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FOREWORD

With the expanding awareness of protecting one of our most precious resources - water - the safeguarding of groundwater supplies and the rehabilitation of such waters becomes critical. The 12th Annual Environmental Systems Symposium chose to highlight groundwater protection and clean-up because of the recent emphasis within industry, government and the Department of Defense on water quality. Safeguarding our groundwater supplies must also be viewed from the perspectives of economic restraints, legal factors, overall environmental quality and human health.

The focus of the Symposium, and the papers presented in these Proceedings, was on groundwater protection and DoD installation restoration, with special reference to the Resources Conservation and Recovery Act. Papers presented dealt with Policy and Overview, Technology, Case Studies, and Management and Implementation.

The objectives of the Symposium were to:

A. Provide a forum to bring together representatives of government, industry and academia who have common interests and share common problems.

B. Present current research, overviews and solutions to the problems.

C. Allow individuals to exchange information with the intention of establishing a basis for further contact, discussions and meetings.

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VINCENT J. CICCONE, PhD, PE
SYMPOSIUM CHAIRMAN

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TOXIC AND HAZARDOUS MATERIAL MANAGEMENT IN DOD

Dr. Donald K. Emig
Office of the Secretary of Defense

It is a pleasure for me to be here today and address this 12th Annual Environmental Systems Symposium. This year, I had the opportunity to be involved in the formulation of the program. I am, therefore, very hopeful that you will find this meeting both valuable and interesting.

It seems that we see, in a continuing basis, the news media reporting on accidents involving toxic or hazardous materials:

- A train derails, or there is a truck accident, and people have to be evacuated from their homes, or
- An abandoned stockpile of toxic chemical wastes is found, or
- We listen to state or local officials talk about the massive public resistance to siting a hazardous material landfill,
- We listen to people whose homes border on operating landfills express their concner for their children's health and safety, or
- We listen to TV reporters interview people whose drinking water is found to be contaminated with low levels of chemicals that most of us have trouble pronouncing, or remembering their names.

As a nation, we have become highly sensitized to the potential long-term health and environmental effects of the so-called "toxic and hazardous chemicals," which are used in great abundance in this country today. In fact, we estimate that in the Defense Department alone, we use some 50,000 different c-emical compounds, which are defined as toxic or hazardous. So much for the importance of this symposium.

During my few minutes with you this morning, I would like to up-date you on the Department of Defense's cradle-to-grave involvement with toxic and hazardous materials. To simplify the discussion, I'd like to separate our program into two general areas.

1st vugraph

First, our current program, which fits into the framework of the resource conservation and recovery act, or RCRA. This program involves those daily aspects of hazardous materials management, and includes the following activities:

- o Procurement,
- o Production,
- o Research and Development,
- o Transportation
- o Storage,
- o Worksite use, and
- o Disposal

Each of our defense installations is responsible to meet all applicable federal, state, and local solid and hazardous waste laws or regulations, it is at that level, the local installation level, that hazardous wastes are tracked from generator, through storage, transportation, and treatment, to disposal. I will concentrate, this morning, on the disposal aspects of that program.

Our second program deals with past disposal sites of the Defense Department. We refer to it as our installation restoration program. Our program preceded the comprehensive environmental response, compensation and liability act - the SUPERFUND Act - by several years and is more comprehensive in scope. I will discuss briefly each of these programs with you this morning.

2nd vugraph

The Defense Logistics Agency was assigned these responsbilities by DOD in May of 1980. In summary, DLA was given a broad charter to be the DOD single manager for disposal of most military hazardous wastes which are generated by our installations. Within DLA, this lead role was largely delegated to the Defense Property Disposal Service, headquartered in Battle Creek, Michigan.

3rd vugraph

The Defense Property Disposal Service is to ensure that toxic and hazardous wastes generated by Department of Defense installations are disposed of in accordance with federal, state, and local laws and regulations. This responsibility includes an evaluation of salvage and resale possibilities; i.e., recycle of materials. An excellent example of DOD's recycle approach was in the recent sale of 368 tons of phosgene (used as a chemical warfare agent by the Army during World War I) to a civilian firm in New York State. The firm will use the chemical (in reality carbonyl chloride) as a raw material reedstock for urethane plastic manufacture.

Collection, storage, and disposal of these toxic and hazardous materials is accomplished through 142 Defense Property Disposal offices which are co-located on military installations throughout the world, and some additional 74 off-installation branches, which serve as collection, storage, and transfer points. DLA's disposal actions are by contract to commercial firms. Contract preparation is handled either at Defense Property Disposal Service headquarters in Battle Creek, or at one of their 5 Defense Disposal Regional offices.

4th vugraph

This vugraph indicates some of DLA's significant accomplishments since their assumption of the Defense Disposal mission. The PCB collection and disposal exercise will be on-going for several years. PCB disposal is by incineration at one of the EPA-approved sites. The DDT disposal action is a one-time requirement. Only the liquid stocks remain to be destroyed, by incineration at sea on the vulcanus. DLA has also picked up responsibility for some 64 service contracts for disposal of wastes from the military departments. These contracts total some $4.9 million this fiscal year.

5th vugraph

This vugraph indicates those materials that remain the responsibility of the Army, Navy, Air Force, and Marine Corps. The second item includes materials such as consecrated religious items, and cryptographic material.

Now I'd like to describe our installation restoration program for you. The program began in 1975. We initiated this program from our concern for the public health and welfare, and environmental quality prior to any public outcry or legislative mandate. We are quite proud of that program and the leadership we have demonstrated to the federal, state, and local governments and to private industry.

6th vugraph

On August 14, 1981, Executive Order 12316 delegated certain authority of the President outlined in the SUPERFUND Act, to the Secretary of Defense. The Secretary of Defense, in recognition of our demonstrated record of achievement in the areas of spill control and installation restoration, was giver responsibility for:

- Response authority (i.e., removal and remedial authority), and
- Investigation, monitoring, survey, and testing authority for Department of Defense facilities or vessels.

- Also, the Secretary of Defense was given authority to undertake such planning, legal, fiscal, economic, engineering, architectural, and any other studies or investigations as necessary for response actions, cost recovery, and to enforce the provisions of the SUPERFUND Act.

7th vugraph

The draft national contingency plan goes on to further recognize Department of Defense on-scene coordinators for Department of Defense facilities. On-scene coordinators are the federal officials responsible for directing and coordinating federal responses under the national contingency plan.

8th vugraph

Within Defense, we have formally delegated the Secretary's authority in Executive Order 12316 to the Secretaries of the Army, Navy, and Air Force. The Assistant Secretary of Defense for manpower, reserve affairs, and logistics on November 20, 1981, formally identified our functioning installation restoration program as the DOD SUPERFUND program.

9th vugraph

This vugraph identifies the objectives of our installation restoration program. Note that our objectives go beyond the SUPERFUND mandate. We are conducting a deliberate review of past hazardous material disposal sites on our facilities to identify, evaluate, and control (as necessary) any potential hazard to health or welfare. We also conduct those same deliberate steps on land and facilities which are excess to the DOD mission, and which will pass on to non-DOD ownership.

10th vugraph

We have required the military departments and defense agencies to establish and operate installation restoration programs, complete records searches at every installation listed on service priority lists by the end of FY 85, and have required them to develop and maintain a priority list of contaminated installations and facilities requiring remedial action. Later on today, Army, Navy, and Air Force speakers will discuss in great detail the functioning and accomplishments of their installation restoration program.

11th vugraph

My final vugraph indicates the Defense installation restoration organization. Each of the military departments has assigned a principal role to an environmental organization to coordinate or accomplish installation restoration activities. The Army also provides program coverage to the Defense Logistics Agency. The Army's toxic and hazardous materials agency is located at the Edgewood area of Aberdeen Proving Ground, Maryland. The Navy's energy and environmental support activity is located at Port Hueneme, California, and the Air Force's engineering and services center is located at Tyndall Air Force Base, Florida. Speakers from each of these organizations will address you later in the program.

My role, at defense level, is to develop and issue policy to the components for the conduct of the program, to ensure we implement requirements mandated by the Congress, and to review progress of the program.

I'm sure many of you are anxious to hear more about the details of the program. I can assure you that our later speakers will provide those details.

By way of conclusion, I would like to restate our pride of the leadership that the Department of Defense has taken to manage hazardous wastes and control contaminants on our installations. We will continue to pursue actively the programs I've discussed with you this morning.

Again, I'm very happy for the opportunity to address you this morning. I know that the speakers assembled here will provide valuable information to us all.

Thank you for your attention, and I'll be happy to answer any questions you have have.

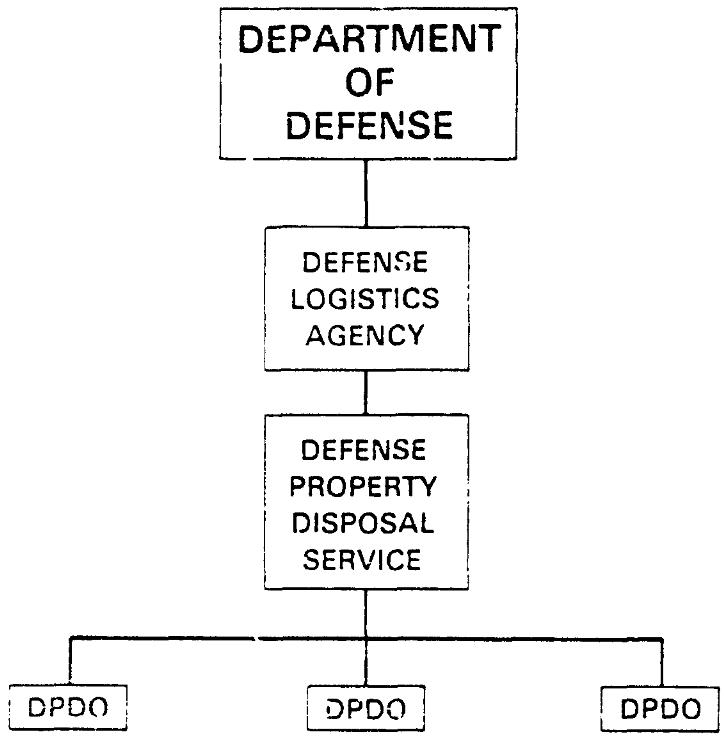
TOXIC AND HAZARDOUS MATERIAL MANAGEMENT IN DOD

- CURRENT PROGRAM (RCRA)
- PAST DISPOSAL (SUPERFUND - INSTALLATION RESTORATION)

CURRENT PROGRAM (RCRA)

- DEFENSE LOGISTICS AGENCY WILL:
  - ENSURE WORLDWIDE DISPOSAL OF DOD HAZARDOUS MATERIALS (WITH EXCEPTIONS),
  - DETERMINE AND PROVIDE INFORMATION TO DOD COMPONENTS ON MARKET AVAILABILITY OF RECOVERABLE RESOURCES,
  - NEGOTIATE SALES CONTRACTS FOR MARKETABLE WASTE PRODUCTS, AND CONTRACT FOR SOLID WASTE SALE TO PUBLIC OR COMMERCIAL RESOURCE RECOVERY OPERATIONS,
  - DISPOSE OF DOD-GENERATED WASTE PETROLEUM, AND
  - ACT AS DOD EXECUTIVE AGENT FOR DISPOSAL OF PCBs AND PCB ITEMS

3279-2



3279 2

DLA ACCOMPLISHMENTS

- PCB DISPOSAL (TO DATE)
  - GUAM STOCKS DESTROYED ($0.27M)
  - OGDEN REGIONAL STOCKS (14 STATES) DESTROYED ($0.41M)
  - COLUMBUS AND MEMPHIS REGIONAL STOCKS (32 STATES) DESTROYED ($1.1M)
  - PACIFIC REGIONAL STOCKS (1 STATE) BID OPENING MAY 28, 1982
  - ALASKA STOCKS – SOLICITATIN RELEASE MAY 28, 1982
  - ODGEN II – AWARD MAY 28, 1982
  - COLUMBUS AND MEMPHIS II – INVENTORIES BEING COMPLETED
- DDT DISPOSAL
  - WORLDWIDE STOCKS TOTAL:
    - •• 240,000 GALLONS LIQUID
    - •• 210,000 POUNDS POWDER
    - •• 62,000 AEROSOL CANS
  - CONUS CONTRACT AWARDED FOR $1.8M

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CURRENT PROGRAM (CONTINUED)

- DOD COMPONENTS WILL REMAIN RESPONSIBLE FOR THE DISPOSAL OF:
  - BY-PRODUCTS OF THE DISPOSAL OF TOXICOLOGICAL, BIOLOGICAL, RADIOLOGICAL, AND LETHAL CHEMICAL WARFARE MATERIALS,
  - MATERIAL THAT CANNOT BE DISPOSED OF IN ITS PRESENT FORM DUE TO MILITARY REGULATION,
  - MUNICIPAL GARBAGE, TRASH, AND REFUSE,
  - CONTRACTOR-GENERATED MATERIALS, WHICH ARE THE CONTRACTOR'S DISPOSAL RESPONSIBILITY,
  - MUNICIPAL AND INDUSTRIAL WASTEWATER TREATMENT PLANT SLUDGES,
  - REFUSE FROM MINING, DREDGING, CONSTRUCTION, AND
  - UNIQUE WASTES AND RESIDUES FROM R&D OPERATIONS.

PAST DISPOSAL (SUPERFUND - INSTALLATION RESTORATION)

EXECUTIVE ORDER 12316
SECTION 2. RESPONSE AUTHORITIES

(C) THE FUNCTIONS VESTED IN THE PRESIDENT BY SECTION 104 (a) AND (b) OF THE ACT ARE DELEGATED TO THE SECRETARY OF DEFENSE WITH RESPECT TO RELEASES FROM DEPARTMENT OF DEFENSE FACILITIES OR VESSELS, INCLUDING VESSELS OWNED OR BAREBOAT CHARTERED AND OPERATED.

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DRAFT NATIONAL CONTINGENCY PLAN (MARCH 12, 1982)

SECTION 300.33 RESPONSE OPERATIONS

(b) (8)......WITH RESPECT TO INCIDENTS ON DEPARTMENT OF DEFENSE FACILITIES, THE OSC SHALL BE FURNISHED BY THE DOD.

PAST DISPOSAL (SUPERFUND - INSTALLATION RESTORATION)

- SECRETARY OF DEFENSE MEMORANDUM OF NOVEMBER 2, 1981, DELEGATED AUTHORITY VESTED IN SEC DEF BY EO 12316 TO SECRETARIES OF ARMY, NAVY, AND AIR FORCE. ASD(MRA&L) ASSIGNED OVERSIGHT RESPONSIBILITY AND POLICY ISSUANCE RESPONSIBILITY.

- ASD (MRA&L) MEMORANDUM OF NOVEMBER 20, 1981, IDENTIFIED INSTALLATION RESTORATION PROGRAM AS DOD SUPERFUND PROGRAM.

