTICLES CONTAMINATED
**WITH PAHS AND VOLATILES. ONSITE RESIDENTS MAY THEN BE EXPOSED THROUGH
  INHALATION OF DUST PARTICLES. DUST PARTICLES MAY ALSO BE INGESTED OR
  DEPOSITED ON SKIN AND OTHER BODY TISSUES.

      - OBJECTIVE: PREVENT DIRECT CONTACT WITH HIGHLY CONTAMINATED
        SOILS.
**
**      CRITERION: 100 PPM TOTAL POLYAROMATIC HYDROCARBONS (PAH'S), OR
**      100 PPM TOTAL VOLATILES (TVS), (FOR THE PURPOSE OF THIS STUDY
**      TOTAL VOLATILES WILL BE DEFINED AS BENZENE, ETHYLBENZENE,
**      TOLUENE, 2-BUTANONE, 4-METHYL, 2-PENTANONE, STYRENE, AND
**      XYLENE).

      - OBJECTIVE: MINIMIZE DIRECT CONTACT WITH MODERATELY CONTAMINATED
        SOILS.
**
**      CRITERION: BETWEEN 10 AND 100 PPM TOTAL PAH'S OR 10 AND 100 PPM
**                 TVS.

      - OBJECTIVE: IMPROVE ACCESS TO SITE FOR HEAVY EQUIPMENT TO
        FACILITATE REMEDIAL INVESTIGATION SAMPLING AND MONITORING AND
  ALTERNATIVE WERE RETAINED AND ANALYZED FOR MITIGATING THE PROBLEMS
  ASSOCIATED WITH THE FRONTIER PARK ROAD. THE FOLLOWING IS A DESCRIPTION
  OF EACH ALTERNATIVE AND ITS RESPECTIVE COST.
**
**ALTERNATIVE 1: ON-SITE STORAGE WITH RELOCATION
**
**REMOVE/EXCAVATE CONTAMINATED SOIL TO BELOW 100 PPM PAHS AND/OR TVS AND
**DISPOSE OF THEM IN AN ON-SITE RCRA STORAGE FACILITY. BACKFILL AS
  NECESSARY WITH NATURAL SOILS. CONSTRUCT A ROAD SO THAT ACCESS IS
**PROVIDED TO ALL AREAS OF THE SITE. CONSTRUCT THE ROAD SO THAT ALL SOILS
**ON THE ROAD, CONTAMINATED WITH GREATER THAN 10 PPM PAHS AND/OR TVS ARE
**COVERED. TEMPORARILY RELOCATE ON-SITE RESIDENTS AND MAINTAIN THEIR
  PROPERTY UNTIL THEIR RETURN. THE COST OF THIS ALTERNATIVE IS $1,266,524.
**
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**ALTERNATIVE 2: ON-SITE STORAGE WITH DETOURS
**
**REMOVE/EXCAVATE CONTAMINATED SOIL TO BELOW 100 PPM PAHS AND/OR TVS AND
**DISPOSE OF THEM IN AN ON-SITE RCRA STORAGE FACILITY. BACKFILL AS
NECESSARY WITH NATURAL SOILS. CONSTRUCT A ROAD SO THAT ACCESS IS
**PROVIDED TO ALL AREAS OF THE SITE. CONSTRUCT THE ROAD SO THAT ALL SOILS
**ON THE ROAD, CONTAMINATED WITH GREATER THAN 10 PPM PAHS AND/OR TVS ARE
**COVERED. PROVIDE TEMPORARY CONSTRUCTION DETOURS TO ALLOW ON-SITE
RESIDENTS ACCESS TO THEIR PROPERTY DURING REMEDIAL ACTIONS. THE COST OF
THIS ALTERNATIVE IS $1,489,106.
**
**ALTERNATIVE 3: OFF-SITE DISPOSAL WITH RELOCATION
**
**REMOVE/EXCAVATE CONTAMINATED SOIL TO BELOW 100 PPM PAHS AND/OR TVS AND
**DISPOSE OF THEM IN AN OFF-SITE RCRA FACILITY. CONSTRUCT A ROAD SO THAT
**ACCESS IS PROVIDED TO ALL AREAS OF THE SITE. CONSTRUCT THE ROAD SO THAT
**ALL SOILS ON THE ROAD, CONTAMINATED WITH GREATER THAN 10 PPM PAHS AND/OR
**TVS ARE COVERED. TEMPORARILY RELOCATE ON-SITE RESIDENTS AND MAINTAIN
THEIR PROPERTY UNTIL THEIR RETURN. THE COST OF THIS ALTERNATIVE IS
$3,353,162.
**
**ALTERNATIVE 4: OFF-SITE DISPOSAL WITH DETOURS
**
**REMOVE/EXCAVATE CONTAMINATED SOIL TO BELOW 100 PPM PAHS AND/OR TVS AND
**DISPOSE OF THEM IN AN OFF-SITE RCRA FACILITY. CONSTRUCT A ROAD SO THAT
**ACCESS IS PROVIDED TO ALL AREAS OF THE SITE. CONSTRUCT THE ROAD SO THAT
**ALL SOILS ON THE ROAD, CONTAMINATED WITH GREATER THAN 10 PPM PAHS AND/OR
**TVS ARE COVERED. PROVIDE TEMPORARY CONSTRUCTION DETOURS TO ALLOW ONSITE
RESIDENTS ACCESS TO THEIR PROPERTY DURING REMEDIAL ACTIONS. THE COST OF
THIS ALTERNATIVE IS $3,575,744.
**
**ALTERNATIVE 5: . ALTERNATIVE ACCESS
**
**PROVIDE TEMPORARY ALTERNATE ACCESS AROUND PORTIONS OF FRONTIER PARK ROAD
**CONTAMINATED WITH GREATER THAN 100 PPM PAHS AND/OR TVS. FENCE THE.
PERIMETER OF THE CONTAMINATED AREAS TO PREVENT ACCESS. CONSTRUCT A ROAD
**SO THAT ACCESS IS PROVIDED TO ALL AREAS OF THE SITE. CONSTRUCT THE ROAD
**SO THAT ALL SOILS WITH GREATER THAN 10 PPM PAHS AND/OR TVS ARE COVERED.
PROVIDE TEMPORARY CONSTRUCTION DETOURS TO ALLOW ON-SITE RESIDENTS ACCESS
TO THEIR PROPERTY DURING REMEDIAL ACTIONS. POSTPONE FURTHER REMEDIAL
ACTION UNTIL REMEDIATION OCCURS AT THE REMAINDER OF THE SITE. THE COST