INSTALLATION RESTORATION PROGRAM

- IDENTIFIES AND EVALUATES PAST HAZARDOUS MATERIAL DISPOSAL SITES ON DOD FACILITIES, CONTROLS CONTAMINATION MIGRATION, AND CONTROLS HAZA.:DS TO HEALTH OR WELFARE,
- REVIEWS AND DECONTAMINATES, AS NECESSARY, LAND AND FACILITIES EXCESS TO DOD MISSION.

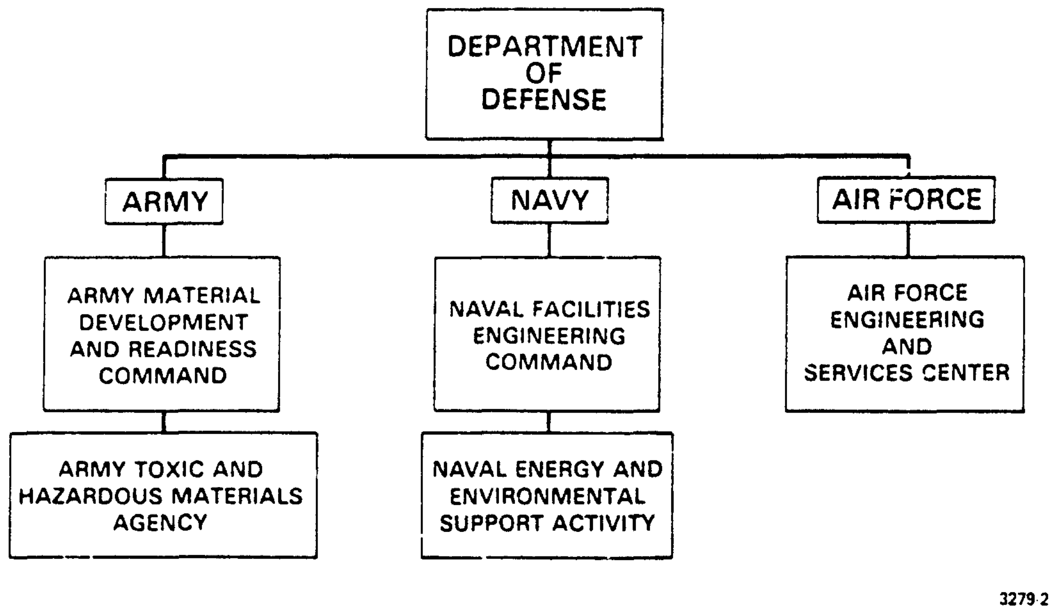
INSTALLATION RESTORATION PROGRAM (CONTINUED)

DOD COMPONENTS REQUIRED TO:

- ESTABLISH AND MAINTAIN INSTALLATION RESTORATION PROGRAMS,
- COMPLETE A RECORDS SEARCH AT EVERY INSTALLATION LISTED ON THEIR PRIORITY LIST BY THE END OF FY 85, AND
- DEVELOP AND MAINTAIN A PRIORITY LIST OF CONTAMINATED INSTALLATIONS AND FACILITIES FOR REMEDIAL ACTION.

3279 2

DEFENSE SUPERFUND (INSTALLATION RESTORATION) ORGANIZATION



DOD INSTALLATION RESTORATION PROGRAM:
A PRIVATE SECTOR VIEWPOINT

Martin R. Hoffmann
Gardner, Carton & Douglas

The DOD address of hazardous waste disposal problems on installations in 1974 foreshadowed later public and Congressional address of hazardous waste. The Army initiated the process not only by identifying its problems but by constituting a body of experts to study and devise solutions to them.

The Installation Restoration Program (hereinafter IRP) no longer moves exclusively with that early aura of enlightened agency volunteerism: a complex legal background has grown up around the hazardous waste problem:

-- The Resource Conservation and Recovery Act of 1976 (RCRA) provides for cradle-to-grave records of hazardous waste generation and disposal.

-- The Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA or Superfund) provides for the cleanup of inactive hazardous waste disposal sites.

-- Executive Order 12316 spells out individual government agency responsibility under CERCLA, delegating the Presidential powers created by that Act.

-- The Defense Environmental Quality Program Policy Memo 81-5 with its attached "concept plan" undertakes to spell out the guidelines for the IRP.

-- Federal Clean Water and Clean Air Acts have been reinterpreted and in some cases readdressed to the problems generated by hazardous waste disposal.

-- State laws -- Clean Water, Clean Air and even "mini-Superfund" Acts -- have been passed and in many cases applied to Federal Government agencies as well as private sector parties.

To outline a single private viewpoint on the IRP would be somewhat difficult. There are several discreet and different private sector viewpoints:

-- A lessor of property to the DOD.

-- A lessee of DOD property, often under a long-term lease.

-- Contractors, who by participation in the containment or other aspects, will address DOD hazardous waste problems.

-- The public at large (taxpayers, neighbors of military posts, newspaper readers and media watchers).

Each of the above private sector members probably has his own perception of the IRP and each of whose perceptions and, indeed, interactions with the DOD will help to determine its success.

It should be recognized at the outset that the foregoing laws, as they address hazardous materials, involve a set of principles which is not clearly understood by the public. These laws generally impose absolute liability without fault for disposal of hazardous materials, past as well as present. This liability is imposed with respect to the disposal of materials at a time when their effects were largely unknown (and in many cases still are). Moreover, the materials involved in many cases have not until recently been detectable in the quantities now alleged as dangerous. And, finally, the technology and methodology for solving a large number of waste disposal problems are undeveloped.

As a practical matter, many of today's hazardous waste situations were created under circumstances where all parties thought they were doing the right thing. This circumstance has been masked to an extent by a series of disposal activities undertaken after the great legislative awakening to the hazardous waste problem and in defiance of those laws. Accordingly, the DOD and certain private sector organizations are now finding themselves the objects of citizen scorn when at the time the problem was created, they were following the most enlightened procedures for waste disposal then in existence.

It should also be recognized that the hazardous waste problem does not lend itself to generous treatment at the hands of the press. Obviously, threats to health and safety may, in the hands of a sensationalist media, put at a severe disadvantage in public relations terms those who are either responsible for the creation of the problem or responsible for its solution.

Two overriding generalizations on the IRP should be made clearly from a private sector point of view:

First, inter-U.S. government rivalry and disagreement in situations of perceived public danger are extremely costly not only to the government but to the agencies engaged in the squabble. Should such squabbles result in either inaction or lack of address to the problem, so much the worse. The remarkable turnaround in the relations between the DOD and EPA generally is heartening and should continue. Constructive resolution of remaining jurisdictional disagreements -- such as CERCLA Section 106 responsibilities for DOD facilities -- should proceed as priority matters.

Second, failure by the DOD to adequately manage and resolve problems in the past will forfeit the public's confidence in current and future DOD operations. The DOD hazardous waste threat to the public essentially is the threat of a bad neighbor. Where operations must be continued on DOD facilities that currently have hazardous waste problems, the willingness to go the extra mile to assure a good neighbor relationship will be important.

The IRP will generate a number of concerns for the different private sector viewpoints outlined above. In the interest of brevity, one or several of these principal concerns can be most effectively displayed from the point of view of a particular private sector individual. The concern obviously will be shared by others as well.

<u>Private Sector Lessor</u>:

A lessor of property to a DOD agency is addressed in DOD Memo 81-5 in a logical and probably deceptively simple manner. The Memo states that decontamination should not be undertaken if the estimated cost thereof exceeds the fair market value of the land. In such a case, the land should be purchased or leased; thereafter, it should be secured and isolated and the environment monitored for thirty years.

This is all right as far as it goes, particularly since it infers that a decontamination operation should be undertaken if the cost is less than continued lease or purchase and isolation. However, another wrinkle is added which illustrates the problems with lessors. The Memo suggests that specified damages be paid to the owner to compensate for restricting future use of the land consistent with the lease and the cost of monitoring the site for thirty years.

The first difficulty is whether, by paying specified damages to the owner for any reason, the DOD can avoid its perpetual responsibility imposed by the law for the DOD generated hazardous waste on the leased land. It would appear that a policy of purchasing the land if the estimated cost of decontamination exceeds the fair market value would be more consistent with the legal theories (as well uncertainties) of future liability.

But a larger problem is the impact on this situation of the so-called "big fence" solution to DOD hazardous waste problems. Under this approach, the ultimate fallback of the IRP is to contain and isolate an installation or a hazardous waste problem by fencing it off and monitoring at the boundary while nature takes its course.

The principal problem with the big fence approach is that nature abhors a vacuum. Society gets restless with unusable land, particularly if that land lies adjacent to urban or other developable situations. In addition to the rather precarious situation of the lessor who sees his leased property tied up behind a fence indefinitely, (he expects it to revert to him someday and he probably has plans for it), the public will not long abide the nonuse of the land.

It would seem that the IRP needs more flexibility than simply the big fence. Consideration of a future use with restricted or controlled access, consistent with a degree of abated contamination would appear to be a better solution. Accordingly, aggressive exploration of future uses for problem properties will not only relieve the anxiety -- and probable awkward legal situation -- in which a lessor finds itself, it may well preclude the postponement today of a problem that will return tomorrow with added complexity and expense factors of several orders of magnitude.

Private Sector Lessee:

The lessee on a DOD facility who participates or shares a hazardous problem on that facility faces a highly complex situation. It would be hard to do justice to that situation in a few paragraphs and this attempt will be merely to highlight the problems.

The lessor/lessee relationship of the DOD and a private company doubtless was formed for mutual convenience in far less complicated times. Mutual benefits were clearly involved: the DOD was able to lease various of its industrial facilities to private firms who are obligated to keep them in working order and be prepared to return them on extremely short notice, often in no more than thirty days. At the same time, the company had facilities at a reasonable cost and probably at a favorable geographic location.

The lease documents probably did not anticipate today's hazardous waste disposal problems, either in terms of the danger of hazardous waste disposal or the scheme of responsibility that has been enacted into law. DOD and lessee waste may be comingled, both on and off the site. As to both the DOD and its tenant, there are extreme ex post facto overtones that stem from the recent legislation.

The lessee finds himself in a highly complicated legal and operational situation. As a lessee, his rights and responsibilities are immediately governed by the lease, and by his landlord. His landlord, however, does not have complete control of the hazardous waste situation. Not only are there state agencies who may take action against the lessee but EPA may attempt to do so also. Additionally, Section 7002 of RCRA provides for suits by private citizens to abate hazardous waste situations. Thus, the tenant may be at the mercy of his landlord for legal and operational flexibility necessary to deal with other enforcement agencies at the time that his landlord may be asserting one or more claims against the lessee based on its responsibilities under the Executive Order delegation under CERCLA. The multilayered decisional process under which the IRP has operated to date invariably works to the disadvantage of the lessee.

Generalizations as to this relationship must necessarily be incomplete, but they are worth noting. First, the DOD has an overriding need to avoid litigation with respect to its hazardous waste problems, as an essential part of maintaining a constructive public relations posture. Second, in view of their similar positions vis-a-vis the public and the enforcement agencies, the DOD agencies and their lessees maintain the original constructive partnership that was anticipated by the lease in view of other potentially adversarial parties. The technical review committee concept which you will hear in the Rocky Mountain Arsenal presentation today will be helpful in this context. Careful, knowledgeable implementation of sensitive public relations support -- which must be directed by the DOD landlord -- must involve the lessee to the fullest extent.

Private Sector Contractor:

The contractor who contemplates bidding on an IRP project is an important ingredient in the DOD hazardous waste picture. The potential for cross-fertilization of technology and operational lessons learned through the coordination of the Corps of Engineers and USATHAMA, who are involved in the civilian Superfund cleanup work, should be heartening to the contracting community. As a practical matter, the EPA Superfund program has proceeded far less rapidly than anticipated so that there should be an abundance of qualified, motivated cleanup contractors available for response to IRP RFPs.

From the point of view of the contractor community, there are two areas of uncertainty that should be classified in implementing the IRP.

First is the perennial question of contractor liability. If the project issued for bid is fully designed and the contractor is to perform pursuant to a statement of work and technical specifications, the liability problems could be no different from the ordinary contract.

However, if the performance of the contract should result or appear to result in an aggravation of the hazardous waste problem or possible off-site release of some kind, the contractor may well be sued by a citizen group or possibly by a state (or even EPA). Additionally, if the contract leaves certain areas open for performance at the discretion of the contractor, the opportunity for future liability could arise. It is not clear whether existing insurance will fully cover such risks and even if insurance was designed to do so, whether the pool of insured companies would be large enough to support reasonable insurance costs. DOD should give consideration to being a self-insuror of the contractor's residual or continuing liability. This could be done by according authority to an on-site coordinator from the Corps of Engineers or the technical staff of the agency involved to supervise contract performance and approve work under the contract which might involve potential future liability.

A second problem arises from the nature of the hazardous waste problems as they occur on sites, both civilian and military. In many cases of hazardous waste removal or cleanup, the problem cannot be fully analyzed and a solution fully designed until the cleanup work has commenced. Drums burst; undiscovered deposits are turned up in the course of excavation; unanticipated chemical reactions occur; undiscovered buried structures may interfere with the removal; and subterranean water courses may not be as anticipated prior to actual on-site excavation. Speed in executing changes to the contract or in redirecting contract efforts will be essential to successful contract completion in such cases. Here again, the flexibility of an on-site coordinator with authority to make such changes and redirections may make the difference between a successful IRP remedial action and a public relations disaster. The applicability of present DARs and other procurement requirements should be made clear at the outset and the needed flexibility anticipated at the RFP stage.

As with other private sector participants, the contractor will be the beneficiary of an enlightened public relations effort and must be a willing contributor to it.

The Private Sector Public-at-Large:

In general, the public will be well served by a successful implementation of the IRP program. The recent improvement in relationships between EPA and DOD agencies is perhaps the most encouraging potent of the success of the IRP. Given that the IRP pre-dated the Federal and many of the State laws under which hazardous waste remedial actions currently proceed, the public will be best served by a program which continues to evolve in sophistication and level of detail, and in which the lessons learned from one project are rapidly applied to the next.

It should be recognized that the U.S. public is wary of situations in their immediate neighborhoods that pose hazards of any kind. Known as the "backyard complex" -- "it may be fine in someone else's backyard but not for mine" -- this is a phenomenon that may pass in time but is already established in other areas of national concern such as defense or industrial facility location and nuclear waste disposal. Public confidence in projects under the IRP can go a long way toward reversing these attitudes.

In summary, and from a private sector viewpoint, the IRP will benefit from address to the following considerations:

-- EPA and DOD need to work closely together in resolving jurisdictional problems. The resolution of off-post migrations from DOD installations is a particular problem deserving of speedy address. The DOD has won its CERCLA Section 104 jurisdiction and EPA is probably in the best position to deal with off-installation Section 106 responsibilities under the Executive Order.