WERL Treatability Database Ver No. 2.0 01/03/80

NAPHTHALENE

CAS NO.: 91-20-3

COMPOUND TYPE: PAH,

FORMULA: C10 H8

CHEMICAL AND PHYSICAL PROPERTIES	REF.
MOLECULAR WEIGHT: 128.17	333A
MELTING POINT (C): 80.5	333A
BOILING POINT (C): 218	333A
VAPOR PRESSURE @ T(C), TORR: 0.082 @ 25	1006A
SOLUBILITY IN WATER @ T(C), MG/L: 30 @ 25	463A
LOG OCTANOL/WATER PARTITION COEFFICIENT: 3.37	163A
HENRY'S LAW CONSTANT, ATM x M3 MOLE-1:4.83 E-4 @ 25	419A

ENVIRONMENTAL DATA	REF.
CHRONIC NONCARCENOGENIC SYSTEMIC TOXICITY	NA
RISK ESTIMATES FOR CARCINOGENS	NA
DRINKING WATER HEALTH ADVISORIES/STANDARDS	NA
WATER QUALITY CRITERIA	345B
AQUATIC TOXICITY DATABASE	5B

FREUNDLICH ISOTHERM DATA

ADSORBENT	MATRIX	K	1/N	Ce UNITS	X/M UNITS	REF.
FILTRASORB 300	C	132	0.42	mg/L	mg/gm	3B
FILTRASORB 300	C	123	0.41	mg/L	mg/gm	780B
FILTRASORB 400	C	277	0.43	mg/L	mg/gm	1056B

NAPHTHALENE

CAS NO.: 91-20-3

INFLUENT CONCENTRATION - 0-100 ug/L

TECHNOLOGY	MATRIX	SIC CODE	SCALE	EFFLUENT CONCENTRATION (ug/L)	PERCENT REMOVAL	REFERENCE	
AS	D		F36	9 (5)	86	1B	-S-
AS	D		P	<0.7 (8)	>99.09	204A	-S-
AS	D		F	5 (11)	89	201B	-S-
AS	D		F38	<3 (4)	>91.9	1B	-S-
RO	D		P	0.02	80	180A	--$
TF	D		F21	<3 (6)	>89	1B	-S-
ChOx(Cl) (B)	I	28	B4	<2	>88	975B	--$
AL	SF		P	<10	>82	192D	---
AS	SF		P	<10	>82	192D	---
RBC	SF		P	<10	>82	192D	---

INFLUENT CONCENTRATION - >100-1000 ug/L

TECHNOLOGY	MATRIX	SIC CODE	SCALE	EFFLUENT CONCENTRATION (ug/L)	PERCENT REMOVAL	REFERENCE
AL	D		P2	13 (11)	88	203A -S-
AL	D		P1	36 (11)	67	203A -S-
AS	D		F60	<10 (5)	>95.4	1B -S-
AS	D		P	6 (12)	95.0	240A -S-
AS	D		P	4 (11)	96.3	203A -S-
AS	D		P1	<10 (5)	>93.0	241B VS-
AS	D		P2	8.9 (11)	97.9	241B VS-
CAC	D		P	79 (11)	27	203A -S-
TF	D		P	74 (11)	32	203A -S-
TF	D		P	14 (11)	88	240A -S-
AL + AL	I	28	F	16 (21)	98.3	233D VS-
AS	I	28	F4	<1	>99.17	975B --$
AS	I	28	F1	<14 (2)	>95.9	6B ---
AS	I	28	F31	<10 (13)	>99.00	6B ---
AS	I	28	F11	<10 (3)	>96.0	6B ---
AL	S		B	23	97.7	371D VS-
AS	S		B	2 (5)	99.5	1050E VS-
AL	SF		P	25	96.5	192D ---
AS	SF		P	25	96.5	192D ---

INFLUENT CONCENTRATION - >1-10 mg/L

TECHNOLOGY	MATRIX	SIC CODE	SCALE	EFFLUENT CONCENTRATION (ug/L)	PERCENT REMOVAL	REFERENCE
AS	I	28	F5	<10 (7)	>99.56	6B ---
AS	S		B	<10	>99.86	202D VS-

INFLUENT CONCENTRATION - >10-100 mg/L

TECHNOLOGY	MATRIX	SIC CODE	SCALE	EFFLUENT CONCENTRATION (ug/L)	PERCENT REMOVAL	REFERENCE
AS	I	28	F33	<10 (14)	>99.952	6B ---
AirS	S		B2	6,200 (5)	74	1328E ---

WERL Treatability Database Reference Number: 1328E

Mumford, R.L. and J.L. Schnoor, "Air Stripping of Volatile Organics in Water", Proceedings of the AWWA Annual Conference, Miami Beach, FL, pp 601-617 (1982).

Several air stripping studies were conducted using a bench scale unit 4 ft high and 3.75 in. ID containing 0.25 in. ceramic berl saddles. Runs were made at air to liquid ratios ranging from 25 to 200. Media depth was 1.5 ft for some runs and 2.5 ft for others.

All data reported herein for media depth = 1.5 ft and air:water ratio = 100:1 (liquid rate = 6.81 m3/m2-hr). Feed water was tap water spiked with organics of interest.

The run labeled B1 had a total THM = 400 ug/L and the run labeled B2 contained 12 solutes at 5 to 50 mg/L each.

END OF DATA

COLIS DATABASE EXAMPLE OUTPUT

SITE PROGRAM APPLICATIONS ANALYSIS
TERRA VAC IN SITU VACUUM EXTRACTION SYSTEM

RISK REDUCTION ENGINEERING LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268

NOTICE

The information in this document has been funded wholly or in part by the U.S. Environmental Protection Agency under the auspices of the Superfund Innovative Technology Evaluation (SITE) Program and under Contract No. 68-03-3255 to Foster Wheeler Envirosponse, Inc. It has been subjected to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute an endorsement or recommendation for use.

A>TYPE TERVAC01.AAR

SECTION 1
EXECUTIVE SUMMARY

Terra Vac, Inc.'s in situ vacuum extraction process has been employed at several Superfund and non-Superfund sites. Available data from four Superfund sites, where field activity has occurred, were reviewed and are summarized in Appendix D of this report.

CONCLUSIONS

The following conclusions, regarding applications of the technology, were drawn from reviewing the data on the Terra Vac in situ vacuum extraction process, both from the SITE Demonstration Test and other available data (Appendices C and D):

- The process represents a viable technology to fully remediate a site contaminated with volatile organic compounds (VOCs).
- The major considerations in applying this technology are the contaminant compound's volatility, site soil porosity, and the site-specific cleanup level.

- The process demonstrated good performance in removing VOCs from soil with measured permeability ranging between 10E-04 and 10E-08 cm/s. In practical terms, the process works well with most soil types. It was determined that air-filled porosity of a soil is a more important factor than permeability in the application of this technology.