-- The "big fence" philosophy is a perfectly legitimate alternative for the present time and may be directly applicable in a number of situations. However, the development of future uses that are consistent with a manageable level of residual hazardous waste will be a far better long-range solution to the majority of DOD hazardous waste problems where complete cleanup is either impractical or not cost-effective.

-- The technical review team concept in which the DOD, EPA, the relevant state and local agencies and lessors or contractors maintain surveillance over IRP information gathering, feasibility studies, project design, and project implementation provides the best opportunity for low profile address to hazardous waste problems consistent with the public interest. Such teams can assure that the maximum talent will be applied as and when needed. The use of such a committee as a basis for an enlightened continued public relations program is readily demonstrable.

-- The hallmark of the IRP program to date -- anticipation, accurate fact finding and analysis, and a continuous development of techniques and approaches -- must be maintained throughout the working life of the IRP.

Finally, it is well on such an occasion to remember one of the great maxims of General Creighton Abrams: "Bad news never gets better with age". In the IRP, DOD is anticipating and facing up to serious problems in a forthright way. There is no more effective means to private sector approval than that.

CORPS OF ENGINEERS ROLE IN REMEDIAL RESPONSE

Noel W. Urban, James D. Ballif, Douglas W. Lamont
U.S. Army, DAEN-CWE-BU

BACKGROUND

The Environmental Protection Agency (EPA) under Executive Order 12316 was assigned primary responsibility for implementation of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (i.e., CERCLA or Superfund). The Superfund program consists of two parts: (1) emergency response (removal action) to hazardous substance spills and uncontrolled sites, and (2) remedial response to cleanup problem sites. Remedial response consists of the following four phases:

1. Investigation of the problem
2. Feasibility study to select the most effective and cost efficient cleanup alternative
3. Final design of cleanup action
4. Implementation (construction) and related tasks

States may elect to manage and direct all or part of the remedial response activities; otherwise, EPA will take the lead. In any case, the state in which the site is located, will still be required to provide 10% or 50% cost - sharing. EPA has a three-tiered process that will determine the extent of Corps assistance under Superfund. The sequence is as follows under which EPA will: (1) determine whether a private entity is liable, and approach that entity to perform the cleanup; if that does not develop, then (2) determine whether the State can/will do the cleanup; and if not, then (3) determine that Federal cleanup is appropriate and request the Corps undertake design and construction.

EPA Selects Army Corps of Engineers To Manage Superfund Work - EPA and the Army Corps of Engineers on February 3, 1982 signed an interagency agreement under which the Corps of Engineers will manage design and construction contracts and provide technical assistance to EPA in support of remedial cleanup of hazardous waste sites.

CORPS RESPONSIBILITIES UNDER THE INTERAGENCY AGREEMENT

At sites where EPA has primary responsibility for cleanup, the Corps will contract out and manage actual design and construction work, once a remedial concept is approved by EPA and the Corps (Figure 1). Overall program guidance, policy, and funding for Corps support will originate with EPA.

1/ Chief, Urban Studies and Management Section, Engineering Division (Civil Works), Office, Chief of Engineers, Washington, D.C.

2/ Civil Engineer, Urban Studies and Management Section, Engineering Division (Civil Works), Office, Chief of Engineers, Washington, D.C.

3/ Civil Engineer, Urban Studies and Management Section, Engineering Division (Civil Works), Office, Chief of Engineers, Washington, D.C.

The Corps will provide, as needed, technical assistance to EPA during the remedial investigation and feasibility study phases. This assistance will be of necessary scope to assure that the proposed remedial action selected by EPA can be engineered and constructed. The Corps will also assist EPA in the review of projects conducted by the States as to their suitability for bidding and construction. In any case, EPA will not assign a remedial action to the Corps for management if the Corps determines that the action is not reasonable to design, construct, operate and maintain.

Management Structure - The Corps will utilize its existing nationwide decentralized management structure, integrating its Superfund responsibilities into the existing Civil Works program. Under the direction of the Chief of Engineers, the Director of Civil Works, will perform executive direction and management activities, in a similar manner to the Corps traditional Civil Works missions, except for the absence of a direct interface with the Office of Management and Budget and Congress on budget and authorization activities. The Directorate of Civil Works, would interface with EPA in determining Superfund issues, policy, funding, priorities, research needs and national program direction within the interagency agreement. The Director, through his staff, will assign projects to Division Engineers, provide field guidance, perform program management activities, conduct Washington level program reviews and coordination, and conduct design and construction oversight. The Chief, Engineering Division, Directorate of Civil Works, has been assigned programmatic responsibility by the Director of Civil Works.

Project Management and Program Coordination - The Chief, Engineering Division, Directorate of Civil Works, will be the Corps National Program Manager. The project management and program coordination function will be assigned by state and will be based on the location of the hazardous waste site in relation to the state-lead district assignment (Table 1). The Division Engineers, through their staff designees, will be regional Corps program managers responsibile for overall project and program management activities. The District Engineer will be the local program manager, providing a project manager for each hazardous waste site designated by EPA.

Design Review - Nationwide, the Missouri River Division (MRD) Engineer has been assigned the responsibility for the contracting, review, and coordination of project design. All actual design will be performed by private architect-engineer firms contracted by the Kansas City and Omaha Districts within MRD. MRD will coordinate the design contracting, resolve design problems, verify design cost estimates, coordinate the design review, and approve the designs. A flow diagram depicting how the engineering and design activity would normally function is shown in Figure 2. The "constructing" or lead district would coordinate design management activities with MRD (See Table 1). MRD will prepare construction bid packages for competitive award to private industry contractors. All Division Engineers will perform regional coordination, program and budget consolidation for projects and activities falling within their respective EPA Superfund boundaries.

Construction Management - The implementation or construction activity will be fully integrated into the existing construction mangement structure at Corps districts, divisions, and at the Office of the Chief of Engineers. State-assigned lead districts (see Table 1) will be responsible for the construction management phase. The "constructing" district will execute contracts let by competitive bid to private industry; and provide contract administration and construction management activities, including financial management and reporting activities. The "constructing" district engineer, or his designee(s), will have contracting officer authority, using bid packages prepared by MRD. The construction effort will be managed by the lead district who will turn over the completed project to the respective EPA regional office.

Other Corps Responsibilities - The Corps will be responsible for developing a site safety plan based on information contained in the remedial investigation and feasibility study. The plan will cover the health and safety of personnel involved in site design and remedial actions, as well as populations in the immediate site area. Implementation of the plan will be shared between EPA and the Corps as follows: Corps responsibility will be limited to design and remedial action personnel, and EPA will coordinate all actions relating to off-site populations. In addition to development of the site safety plan, the Corps will be responsible for environmental monitoring during the design and construction phases; preparation of site operation and maintenance manuals; facility start-up; operator training; and, assisting EPA in the implementation of community relations plans. The Corps will not be responsible for: establishing Superfund priorities; site selection; cost recovery; public involvement; obtaining state assurances for the disposal site, cost sharing, and maintenance; environmental impact statement preparation; obtaining permits; legal determinations; obtaining real estate rights; and, performing operation and maintenance activities.

Announcement of Design and Construction Work - Architect-engineer firms and construction contractors can get information on upcoming work by:

1. Keeping their current DA Form 254's on file with MRD and the Kansas City and Omaha districts for design, and with the geographic lead district for construction.

2. Watching "Commerce Business Daily" announcements.

3. Keeping in contact with the geographic lead district procurement office.

In addition for construction, each District Engineer maintains a list of prospective bidders who have expressed interest in specified types of procurement that may occur within his assigned geographic area. Annually, in February, each Division Engineer publishes for distribution to the construction industry and suppliers, a schedule of major construction procurements expected to be advertised for bids over a 20 - month period. The Corps will use its standard contracting and procurement procedures. Small business set asides will be in accordance with the criteria set out in the Federal Procurement Regulations at FPR 1-1-706-5(a).

FIGURE 1

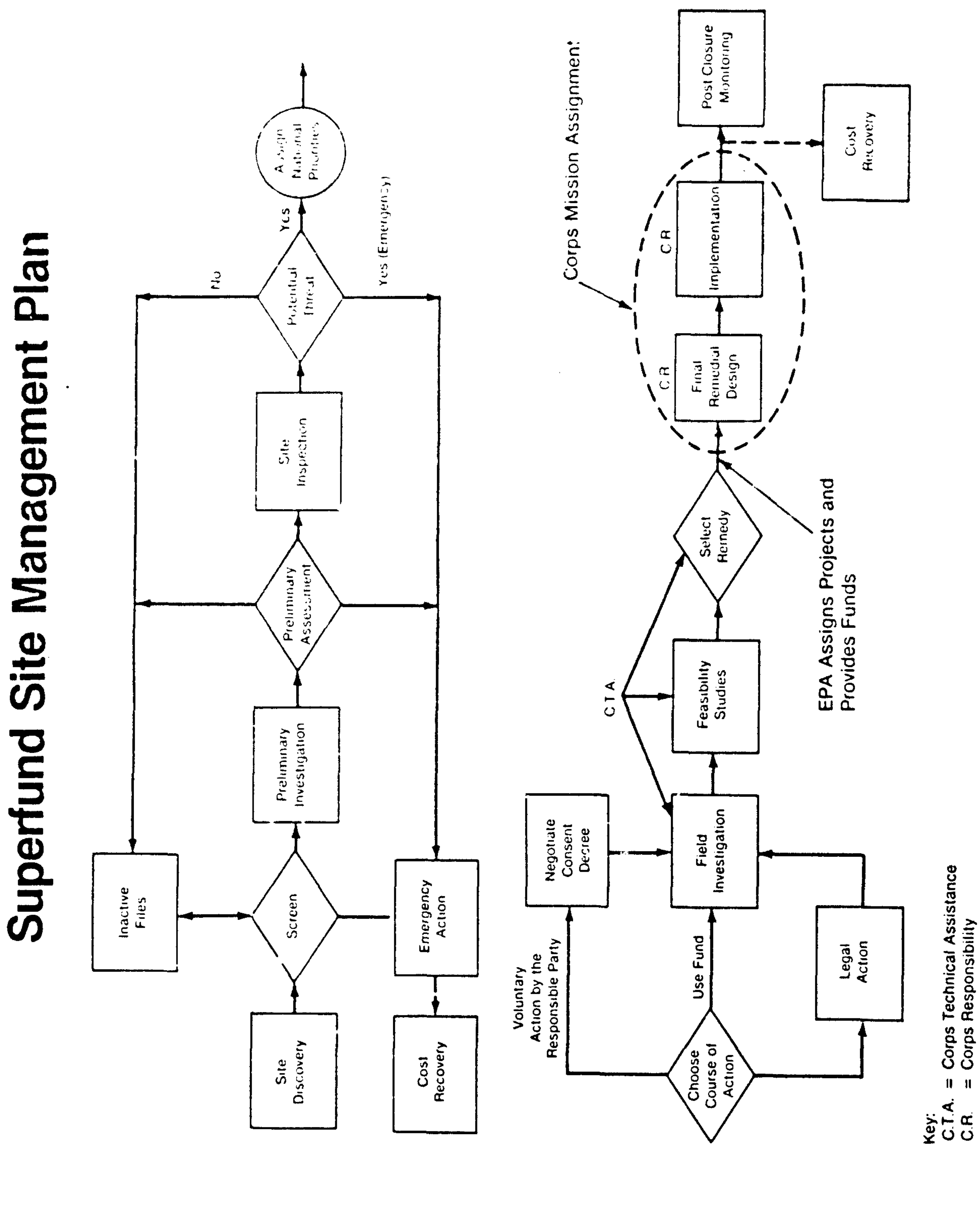
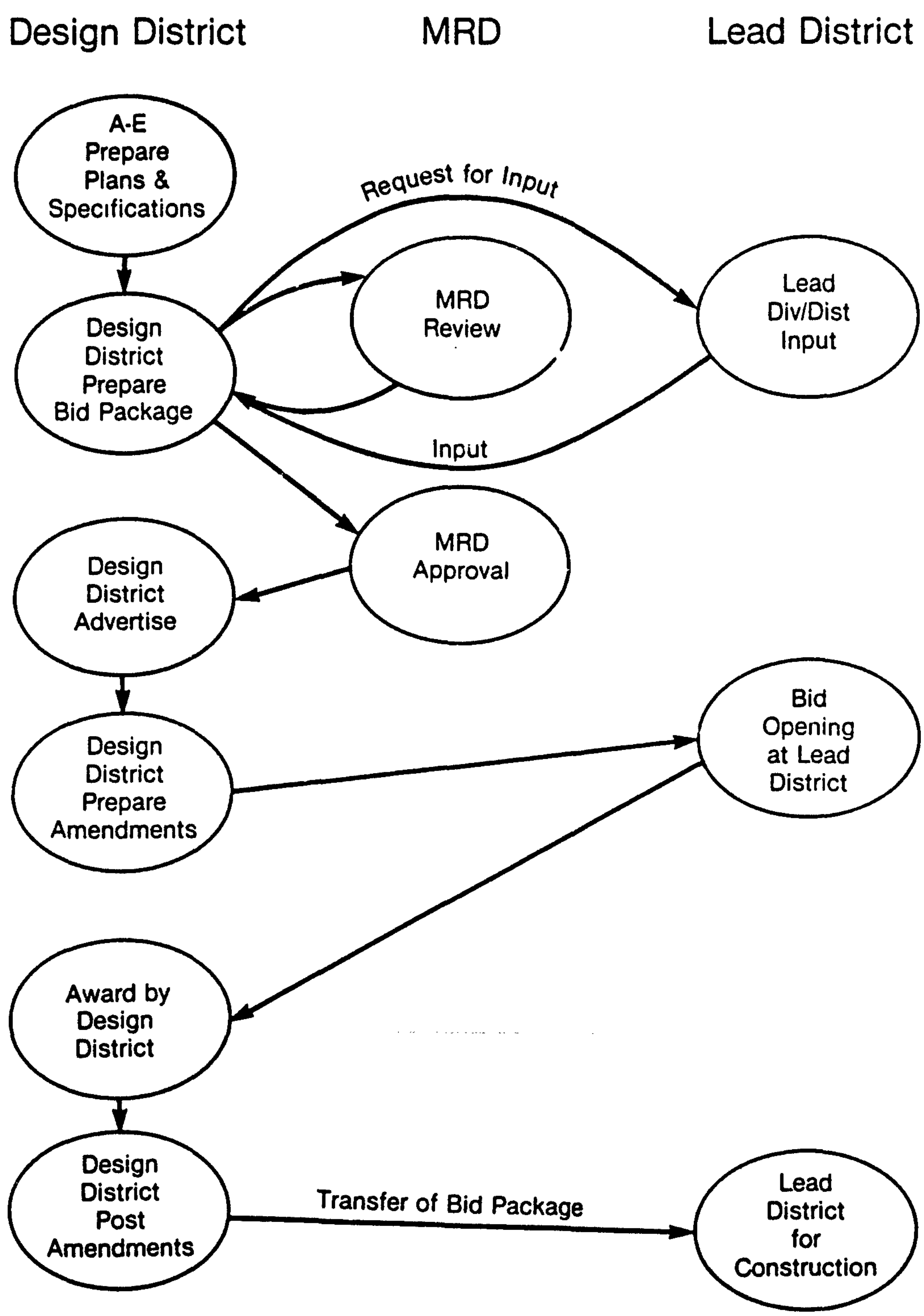