- It is of utmost importance where soils of low permeability and high moisture content, i.e. low air-filled porosity, are encountered that a pilot demonstration test be considered to determine the feasibility of dewatering the soil.

- The process operated well in all weather conditions. There had been concerns raised on its applicability during extreme winter conditions. The technology is relatively simple and should be considered reliable.

- Chemicals with Henry's Constant greater than 0.001 (dimensionless) have been successfully extracted by the Terra Vac process. The process

A>TYPE TERVAC02.AAR

SECTION 2
INTRODUCTION

THE SITE PROGRAM

In 1986, the EPA's Office of Solid Waste and Emergency Response (OSWER) and Office of Research and Development (ORD) established the Superfund Innovative Technology Evaluation (SITE) Program to promote the development and use of innovative technologies to clean up Superfund sites across the country. Now in its third year, SITE is helping to provide the treatment technologies necessary to implement new federal and state cleanup standards aimed at permanent remedies, rather than quick fixes. The SITE Program is composed of three major elements: the Demonstration Program, the Emerging Technologies Program, and the Measurement and Monitoring Technologies Program.

The major focus has been on the Demonstration Program, which is designed to provide engineering and cost data on selected technologies. To date, the demonstration projects have not involved funding for technology developers. EPA and developers participating in the program share the cost of the demonstration. Developers are responsible for demonstrating their innovative systems at chosen sites, usually Superfund sites. EPA is responsible for sampling, analyzing, and evaluating all test results. The result is an assessment of the technology's performance, reliability, and cost. This information will be used in conjunction with other data to select the most appropriate technologies for the cleanup of Superfund sites.

Developers of innovative technologies apply to the Demonstration Program by responding to EPA's annual solicitation. EPA also will accept proposals at any time when a developer has a treatment project scheduled with Superfund waste. To qualify for the program, a new technology must be at the pilot or full scale and offer some advantage over existing technologies. Mobile technologies are of particular interest to EPA.

Once EPA has accepted a proposal, EPA and the developer work with the EPA regional offices and state agencies to identify a site containing wastes suitable for testing the capabilities of the technology. EPA prepares a detailed sampling and analysis plan designed to thoroughly evaluate the

IRIS CHEMICAL FILE STRUCTURE

1.0 CHRONIC HEALTH HAZARD ASSESSMENT FOR NONCARCINOGENIC EFFECTS

1.1 REFERENCE DOSE FOR CHRONIC ORAL EXPOSURE (RfD)
- 1.1.1 Oral RfD Summary
- 1.1.2 Principal and Supporting Studies (Oral RfD)
- 1.1.3 Uncertainty and Modifying Factors (Oral RfD)
- 1.1.4 Additional Comments (Oral RfD)
- 1.1.5 Confidence in the Oral RfD
- 1.1.6 EPA Documentation and Review of the Oral RfD
- 1.1.7 EPA Contacts (Oral RfD)

1.2 REFERENCE DOSE FOR CHRONIC INHALATION EXPOSURE (RfD) (structure not available at this time although will be very similar to the structure of the oral reference dose section)

2.0 CARCINOGENICITY ASSESSMENT FOR LIFETIME EXPOSURE

2.1 EVIDENCE FOR CLASSIFICATION AS TO HUMAN CARCINOGENICITY
- 2.1.1 Weight-of-Evidence Classification
- 2.1.2 Human Carcinogenicity Data
- 2.1.3 Animal Carcinogenicity Data
- 2.1.4 Supporting Data For Carcinogenicity

2.2 QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM ORAL EXPOSURE
- 2.2.1 Summary of Risk Estimates
- 2.2.2 Dose-Response Data (Carcinogenicity, Oral Exposure)
- 2.2.3 Additional Comments (Carcinogenicity, Oral Exposure)
- 2.2.4 Discussion of Confidence (Carcinogenicity, Oral Exposure)

2.3 QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM INHALATION EXPOSURE
- 2.3.1 Summary of Risk Estimates
- 2.3.2 Dose-Response Data for Carcinogenicity, Inhalation Exposure
- 2.3.3 Additional Comments (Carcinogenicity, Inhalation Exposure)
- 2.3.4 Discussion of Confidence (Carcinogenicity, Inhalation Exposure)

2.4 EPA DOCUMENTATION, REVIEW, AND CONTACTS (CARCINOGENICITY ASSESSMENT)
- 2.4.1 EPA Documentation
- 2.4.2 Review (Carcinogenicity Assessment)
- 2.4.3 U.S. EPA Contacts (Carcinogenicity Assessment)

3.0 HEALTH HAZARD ASSESSMENTS FOR VARIED EXPOSURE DURATIONS

3.1 DRINKING WATER HEALTH ADVISORIES
- 3.1.1 One-Day Health Advisory For A Child
- 3.1.2 10-Day Health Advisory For A Child
- 3.1.3 Longer-Term Health Advisory For A Child
- 3.1.4 Longer-Term Health Advisory For An Adult
- 3.1.5 Drinking Water Equivalent Level/Lifetime Health Advisory
- 3.1.6 Organoleptic Properties
- 3.1.7 Analytical Methods For Detection in Drinking Water
- 3.1.8 Water Treatment
- 3.1.9 Documentation and Review of HAs
- 3.1.10 EPA Contacts

3.2 OTHER ASSESSMENTS
(content and structure to be determined)

4.0 U.S. EPA REGULATORY ACTIONS

4.1 CLEAN AIR ACT (CAA)

4.2 SAFE DRINKING WATER ACT (SDWA)

4.3 CLEAN WATER ACT (CWA)

4.4 FEDERAL INSECTICIDE, FUNGICIDE AND RODENTICIDE ACT (FIFRA)

4.5 TOXIC SUBSTANCES CONTROL ACT (TSCA)

4.6 RESOURCES CONSERVATION AND RECOVERY ACT (RCRA)

4.7 SUPERFUND (CERCLA)

5.0 SUPPLEMENTARY DATA

5.1 ACUTE HEALTH HAZARD INFORMATION

5.2 PHYSICAL-CHEMICAL PROPERTIES

6.0 REFERENCES

SYNONYMS:

PHRED EXAMPLE OUTPUT

CAS	WQC Drinking Water Only	DW MCLs (mg/ℓ)	DW MCLG (mg/ℓ)	Ref Dose (ug/ℓ)
Acetone 67641	—	—	—	—
Benzene 71432	0 (0.67 µg/ℓ)	—	0	0.35
Benzo(a)pyrene 50328	0 (3.1 ng/ℓ)	—	—	—
Benzo(k)fluoranthene 207089	0 (3.1 ng/ℓ)	—	—	—
Carbon Disulfide 75150	—	—	—	—
Chloroform 67663	—	0.1 h/	—	—
Chrysene 218019	—	—	—	—
Dibutyl Phthalate 84742	44 µg/ℓ	—	—	—
1,3-Dichlorobenzene 541731	470 µg/ℓ	—	—	NA
1,1-Dichloroethane 75343	Insufficient data	—	—	—
Dichloromethane 82751	see Halomethanes	—	5	—
Fluorene 86737	—	—	—	—
Naphthalene 91203	Insufficient data	—	—	—
Phenanthrene 85018	0 (3.1 ng/ℓ)	—	—	—
Phenol 108952	3.5 µg/ℓ	—	—	—
Pyrene 129000	—	—	—	—
Toluene 108883	15 µg/ℓ	—	—	NA
1,1,1-Trichloroethane 71556	19 µg/ℓ	—	0.2	22000
Vinyl Chloride 75014	0 (2.0 µg/ℓ)	—	0	0.015
Xylene (mixed) 1330207	—	—	—	NA

QSAR EXAMPLE OUTPUT

CHEMICAL AND PHYSICAL PROPERTIES WORKSHEET

CAS : 75-99-0
NAME : Propanoic acid. 2,2-dichloro-
SMILES O-C(O)C(Cl)(Cl)C

*	Property	Value and Units	Source	Method Error
1	Mol Wgt.	142.00 g/mol	Calc.	
2	Parachor	248.00	Calc.	''''
3	Mol Ref.	27.30	Calc.	Ave. % Error - 5
4	Mol Vol.	119.00 cm 3/g.m.	Calc.	''''
5	LogP	1.47	C logP	''''
6	Melt Pt.			
7	Boil Pt.	188.00 C 0760mm	Meas	
8	V. Press.	0.44 mmHg	Calc.	Ave. % Error = 39.0
9	Ht. Vpr.	4103.00 cal/mol	Calc.	Ave. % Error = 1.85
10	pKa	1.339 25C	Calc.	
11	Sol H2O	13.70 gm/L	Calc.	''''
12	S. Area			

Property c)hanged or D)etailed Connectivity I)ndices or Q)uit

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