Superfund Site Management Plan
Site Discovery
Screen
Inactive Files
Emergency Action
Cost Recovery
Preliminary Investigation
Preliminary Assessment
Site Inspection
Potential Threat
No
Yes
Yes (Emergency)
Assign National Priorities
Choose Course of Action
Voluntary Action by the Responsible Party
Use Fund
Negotiate Consent Decree
Field Investigation
Legal Action
C.T.A.
Feasibility Studies
Select Remedy
EPA Assigns Projects and Provides Funds
C.R.
Final Remedial Design
C.R.
Implementation
Corps Mission Assignment
Post Closure Monitoring
Cost Recovery
Key:
C.T.A. = Corps Technical Assistance
C.R. = Corps Responsibility

FIGURE 2

Usual Process



Missouri River	NE	Kansas City District	VII
	IA	Kansas City District	VII
	MO	Kansas City District	VII
	KS	Kansas City District	VII
	MT	Omaha District	VIII
	ND	Omaha District	VIII
	SD	Omaha District	VIII
	WY	Omaha District	VIII
	CO	Omaha District	VIII
South Pacific	NV	Los Angeles District	IX
	AZ	Los Angeles District	IX
	CA	Sacramento District	IX
	UT	Sacramento District	VIII
North Pacific	WA	Seattle District	X
	OR	Portland District	X
	ID	Walla Walla District	X
	AK	Alaska District	X
Pacific Ocean	AMER SAMOA	Pacific Ocean Division	IX
	GUAM	Pacific Ocean Division	IX
	HI	Pacific Ocean Division	IX

DEPARTMENT OF THE ARMY
RESPONSE TO SUPERFUND — POLICIES AND PROGRAMS

D. PALMER, AICP, R. NEWSOME, P.E., M. READ
OFFICE OF THE CHIEF OF ENGINEERS

INTRODUCTION

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA/SUPERFUND) added a new dimension to environmental management for both private industry and government, principally state and federal government. The Act is both retrospective and prospective in that past activities as well as future incidents of releases of hazardous substances are addressed. Both aspects have applicability to the Department of the Army. We would like to briefly outline the Army organization for dealing with Superfund issues; state current policy in this area; and address certain action areas where policy has yet to be fully developed. Finally, in the programs section of this paper we will explain two of the Army's program responses to CERCLA.

ORGANIZATION

By Executive Order 12316 of 14 August 1981, President Reagan delegated certain of his authority under the CERCLA to the heads of named departments. The Department of Defense, being so named, redelegated those same authorities to the secretaries of the several military departments. In the case of the Department of the Army, these authorities rest with the Assistant Secretary of the Army for Installations, Logistics and Financial Management (ASA,(IL&FM)) and are administered by his Deputy for Environment, Safety and Occupational Health (DESOH). Although DESOH has primary responsibility, the Deputy for Installations and Housing (DI&H) and the Deputy for Logistics (DLOG) also of ASA,(IL&FM) have roles in specific superfund activities, respectively the excessing of property and the packaging of spill residue, and in some cases, its contract disposal. Below the secretariat level, a number of Army staff agencies have key roles. The most involved staff elements being the Office of the Chief of Engineers - policy and program responsibility and the Director of Military Support - Civil emergency assistance and National Response Team assistance. Others, such as the Office of the Deputy Chief of Staff for Logistics, the Office of the Surgeon General, and the Office of the Judge Advocate General have substantial involvement.

POLICY

In the mid '70's, the Army was faced with performing remedial control activities due to regulatory agency actions at several installations where past waste disposal practices had caused contamination of surface streams and groundwater. Additionally there was a need to decontaminate Army owned real estate that was considered to be excess to Army needs. These two separate, but related requirements resulted in the Installation Restoration program to be discussed shortly. But of equal importance, basic policies were established for guiding responses to instances of contamination found on or migrating from Army installations.

The Army's basic policy for currently owned property is containment of contaminants within the military boundary. For property designated for release (excessing) through the General Services Administration (GSA), decontamination for like use (a degree of hazard approach, if you will) or complete restoration to an uncontaminated state is the guide. The costs associated with the latter will obviously influence ownership decisions. For practical, economic reasons, some facilities may be placed in a caretaker status and remain under military control.

Because, by definition, the CERCLA includes the same hazardous wastes identified for regulation under the Resource Conservation and Recovery Act (RCRA), there may be some confusion as to which act is applicable in any particular circumstance.

We consider the difference between these two laws a matter of verb tense. That is, RCRA is a present tense law. It applies to existing operational hazardous waste facilities which are required to have RCRA operating permits. Releases from these facilities must comply with remedial response requirements under RCRA and not CERCLA.

CERCLA, on the other hand, deals with contamination caused by past operations or from future spills or releases of hazardous substances.

This difference is important to understand since the Army is delegated responsibility for implementation of a CERCLA and not a RCRA response. It then becomes important to determine if contaminants result from existing operations or from previous activities. Funding and authority differ, even though the response and responding agency may be the same.

This raises a number of unresolved policy issues concerning previously owned property (retrospective aspect of CERCLA) and situations in which the Army is an aggrieved party in a hazardous waste spill. We currently have examples of both instances. And it should be noted that neither are resolved.

ACTION AREAS

As presented above, there are a number of unresolved areas of concern with respect to CERCLA and Army responsibilities there under. Policy formulation is under way but not as yet complete on issues such as

1. responsibilities for excessed property;
2. third party situations;
3. and National Contingency Plan (NCP) implementation.

Specific issues under the NCP that we feel must be explicit as to the Army's role as an On-scene coordinator (OSC) are:

1. Emergency response/on-scene coordinator duties (jurisdiction and funding);
2. Investigative and entry authority;
3. Natural Resource Trusteeship;
4. Notification of potentially injured parties;
5. And remedial response requirements.

PROGRAMS

As explained, the Army's current activities associated with the development of our Superfund response program are oriented around CERCLA's remedial response requirements. Remedial response is differentiated from our CERCLA emergency response responsibilities which, it is envisioned, will be addressed through modifications to our existing Spill Prevention Control and Counter Measure Plans for control of future accidental releases of hazardous substances into the environment.

By remedial response, it is meant the development of courses of action to contain or eliminate situations where our past hazardous material storage, treatment or disposal actions may have resulted in the release, or substantial

A separate but related program which will deal with hazardous contaminants control is the Army's Resource Conservation Recovery Act (RCRA) groundwater monitoring program. This program specifically responds to the RCRA groundwater monitoring requirements around permitted sites. This program is administered through the Army MACOMs and installations (customers), the Army Environmental Hygiene Agency (program quality control) and the Huntsville Engineering Division (contracting of sampling analysis and assessment surveys). The program currently consists of thirty Army installations for which samples of groundwater are being analyzed to determine RCRA compliance status. To date, three DARCOM installations have been identified as requiring detailed groundwater assessments and potential remedial action. Contracts for two of these installations are scheduled for FY 82. It is not anticipated that more than four or five additional assessment studies will be required under this program. Costs for this type assessment study varies considerably in the range of $25,000 to over $500,000

IMPLEMENTATION OF

NAVY ASSESSMENT AND CONTROL OF INSTALLATION POLLUTANTS PROGRAM

Daniel L. Spiegelberg, LCDR, CEC, USN
Naval Energy and Environmental Support Activity

I. PROGRAM OVERVIEW

In September 1980, the Department of the Navy initiated the Navy Assessment and Control of Installation Pollutants (NACIP) Program to identify, assess, and control contamination from past hazardous waste disposal operations at Navy and Marine Corps activities.

Also known by the acronym NACIP, it is the Navy's version of the Department of Defense Installation Restoration Program. The Naval Facilities Engineering Command, already supporting Navy and Marine Corps commands in other environmental matters, was designated as program manager for the NACIP program.

The NACIP program consists of three phases:

1. Initial Assessment

2. Confirmation

3. Corrective Measures

Most documents list the Navy program in four phases. However, a fortncoming change will combine two of those phases to result in the three-phase program identified here. The Initial Assessment phase is an initial look at an activity to determine whether a potential problem exists from past hazardous material operations. Confirmation involves a more comprehensive investigation of specific locations identified at an activity to define the limits of the problem. Monitoring wells, sampling and chemical analysis are used to collect hard data in this phase. Finally, Corrective Measures such as containment, treatment, and decontamination are used as necessary to correct a problem confirmed as a health or environmental threat. The Corrective Measures phase would include any technology development needed to solve the problem.

The Naval Facilities Engineering Command has designated the Naval Energy and Environmental Support Activity (NEESA), Port Hueneme California, to execute the Initial Assessment phase. The six regionally-located Engineering Field Divisions of the Naval Facilities Engineering Command will execute the Confirmation and Corrective Measures phases of the program. The remainder of this presentation will focus on the Initial Assessment phase of the NACIP program.

II. INITIAL ASSESSMENT

Initial Assessment Studies will be performed at 79 Navy and Marine Corps activities identified as having a potential for contamination due to their past industrial operations and the geophysical characteristics of the area. Activities were chosen based on information gathered through Navy-developed questionnaires and through notification forms filed under the Comprehensive Environmental Response, Compensation, and Liability Act. Studies will be performed first at activities which are expected to pose the most serious problems.

The Department of Defense has directed that Initial Assessment Studies be completed at all 79 activities by Fiscal Year 1985. To date, studies have been initiated at 25 of those activities. In order to accomplish the Department of Defense requirement, 80% of the remaining studies will be performed by contract.

An Initial Assessment Study is performed by a team of qualified engineers and scientists. A typical Initial Assessment Study team would include the following individuals: team leader, environmental engineer, hydrogeologist, chemist, biologist and any other specialist who could provide needed expertise for a specific study, (e.g., ordnance expert, etc.)

An Initial Assessment Study can be broken down into three parts: record search, site visit and report preparation. The study begins with a complete review of documented information on the activity such as reports, correspondence, and aerial photographs. During visits to the National Archieves, regional Records Centers, Explosives Safety Board, US Geological Survey and other offices, leads are developed concerning past hazardous materials operations which will be pursued during the activity visit. The site visit allows a first-hand view of the activity through ground tours and helicoper overflights. More importantly, however, the site visit provides an opportunity to interview base personnel to locate problems resulting from past handling and disposal of hazardous materials. Following the site visit, a report is written which describes the activity's past operations and contains recommendations for follow-on work. As noted earlier, follow-on work might include monitoring to confirm and define the problem and implementation of corrective measures. This systematic approach will allow the Navy to effectively protect human health and the environment while doing so in a cost-effective manner.

III. INITIAL ASSESSMENT STUDY CONTRACTS

Most of the Initial Assessment Studies will be performed by contract with engineering firms. During Fiscal Year 1983, seven contracts are planned with up to three activities included on a single contract.

Contracts will be Engineering Service Contracts with selection based on technical qualifications as presented on Standard Forms 254 and 255. Price negotiations will follow selection with the intent of awarding a firm fixed price contract to the selected firm. Additional information on individual contracts will be included in synopses published in the Commerce Business Daily.

FLOW PATH DEFLECTION AND MIGRATION RATES OF TNT AND RDX CONTAMINANTS IN AN ALLUVIAL AQUIFER

R. Schalla
Battelle Memorial Institute
Pacific Northwest Laboratory

A multiphase contaminant/assessment survey was conducted by Battelle at an Army Depot in the northwestern United States as part of the U.S. Army Toxic and Hazardous Materials Agency's Installation Restoration Program. The depot is underlain by alluvial deposits comprised of layers and lenses of sand, gravel, silt, and clay, and by composites of these soil particles which become progressively finer toward the west and north. The alluvium is underlain by a fairly impermeable layer formed by flood basalts of the Columbia River Group, which are usually capped by clay and silt within the depot boundaries. Even where the clay is not present, columnar basalts exhibit low vertical hydraulic conductivities (3×10^{-6} to 10^{-10} cm/sec -- Gephart et al. 1979). Hence, the amount of vertical leakance is quite small, although the potential for vertical flow is downward to the basalt aquifers.

During the first phase, we installed a network of 11 monitoring wells in the alluvial aquifer to detect contaminant migration from suspected source areas. We analyzed ground-water samples, and surface and subsurface soil samples for pesticides, herbicides, munitions, heavy metals, nitrates, semivolatile organics, and other potential contaminants. A single source was determined to have contaminated the aquifer with 2,4,6-trinitrotoluene (TNT), cyclotrimethylenetrinitramine (RDX), and minor amounts of dinitritoluene (DNT) and nitrate. The high concentrations of TNT and RDX were found 300 m upgradient from the lagoons. Based on information from soil boring logs of the four monitoring wells nearest to the TNT disposal lagoons, we inferred that two layers of lacustrine (lake bed) sediments consisting of clay and silt were present above the water table. Based on scant data, we hypothesized that explosive contaminants migrated downward through unsaturated sands and gravels, and then perched on the first of two silt-rich lacustrine layers. When enough hydraulic head developed to overcome surface irregularities on top of the lacustrine layer, ground water flowed to the southeast (opposite the dominant northwest regional ground-water gradient) until the edge of the silt layer was reached. A downward vadose migration continued until contaminants entered the unconfined alluvial aquifer, or perched temporarily where the second lacustrine layer was encountered.

During a second study phase, we installed additional monitoring wells and performed chemical analyses near the TNT washout lagoon. The results of this second phase supported the conceptual model; however, the markedly different distributions of TNT and RDX concentrations in the alluvial aquifer contradicted the anticipated relative mobility of these co-disposed munitions.

METHOD

The specific objective of the second phase was to delineate the present and future extent of contamination from the TNT washout area. To do this, we studied several aspects of the contaminants: 1) quantity, 2) type, 3) approximate initial concentration, and 4) duration method of surface disposal. Much of the data listed above is not well known. Consequently, emphasis of the second phase study was directed toward confirming our initial hypothesis and refining our preliminary conceptual model of the hydrogeologic system in the vicinity of the TNT washout area. The conceptual model takes the following into account:

- the influence of stratigraphy, structure (geometry), and lithology on the migration of explosive contaminants in the vadose and saturated zones, primarily, the configuration and orientation of the lacustrine deposits
- the relationship of distributions of TNT, RDX, and related nitrate concentrations to dynamic seasonal changes in the flow pattern and heterogeneities.

Based on our knowledge of the area and on disposal methods of explosives, our survey team assumed that where the contaminants have reached the aquifer, the highest concentrations of these are in the upper portions of the saturated zone. Five additional monitoring wells were installed and numerous shallow soils borings were made near the TNT washout lagoons. Analyses for explosives were performed by High Performance Liquid Chromatography (HPLC) and Gas Chromatography with an Electron Capture Detector (GC-ECD).

RESULTS

Our hypothesis that the flow path is defected by lacustine deposits was confirmed during the second phase and an improved understanding of the flow regime and migration of pollutants was obtained. Calculated average linear flow velocities vary from 6 to 23 cm/day along the projected flow path.

Soils, subsoils, and ground water in and underlying the TNT washout lagoons were found to contain TNT, RDX, DNT, and nitrate degradation products. Significant contamination from explosives was identified in the TNT washout lagoons.

The quantity of the waste solution discharged was estimated by the Depot staff to be between 2 and 8.5 million gal/year for a period of 10 years, beginning in 1956. The washout process was operated six months out of the the batches of 54,000 gal were discharged into the lagoons as often as three or four times per month. Concentrations of TNT and RDX entering the saturated zone are probably much higher than those detected in the test wells, in which levels are well below the solubility limits for these explosives.

Solubility, potential sorption, and chemical and microbial degradation of TNT and RDX are important factors for interpreting these findings. The significance of the latter item is discussed by Osmon and Klausmeier (1973), who show that TNT in low concentrations disappears during microbial growth in the presence of other organic substrates. However, no breakdown of RDX has been observed.

Areas with low-level contamination in the unsaturated should be subject to some slow microbial degradation (half lives on the order of years), but this natural mitigation process should take a long time. The attenuation mechanism that operates in the unsaturated zone will not prevail in the abiotic quifer. Hence, the alluvial aquifer underlying the washout lagoon area is the location of concern for TNT, RDX, DNT, and nitrate residues. RDX is reported to be less soluble in water than TNT (0.0065 g/100 g of water at 20°C compared to 0.013 g TNT/100 g water at 20° -- U.S. Army and Air Force 1967). Caution is necessary here. Field data collected seem to contradict this statement. This contradiction may reflect that the information cited in the U.S. Army Technical manual is based on our laboratory data which are probably not applicable to the field conditions at the Depot.

Determining the location and configuration of the contaminant plumes of TNT, RDX, and NO_3 is also important. Because the organic content in the saturated zone is believed to be quite low and the permeability is quite high, we initially assumed that little attenuation or retardation of the TNT and RDX concentrations is taking place, and that the front of the plume is probably moving at about the same average linear velocity as the water molecules. Subsequent data suggest that this may be true for RDX and nitrates, but not for TNT. The initial second phase sampling was conducted on July 16, 1981. The second round of sampling was conducted on November 6, 1981, covering the five new wells in addition to the original four washout lagoon wells. Both the July and November sampling rounds confirmed the presence of explosive related contaminants in the aquifer. Significant concentrations of TNT and RDX were found at different locations around the lagoons.

Associated nitrates may form an early arrival front because the mobility of nitrate is greater and adsorption is far less than for TNT. Unlike the apparently interactive TNT, the RDX contaminants have migrated almost as rapidly as the nitrates with respect to the first arrival front and less so for concentration gradients.

The concentration distributions of RDX and nitrate are widespread and both exhibit a southward distortion. The southward distortion of the plume can be explained by transient changes in the potentiometric surface of the alluvial aquifer. Water levels taken in the spring (before the irrigation pumping season) and fall (immediately after the pumping season) differ considerably. Flow during the winter and spring follow the regional northwest flow gradient, but heavy pumping by numerous irrigation wells that tap the alluvium alters the gradient toward a southwesterly flow, probably during late summer and early autumn. The ground-water gradient in the area of the TNT lagoons is minimal, particularly during the pumping season.

CONCLUSIONS

The conclusions are summarized in the order in which events occurred along the flow path from the beginning of TNT waste disposal operations to the present. The original contaminants migrated vertically to the low permeability silt layers, then developed sufficient positive hydraulic head in the perched zones to flow laterally to the southeast and finally entered the saturated zone.

Ground water moved northwest with the regional flow gradient for most of the year, except when transient southwest flow conditions prevailed. These conditions caused distortion of the RDX and TNT contaminant plumes in a southwesterly direction. Nitrate contaminants appear to have moved most rapidly at an average of 7 cm/day, approximately equal to the estimated average linear flow velocity of water molecules. The first arrival front of RDX appears to have migrated almost as far as the nitrate. Both illustrate the southwestward distortion of the contaminant plumes caused by irrigation pumping which resulted in seasonal changes in the potentiometric subsurface. The apparent higher mobility of RDX suggests that, despite its low solubility, RDX does not adsorb strongly on soils or degrade; therefore, little attenuation occurs. The TNT plume does not appear to have migrated as far as the RDX. Were the TNT contaminant plume moving at a rate close to that of RDX, it should have been detected in at least some of the down gradient monitoring wells.

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Development of Industrial Waste Water Lagoon Restoration Technology

Robert P. Bartell
Edward F. Colburn

US Army Toxic and Hazardous Materials Agency

Lagoons have been used extensively for the disposal of Army industrial operation wastes for over 30 years. These industrial operations have included: explosives, propellant, pyrotechnics and detonator production, loading and assembling of munitions, and painting, degreasing and electroplating operations.

Generally, use of lagoons is being phased out and being replaced by more effective treatment systems that allow direct discharge of effluents into receiving water. Many lagoons remain, however, and have been identified as quantitatively the Army's biggest potential source of ground water contamination. In some cases, migration of pollutants from lagoons has been positively identified as the cause of ground water pollution. Thus, there is a definite need to develop effective technology to eliminate these pollution sources and to restore the lagoons.

Although numerous lagoon problem areas are now evident and represent a major installation restoration problem that will ultimately cost many millions of dollars to remedy, their past use cannot be condemned. They were primarily employed at a time when better technology was not available and when regulatory requirements were such that use of Federal funds were not justified to develop and install better systems. These lagoons served their purpose at the time and were of value because their use prevented the overburdening of receiving waters with hazardous pollutants.

Lagoons were primarily used at Army arsenals, ammunition plants and depots. There are approximately 50 installations of this type containing several hundred lagoons of concern, many of which have a questionable integrity, such that they are considered to be prime potential sources of ground water contamination.

The major pollutants that can be contained in these lagoons are: explosive compounds, trinitrobenzene, tetryl, lead based detonator compounds, nitrocellulose, pyrotechnic mixtures, degreaser solvents (chlorinated hydrocarbons), plating wastes, and heavy metals. In some cases a lagoon received wastes from a single type of operation and only those associated pollutants would be present. In other cases lagoons received wastes from a number of different operations and contain a potpourri of pollutants.

Because of the many different locations of the lagoons, configurations are variable. Different subsurface characteristics exist with varying soil types, porisities and permeabilities. In most cases, a ground water aquifer lies somewhere under the lagoon. Lagoons are usually located in a cluster at a remote location and may be connected by a diking system. They are often rectangular with sides of 50 to 200 feet and usually less than 10 feet deep.

Analysis of various lagoon sediments has shown that significant variations in pollutant composition and concentration occur laterally and with depth. Sediments have actually been analyzed which contain as high as 50 percent explosives. The same pollutants that are in the sediment are present in the lagoon wast. water at concentrations from below detectable to the maximum allowed by their respective solubilities.

The main characteristics of waste water lagoons that are of concern in the restoration technology development program are:

Wide range of pollutant concentrations.

Heterogeneous sediment composition.

Possible presence of unexploded ordinance items (UXO).

Potential for pockets of propellant, explosive, pyrotechnic material (PEP).

Not biologically active.

Of particular concern is the need to include a very high confidence methodology for detecting and safely handling UXO's and PEP hot spots in the sediments.

One of the mission tasks of the US Army Toxic and and Hazardous Materials Agency (USATHAMA) is to manage the necessary development of technology for Army installation restoration. With regard to lagoons, it is obvious that there is a lack of adequate technology to contain and/or remove and dispose of lagoon contamination. In our technology development program, we have initiated a two-thrust effort. One, we are working towards developing what we call innovative, best, new, technology; that is, beyond the current state-of-the-art. Priority criteria are efficiency, adaptability and cost. Our target is to be able to implement this technology in the FY85-86 time frame. In the meantime, we are exerting efforts to adapt current applicable state-of-the-art procedures to address decontamination and restoration requirements that must be undertaken before new technology will be available. In doing this, we will most probably be trading expediency for poorer cost-effectiveness, but at least will be able to conduct those installation restoration operations that are necessary and cannot be postponed.

Several other major efforts are being undertaken by USATHAMA in the installation restoration technology development program including:

Removal of solvents from soil and ground water.

Treatment of unsecured landfills.

Hazardous materials handling technology.

Decontamination of chemical agent and explosives contaminated structures.

Lagoon liner integrity.

Stabilization of ash piles.

In situ lagoon sediment treatment.

The general approach being used by USATHAMA in these technology efforts (as outlined below) has been structured so as to avoid certain undesirable problems that can occur in any Research and Development program.

Problem definition.

Identify treatment concepts, establish treatment criteria.

Comparative evaluation and rank-ordering of treatment concepts; selection of concepts to be studied experimentally.

Demonstration of concept feasibili.y.

Further lab/bench scale evaluation; sensitivity of significant parameters; maximum practical effectiveness.

Reassessment of comparative merits/disadvantages of methods tested; select best concept(s) for field demonstration.

Field demonstration/pilot plant testing/concept optimization.

Data package for design/implementation of select concept.

The problem definition step includes a review of previous work done in the area to identify data gaps and to prevent duplication of effort. Establishing performance criteria as completely as possible at the outset of development is important so as to avoid overlooking pertinent performance requirements later in the development stage when steps might have to be retraced and efforts repeated to insure development of the proper technology. The main criteria to be considered are: relative cost-effectiveness, disposal or containment efficiency, and adaptability of the treatment method or process to similar problems at different locations. It is also important that candidate technology concepts be carefully evaluated pricr to testing in order to place the proper priorities on technologies with the greatest potential thereby avoiding a more arbitrary selection of alternatives without allowing the necessary time to evaluate the possible adverse implications and future consequences of that type of selection.

In addition to the technical and cost factors, there is a need to establish criteria for allowable, residual contaminant levels after restoration. Such criteria does not exist at this time. There is a joint effort to establish this criteria that has been initiated by USATHAMA, the Army Health Services Command and EPA. An attendant consideration is post-restoration monitoring. Requirements for monitoring are expected to vary with the different candidate technologies and will have a significant impact on which technolgy is ultimately selected for implementation.

In summary, we can say that the need for development of technology to restore Army industrial waste water lagoons and to address other Army pollution problems has been firmly established. A dedicated program to develop this technology has been initiated with planned goals and milestones. It is expected that this will be an expensive undertaking. USATHAMA's plan is to translate the dollar costs of technology development to dollar savings in actual restoration operations that implement the technology we develop.

SILRESIM: A HAZARDOUS WASTE CASE STUDY

John D. Tewhey
John E. Sevee
Ronald A. Lewis
Richard L. Fortin

PERKINS JORDAN, INC.

When the Silresim Chemical Corporation's chemical waste reclamation facility in Lowell, Massachusetts was abandoned in January 1978, about one million gallons of hazardous material were left behind in drum and bulk storage. The five-acre reclamation facility, established in 1971, had been accepting approximately three million gallons of oil wastes, solvents, chemical process wastes, plating wastes, heavy metal-containing sludges and other materials each year from Silresim Corporation clients. The facility was designed and licensed for the ultimate disposal or recycle of these chemical wastes. Site investigations conducted in 1977 revealed license violations; the license was revoked when Silresim declared bankruptcy later that year.

The Commonwealth of Massachusetts, Department of Environmental Quality Engineering (DEQE) initiated efforts to clean up the site and by September 1981 all stored materials had been removed. In October 1981, Perkins Jordan began a two-part study to characterize the nature and extent of soils and groundwater contamination caused by the hazardous materials and to recommend actions to remediate the contamination problem.

PART 1: THE HYDROGEOLOGIC INVESTIGATION

The site is located at the edge of an industrial area south of Lowell's central business district. The Lowell Connector, Boston and Maine Railroad tracks, River Meadow Brook, and several residential areas are all within close proximity to the site. To assess the extent of surface and subsurface contamination, investigations of the surficial soil, surface water, subsurface soil, and groundwater were conducted at both on-site and off-site locations.

Twelve backhoe dug test pits - eight located in on-site, high-use areas and four in adjacent surface runoff areas - were sampled for shallow soils analysis. Five borings were installed for deep soils exploration, one in the center of the site and four at various locations around the perimeter of the site.

A deep monitoring well was installed at each boring location and shallow wells were positioned at four borings. The monitoring wells served two purposes. The physical characteristics of the groundwater regimes were determined by means of in-situ permeability measurements and groundwater level measurements. The level and extent of chemical contamination in groundwater was determined by means of gas chromatography/mass spectroscopy (GC/MS) analyses of organic constituents.

Surficial soil samples were collected in or near the closer residential areas to assess the extent of airborne contaminant migration. Surface and groundwater samples were obtained from surrounding areas including the River Meadow Brook. A subsurface metal detection survey was also performed at the site to identify any underground storage tanks.

PART 2: LONG-TERM EFFECTS AND REMEDIAL ACTION

How will contamination affect the areas surrounding the site 10, 15, or 50 years from now? The second phase of Perkins Jordan's study was directed towards determining these long-term effects and recommending methods of inhibiting contaminant migration.

Mathematical models were used to predict future migration through air emissions and groundwater flow and discharge. The models were applied to three potential receptors of the contaminants: 1) the Lowell Iron and Steel plant, the closest occupied structure to the site in the path of groundwater flow; 2) the Robinson Street area, the only residential area within the anticipated bounds of the contaminated groundwater flow; and 3) the River Meadow Brook, which is the ultimate discharge area for groundwater flow from the Silresim site.

Five remedial conditions were considered: 1) "no action", 2) clay capping; 3) clay cap and slurry wall; 4) groundwater removal and treatment; and 5) soil excavation and removal. The groundwater and air transport models were used to evaluate each alternative remedial action in terms of the contamination levels that could be expected to reach the three receptors over the next century.

If no corrective action is taken at the site, the first evidence of contaminated groundwater (1 ppb) will reach the receptors in five, 20, and 27 years, respectively. Maximum contaminant levels (8 ppb) will arrive in 25, 75, and 90 years. These levels do not exceed OSHA air quality standards or EPA drinking water criteria. In addition, there are no known users of the groundwater along the contamination plume. Based on these factors, no remedial action is considered to be warranted to specifically reduce contamination via groundwater flow.

However, air emissions emanating from the contaminated soils and groundwater are a concern. The ability of the four remedial actions to reduce air emissions was evaluated based on the concentration levels and amount of exposure expected at each receptor. The cost of construction and/or operation of the four alternative remedial actions at three levels of implementation (20, 70, and 90 percent) and the duration of contaminant levels at the site were also evaluated in order to assess the effectiveness of the remedial schemes.

The clay cap and slurry wall, groundwater removal and treatment, and soil excavation and removal options each involve excavation which will aggravate air emissions. Clay capping alone was the most cost-effective, positive control option evaluated and was recommended for implementation in order to reduce the effects of contamination at the Silresim site. Air and groundwater monitoring were recommended in order to verify the findings obtained from air emissions and groundwater modeling.

THE RESULTS

The visual effects of contaminants in surface runoff were evident at the site itself: vegetation was dead or nonexistent and the soil was discolored and emitted an odor. Laboratory analyses of the surface soil, shallow subsurface soil, and groundwater samples collected during the study indicated that about 6,000 gallons of volatile organic compounds currently exist in the soil and groundwater beneath the Silresim site.

The zone of maximum soil contamination (1,000,000 ppb of volatile organic substances) is limited to on-site high use areas in the central portion of the site and along the northern perimeter. Maximum soils contamination levels were found at 10 feet or less below the surface. The zone of maximum groundwater contamination levels occurs at depths of 20 feet or less. The rate of horizontal groundwater flow beneath the Silresim site is approximately 15 feet per year. The direction of groundwater flow is toward the north.

The horizontal contamination plots for soils and groundwater indicate that subsurface contamination exists beyond the boundaries of the site to the north, in the direction of surface runoff and groundwater flow. Groundwater samples obtained from upgradient monitoring wells located south of the site show little or no evidence of contamination.

Most of the chemical contamination occurs in the shallow soils and groundwater: about eight percent of the waste volume is dissolved in the groundwater while 92 percent is held in the soils. Contamination levels in soil and groundwater decrease as distance from the site increases.

Dilution of chemical contaminants in groundwater occurs by means of dispersion through groundwater flow and molecular diffusion. Unless the contaminants are removed from the subsurface, or their movement is inhibited, they will continue to migrate away from the site, either in the form of air emissions from the soil or through groundwater flow.

The Air Force Installation Restoration Program and Technical Methods and Results of Confirmation Studies at Langley Air Force Base, Virginia

Jerry A. Steinberg, Ph.D., P.E.[1] and Gary Fishburn, Major, USAF[2]

1.0 INTRODUCTION

This presentation contains three principal sections. First, information concerning the Air Force Installation Restoration Program in general is given. Emphasis is placed on describing transition from Phase I investigations to conducting Phase II investigations by establishing a priority ranking of sites. Current technical work and levels of effort are also presented. Second, an overview of the Langley AFB Phase II investigation is given. Finally, several key aspects of the study are highlighted because of applicability to general installation restoration efforts.

2.0 THE AIR FORCE PROGRAM--STATUS AND DIRECTION

Phase I Installation Restoration Program investigations have identified over 400 sites at more than 20 installations where hazardous materials have been disposed in a manner which may result in environmental contamination.

Each site identified in the Record Search (Phase I) was rated to determine the potential for environmental contamination at the site. The rating system used was a modification of the JRB rating scheme developed for the EPA. The Air Force rating system was developed by representatives of the USAF (Occupational and Environmental Health Laboratory) OEHL, Engineering Services Center (AFESC), and the consulting firms of CH2M Hill and Engineering Science.

Numerical ratings ranging from 23 to 85 were obtained through application of this system to the identified sites. Ratings for each site represent potential degree of environmental hazard associated with each site and permit the Air Force to identify locations which should be promptly investigated to insure environmental contamination is not threatening

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(1) Dr. Steinberg is a Senior Staff Water Resources Engineer at Water and Research, Inc., Gainesville, Florida.

(2) Major Fishburn is Chief of the Water Quality Branch, OEHL, Brooks AFB, Texas.

public health and welfare. Ratings also insure that more serious concerns are addressed before sites with little potential for environmental contamination are investigated.

Ratings of sites are reviewed by Air Force officials and priorities are established for Phase II investigations. A summary of the ·esults of site ratings are presented below. Of the sites rated the median score was 48. The 90 percentile score was 67. This indicates that the top 10 percent of sites rated this value or higher.

The distribution of scores is shown in the histogram presented in Figure 1.

Top 40 sites identified included:

19 Landfills,
5 Spill Sites,
5 Chemical Disposal Areas,
3 Fire Training Areas,
2 POL Storage, and
6 Sludge Disposal Sites.

Experience in the use of the Air Force site rating methodology has led to modifications in the rating system employed. The USAF Hazard Assessment Rating Methodology (HARM) was presented at the American Society of Civil Engineers meeting in April 1982 in Las Vegas.

In August, 1981, $800,000 was made available for Phase II survey work at USAF facilities. At that point only four bases had completed Phase I Record Search investigations. Consequently, those four bases were selected for Phase II work. Bases selected were Langley AFB, Virginia, Griffiss AFB, New York, McClellan AFB, California, and Edwards AFB, California. Costs associated with these studies were Langley AFB (64K), Edwards (125K), Griffis (137K), and McClellan (474K). Average expenditure was 200K.

There are currently 66 installations identified on an Air Force priority listing. These bases must have Record Search investigations performed by 1985.

The entire Phase II effort is estimated to cost in excess of 20 million dollars. Initial studies are anticipated to cost more since more serious potential problems will be addressed first.

The actual procedures used to implement Phase II efforts are summarized in Figure 3.

3.0 OVERVIEW OF THE LANGLEY PHASE II STUDY

This Phase II--Field Confirmation Study of Langley Air Force Base, Virginia was conducted during the fall of 1981. The Phase I--Records

Search Study identified 12 areas of potential contamination. Phase II was designed to determine presence or absence of contamination at these areas and to assess potential for contaminant migration. A preliminary site visit was followed by sample site selection, monitor well installation, sample collection, laboratory analyses of soil and water samples, data assessment, and report preparation.

Figure 3 shows the base and the sites investigated.

Areas investigated include four former landfills, one septic tank area, one abandoned chemical leaching pit, four areas of possible fuel contamination, one transformer storage area, and one pesticide/herbicide storage area. Surface water, groundwater, and creek sediment sampling was conducted.

Monitor wells were finished in the water table aquifer which is composed of sand, silt, clay, and shell. Neither the water table aquifer nor the artesian aquifers are used for public water supply due to generally poor water quality. Movement of groundwater is predominently horizontal and toward the nearest surface water. Vertical movement of groundwater is limited by clay confining beds and by the upward hydraulic gradient in the artesian aquifers.

4.0 RELEVANCE OF THE LANGLEY STUDY TO INSTALLATION RESTORATION IN GENERAL

4.1 ROLE OF THE PRE-SURVEY

One purpose of performing a pre-survey for Phase II work is to familiarize the Phase II team (in many cases a contractor) with the base and environs. However, there is perhaps an even more important purpose: Recommendations of the Phase I study are carefully screened and considered.

This in no way is intended as a criticism of the professionals who complete Phase I. Rather, it underscores the advantages of bringing a second technical opinion to focus on the issues. Furthermore, the Phase II team approaches the situation from a different perspective--that of seeking confirmation of contamination and considering alternative restoration measures.

At Langley several aspects of work, as recommended in Phase I, were amended. Examples of modifications include:

1. Numbers of monitoring wells were reduced,
2. Depths of core samples were changed to cover the same total depth with fewer samples,
3. Surface water sampling were added, and
4. Water quality constituents were changed.

These modifications were made only after direct consultation with engineers and scientists who conducted Phase I work. The direct dialogue was facilitated by Air Force personnel, and it was especially easy in this case because both contractors are in Gainesville, Florida.

Another useful aspect of the presurvey is that it permitted first-hand scouting for any necessary subcontractors. At Langley, subcontractors included well borers and land surveyers.

4.2 DIFFICULTY DEFINING SITE BOUNDARIES

An important output of Phase I is definition and description of specific potential contamination sites. One relevant aspect is delimiting site boundaries. However, available information may not permit boundaries to be located, or worse, boundaries may be inaccurately defined.

At Langley, inability to precisely define limits of landfilling operations affected Phase II work. Figure 4 shows sampling sites in the vicinity of Landfill 10, Old Septic Tank #6, and some other sites. Two monitoring wells shown were eventually found to be sited within, instead of beyond, landfilled areas. Furthermore, one of these wells was installed for use as an upgradient, background water quality, well. In the lower center of the slide, Well P-8 is shown. While drilling this upgradient well for the Septic Tank, buried trash was encountered. Apparently, Landfill 10 extended this far to the south.

Well P-10, in the upper-left portion of the slide, was intended as a downgradient well for Landfill 10. Buried material was encountered while drilling it also.

Well P-7 was adopted as a substitute for P-8. Sampling showed no influence from Septic Tank #6 and it is further removed from Landfill 10 than Well P-8 is. An alternate location for P-10 was not established because the terrain closer to the creek was not accessable to the drilling rig.

4.3 DIFFICULTY WITH PETROLEUM ANALYSIS

Quantifying amounts of fuel substances in soils has proven to be a most difficult analytical task. Following careful quality control checks, apparently satisfactory gas chromatograph performance was found to be relatively inaccurate. There is some question regarding whether or not totally reliable methods exist to quantify past fuel contamination. Therefore, in general, such data generated during installation restoration work should be cautiously used.

At Langley, four areas of suspected fuel contamination were analyzed. Two cores were taken in each area and soil samples were taken at 2, 4, and 6 feet below land surface from each core. Two analytical procedures were utilized to measure the fuel content of these samples. The first procedure was to purge the sample at 80°C with nitrogen into a gas chromatograph (GC) and compare the response with known amounts of aviation gasoline, diesel fuel, and kerosene. The results of these tests did not correspond very well with subjective "nasal analyses." Also, on one sample which had a "fuel" odor, late eluting GC peaks were observed which were not characteristic of the reference materials. It was suspected that this analytical procedure may not be adequate to accurately detect "older" contamination since the more volatile components may have been lost over time. Consequently, a gravimetric procedure utilizing Freon extraction was utilized on these samples also. This procedure should have the advantage of detecting less volatile higher molecular weight compounds and the disadvantage that some volatile materials will be lost during the Freon evaporation step. In an effort to distinguish "fuels" from other organics in the soil, samples having higher concentrations of extractable organics were subjected to a silica gel cleanup. Silica gel should adsorb fatty acid-type materials and pass the "fuel" type organics. Results of recovery studies on kerosene and diesel fuel gave the following results:

	Percent Recovery	
	No Cleanup	Silica Gel Cleanup
Kerosene	36	20
Diesel	75	47

These results indicate that this procedure is capable of detecting these compounds but at relatively low recovery rates. Consequently, in analyzing the results it should be noted that actual concentrations may be somewhat higher than indicated by this test. No precise correction for low recovery can be made since the actual recovery rate for whatever material is present is not known.

In samples which showed detectable amounts of hydrocarbons, generally higher concentrations of hydrocarbons were detected by the Freon extraction procedure than by the GC procedure. However, much of this material was found to be of nonfuel origin, as indicated by the silica gel cleanup data.

4.4 SURFACE WATER SAMPLING INCLUDED IN CONFIRMATION WORK

As noted earlier, one amendment to the Phase I recommendations, was to add designated additional surface water sampling sites. This is significant because so much attention is given to potential subsurface contamination in the installation restoration program. Formally, pollutant transport via surface waters is included in the program, yet concerns for groundwater contamination clearly dominate.

At Langley, landfill proximity to two creeks suggested surface water sampling. During the presurvey, areas of standing water were found. These areas were suspected of being directly connected to the creek during periods of high flow. Therefore, they were sampled also.

In general, surface waters in the creek and in ponded areas did not show above-background pollutant levels.

4.5 ENCOUNTER OF UNEXPECTED CONTAMINATION

Surface water and sediment sampling in Tabbs Creek revealed no significant contamination from three landfills adjacent to it. This was indicated from data taken upstream of, at, and downstream of the landfills. Sampling data did indicate the presence of pollutant materials at one background sampling station. Although unexpected, careful analysis and data review led to an awareness of potentially important conditions different from typical background conditions. By maintaining close co-ordination among contractor, OEHL, and base environmental staff, this awareness was responded to quickly. Magnitude and extent of this additional problem are currently being investigated.

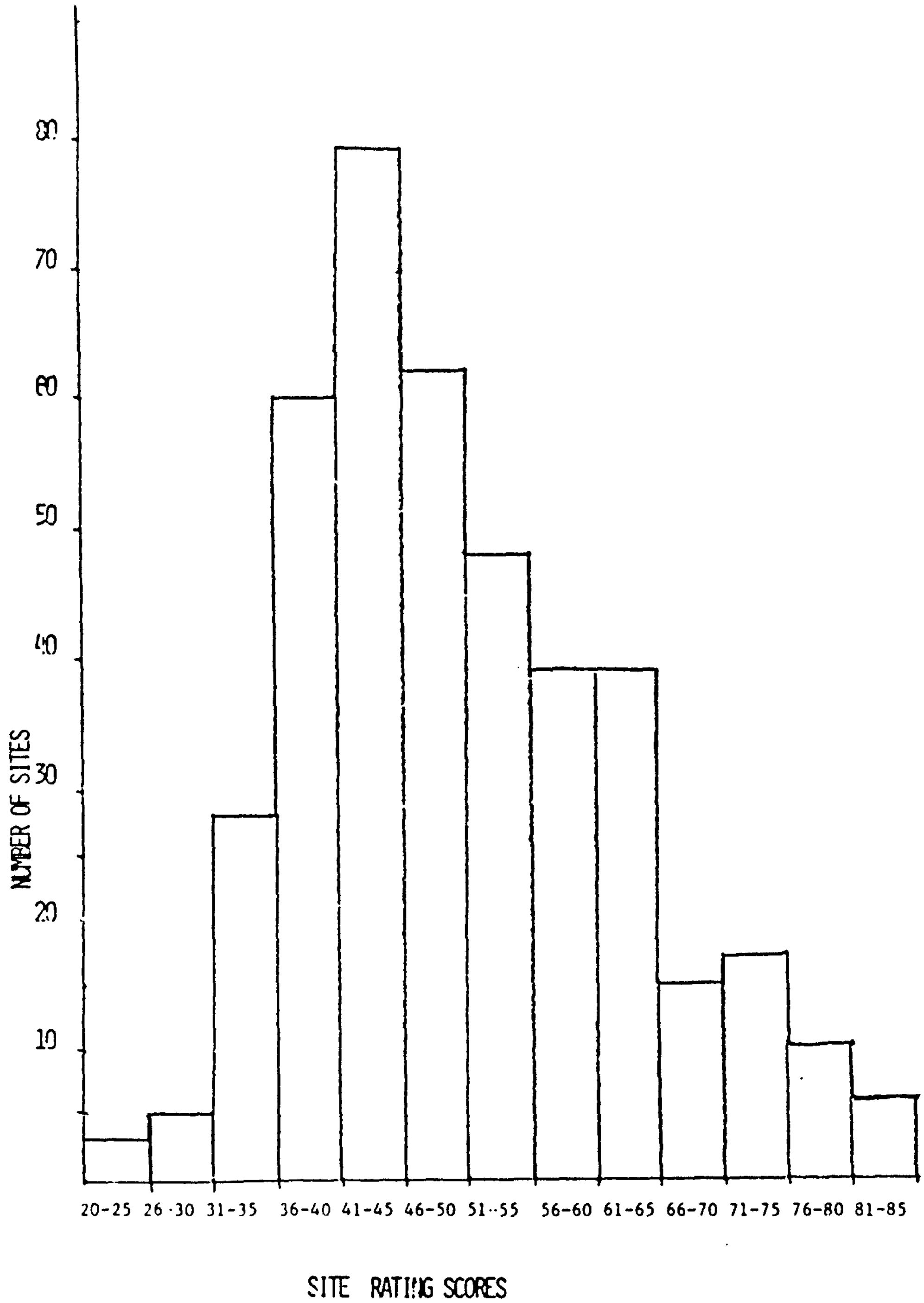


FIGURE 1. Installation Restoration Program Site Rating Summary

Receipt and Review of Phase I Records Search by Base, MAJCOM, AFESC OEHL, AFRCE and AIR STAFF.

MAJCOM/SG Prepares Coordinated Comments;

↓

OEHL Prepares SOW for Phase IIA, Preliminary Survey

↓

MAJCOM Coordinates on SOW

↓

OEHL Initiates Preliminary Survey with On-Call Contractor

↓

Contractor Performs Preliminary Survey and Prepares Cost Estimate

↓

MAJCOM/SG Evaluates and Coordinates Preliminary Survey Cost Estimate and Prioritizes Bases and/or Sites

↓

HQ AFMSC/SGPA Prepares Master Priority List for Phase IIB, Comprehensive Survey

↓

USAF OEHL Initiates Phase IIB Comprehensive Surveys for Funded Bases/Sites using Priority List

↓

Contractor Performs Comprehensive Survey and Prepares Reports. (MAJCOM/SG/DE and AFESC, Coordinate on any Implementation Decisions and Interim or Draft Reports.)

↓

USAF OEHL Reviews Final Report and Transmits It to MAJCOM/SG for Further Distribution

↓

MAJCOM/SG Completes Medical Survices Phase IIB Review and Transmits Final Report to MAJCOM/DE for PHASE III Consideration.

Figure 2. Installation Restoration Program Phase II Flow Diagram

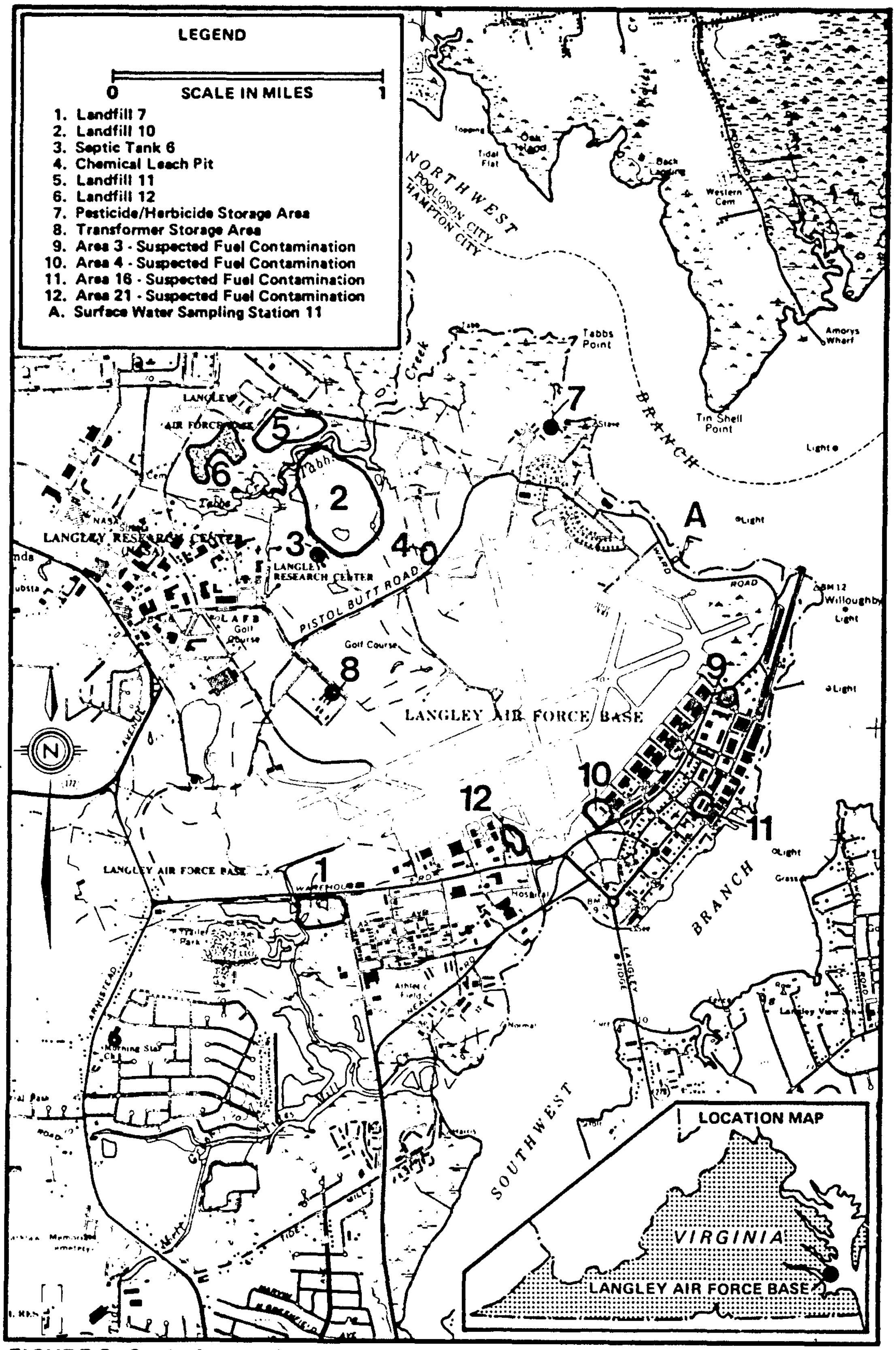


FIGURE 3. Study Areas at Langley Air Force Base, October 1981

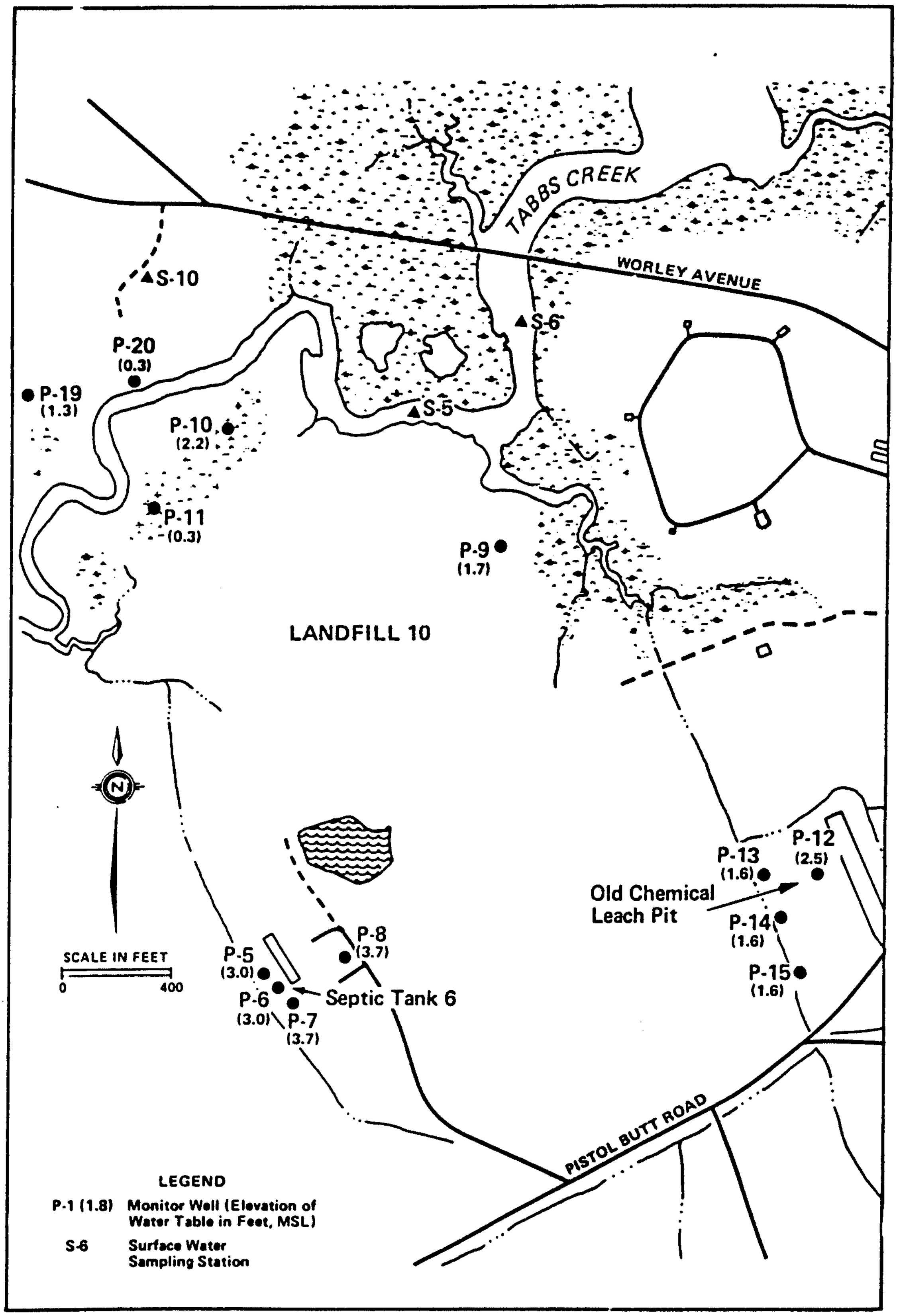


FIGURE 4. Monitor Wells and Surface Water Sampling Stations for Landfill 10, Septic Tank 6, and the Old Chemical Leaching Pit, Langley Air Force Base, October 1981

INSTALLATION RESTORATION PROGRAM AT ROCKY MOUNTAIN ARSENAL: A CASE STUDY

Donald L. Campbell
Marlene B. Lindhardt

US Army Toxic and Hazardous Materials Agency

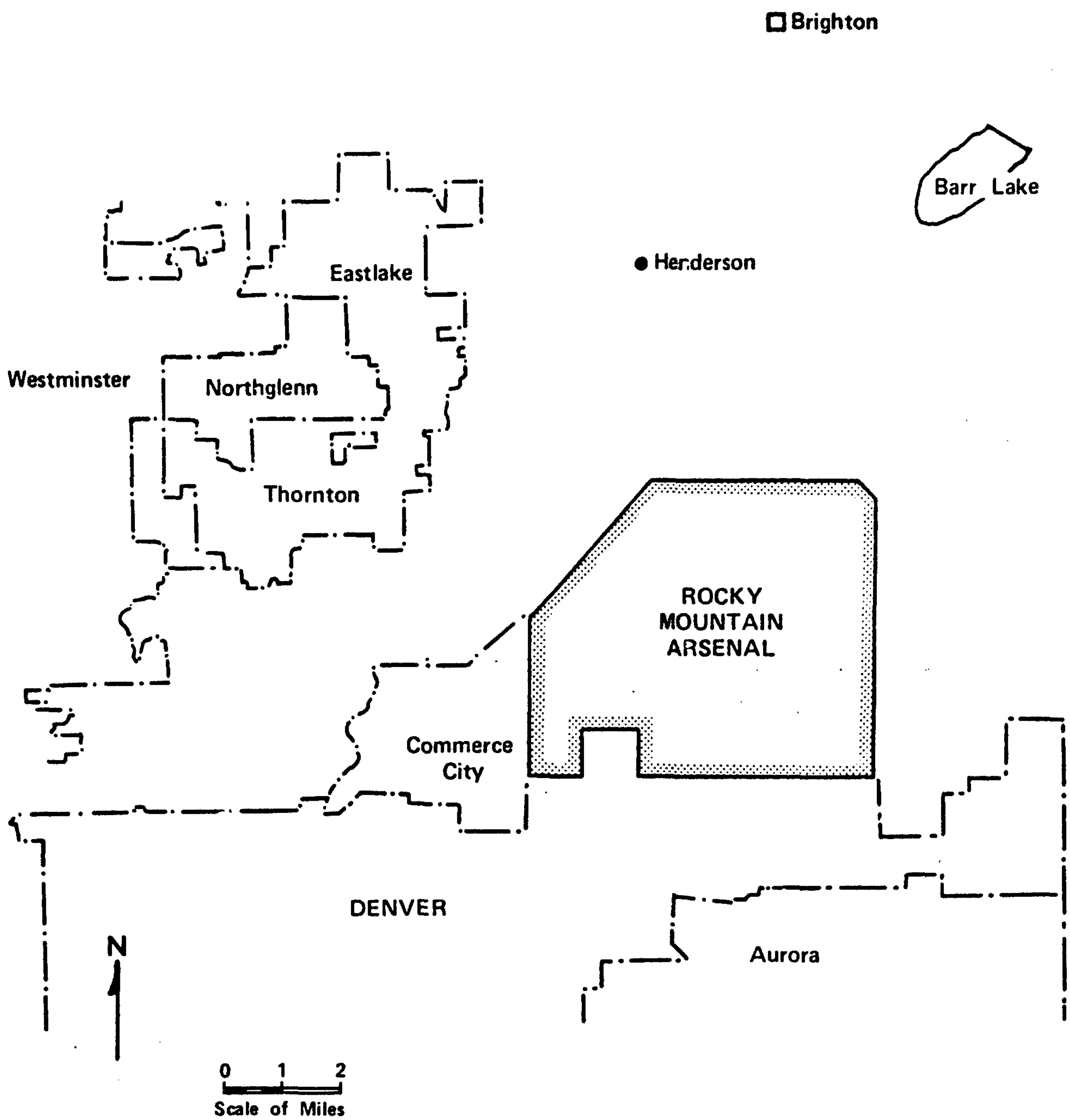
INTRODUCTION

This case study of the contamination control program at Rocky Mountain Arsenal (RMA) presents an overview of the site environment, a summary of the contamination problem at the arsenal and discussion of the ongoing program to define a final control strategy for RMA. Notable factors which indicate the singularity of the RMA-IR program include size, complexity and uniqueness of the project.

RMA is the largest and longest running Installation Restoration (IR) program with the Department of the Army. The project has been active within the US Army Toxic and Hazardous Materials Agency (USATHAMA) since 1976. To date, over $43 million has been spent to define the migration problems and provide limited remedial actions. Projected completion costs are in the range of $100 to $200 million. The program is nonpartisan in that it includes IR and RCRA remedial programs concerning contamination due to Army and lessee activities.

Data collection and analysis on the Arsenal has been extensive. Over 1,500 wells have been drilled on the 25 square mile site. An additional 200 wells are projected to be installed before the project is completed. 4,000 - 6,000 water and ecology analyses are completed each month. This is equivalent to a total of 270,000 sampling and analysis data points within the USATHAMA data management computer system. Currently there are over 900 technical reports in our RMA Information Center.

The complexity of the RMA-IR program is further compounded by the Arsenal's proximity to the City of Denver, residential suburban communities and Stapleton International Airport. This location creates extensive political visibility of the Army's plans for containment and/or cleanup of the site. A precedent setting memorandum of agreement is being prepared by the Colorado Department of Health, EPA Region VIII, Shell Chemical Company and the US Army to establish responsibilities and major milestones concerning the Army's CERCLA/Superfund response for RMA.



MAP OF RMA – DENVER VICINITY

USATHAMA has used an unique approach in dealing with these circumstances. A multi-organizational team of specialists has been established to carry out the problem definition and technology development efforts supporting the IR program at RMA. Personnel at the Arsenal, Corps of Engineers Waterways Experiment Station and numerous contractors have pooled their expertise to complete the RMA-IR program.

The background information provided here illustrates that the RMA-IR project is not typical of other USATHAMA surveys and that the degree of effort expended on this program is likely to be unnecessary at other contaminated sites. This contamination control program was initiated during a time period when groundwater containment and treatment technology was in its infancy. RMA has represented a test bed for research and development action for USATHAMA over the years. Changing environmental regulations during the preceding presidential administration necessitated shifting emphasis from arsenal boundaries to contaminant sources. President Reagan recently signed an executive order giving lead agency responsibility for the CERCLA response on RMA to the Department of Defense. This action may cause another shift in program emphasis.

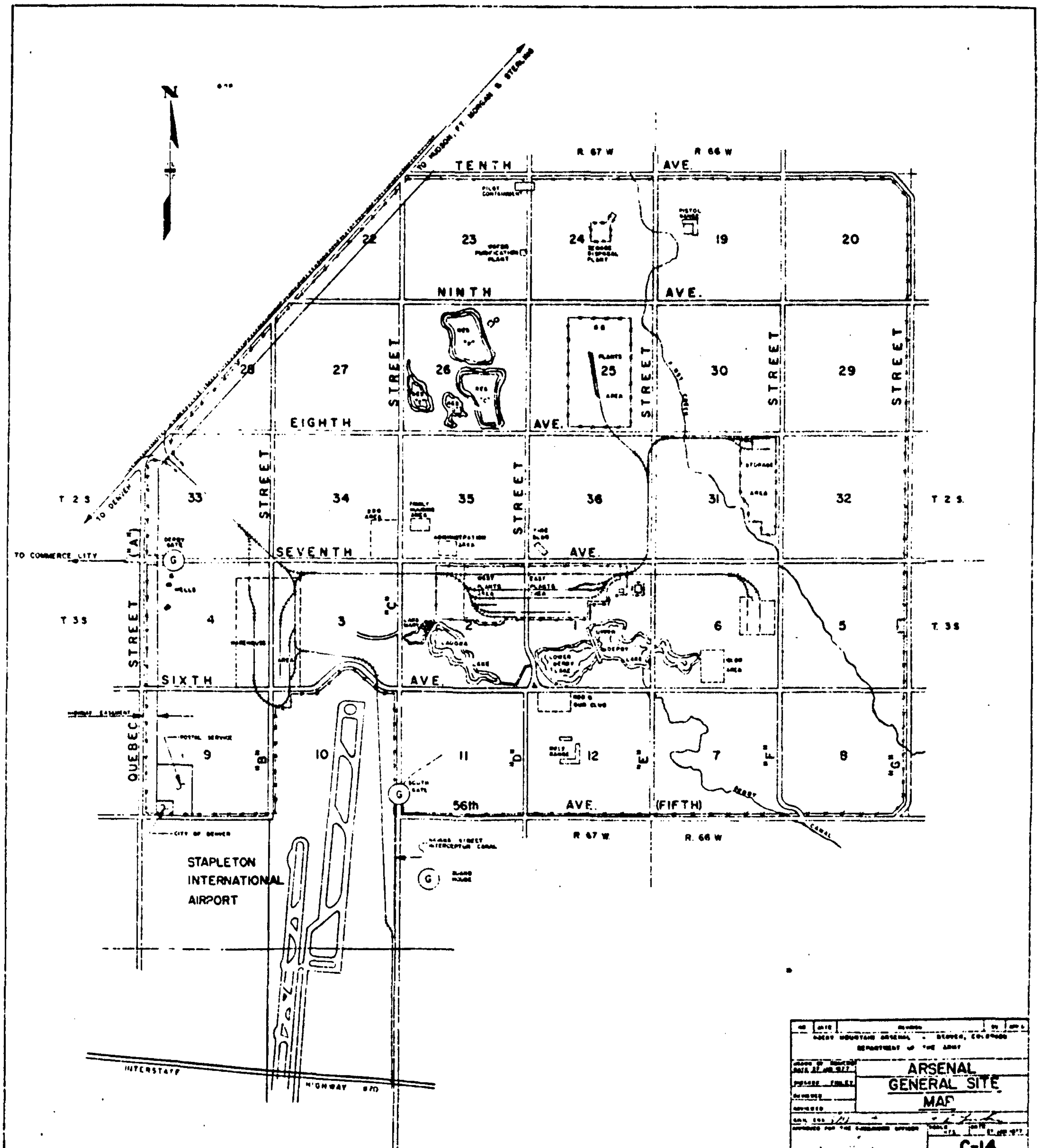
ENVIRONMENTAL SETTING

Rocky Mountain Arsenal is adjacent to the populated center of Denver, Colorado. Stapleton International Airport is directly south of the Arsenal. Land use around RMA is diverse as it is bounded by a light industrial complex to the southeast, the residential areas of Commerce City and Irondale to the west and northwest, and agricultural land to the north and east.

RMA encompasses 17,000 acres of gently rolling topography. Contamination is concentrated in the uppermost aquifer, the Pleistocene alluvial sand and gravel deposit. This aquifer is up to 100 feet thick at RMA and includes a buried stream channel which crosses the arsenal in the east to northwest direction. A minor amount of contaminants may also be found in the underlying Denver aquifer which is part of the Cretaceous-Tertiary Denver Formation. This formation consists of interbedded shale, claystone, siltstone and sandstone. These elements form a complex system of interconnected beds of permeable and relatively impermeabale sediments that have different capacities to store and transmit water. The thickness of the Denver aquifer varies from 250-400 feet under RMA. Outcrops of the formation are found on the Arsenal.

Groundwater flow under the Arsenal is generally from southeast to northwest. The alluvial aquifer discharges water downward into the Denver Formation. The potentiometric surface in the Denver aquifer provides the necessary hydraulic gradients for artesian conditions in some areas on the arsenal. For the most part, though, groundwater moves laterally through the Denver aquifer.

Surface water flow at the Arsenal is equally complex. Two major watersheds contribute to the hydrologic makeup, First Creek and Irondale Gulch. First Creek is a well defined channel on the eastern side of RMA. Due to the highly permeable nature of its bottom sands, continuous flow occurs only during periods of high rainfall. The Irondale Gulch is undefined and subject to change as surrounding areas are developed. Water in this drainage basin flows onto the Arsenal at various points then infiltrates, adding to the groundwater flow.


N
TO BRIGHTON, FT. MORGAN & STERLING
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STREET
EIGHTH
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32
T. 2 S.
TO DENVER
TO COMMERCE CITY
SEVENTH
AVE.
4
3
2
1
6
5
T. 3 S.
QUEBEC
"A"
SIXTH
AVE.
9
10
11
12
7
8
"B"
"C"
"D"
"E"
"F"
"G"
56th
AVE.
(FIFTH)
R. 67 W.
R. 66 W.
STAPLETON
INTERNATIONAL
AIRPORT
INTERSTATE
HIGHWAY 270
ARSENAL
GENERAL SITE
MAP
C-14

The primary areas of concern in the contamination control program are:

o The south plants area. Mustard operations were conducted in the past. Currently, Shell Chemical Company operates under a lease agreement.

o The north plants area. Nerve agent, GB, was manufactured and later demilitarized.

o Basins A through F. These basins were used at various times for disposal of liquid wastes from both Army and Shell Chemical operations.

o Sewer system. Lines connecting the plants areas are an additional concern due to probable leakage of wastes.

The south plants area was constructed in 1942 to produce the blister agents mustard and lewisite. Since 1952, a major portion of the facilities in this area have been leased to Shell Chemical Company and used for production of various agricultural chemicals. Liquid and solid wastes from both the south plants and north plants areas were deposited in the Basin A region from 1942 to 1957. This liquid basin is an unlined evaporation depression occupying approximately 200 acres and is situated directly north of the south plants area. Another major pollution source is Basin F which is northwest of Basin A. Constructed in 1956, it is an asphalt lined evaporation lagoon. Basin F encompasses 93 acres with a capacity of 240 million gallons. It currently holds approximately 50 million gallons of liquid wastes.

RMA-IR CONTAMINATION CONTROL PROGRAM

In 1975, US Army Toxic and Hazardous Materials Agency was assigned the resposibility for the RMA Installation Restoration program. The objectives of this program are to comply with state and federal regulations pertaining to discharging pollutants to the off post environment and to identify the sources where contamination has a potential to migrate. Major elements of the USATHAMA program are:

o Identify existing and potential pollutants.

o Identify the sources of these pollutants.

o Define necessary action to stop pollutant migration.

o Assure recommended actions fulfill regulatory requirements.

o Recommended and implement interim action when necessary.

o Implement recommended control actions to stop release of pollutants.

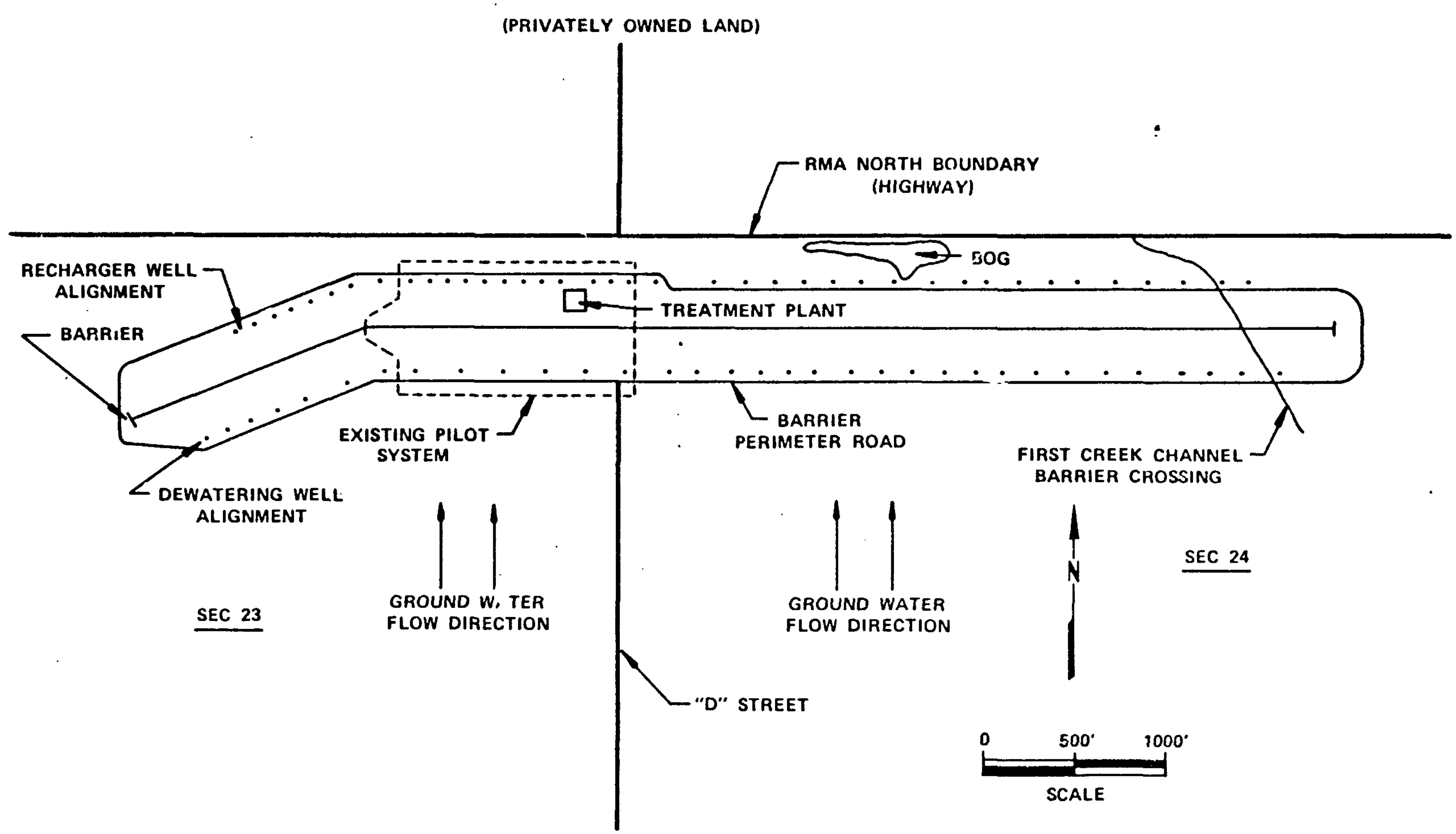
The initial effort to fulfill the program objectives was the implementation of a groundwater, surface water and ecological surveillance program to evaluate environmental quality both on and off the Arsenal. The State of Colorado, Shell Chemical Company and RMA all participated in this joint sampling and analysis 360° program. Results have demonstrated that contaminant migration off the Arsenal is limited to groundwater route.

Monitoring the alluvial aquifer through a series of geotechnical surveys which included well drilling, downhole geophysics and pump tests has resulted in the interpretation of possible migration pathways. This study established the direction of groundwater flow and that known contamination sites such as the south plants area, Basins A and F are situated over groundwater flow paths leading off the north and northwest boundaries.

Sampling and analysis of groundwater from numerous wells resulted in identification of pollutants of concern at RMA. The contaminants include diisopropylmethylphosphate (DIMP), a byproduct of nerve gas manufacture and dibromochloropropane (DBCP), an herbicide produced by Shell Chemical Company known as nemagon. Other pollutants of concern include aldrin, dieldrin, endrin, chloride, dicyclopentadiene (DCPD), dithiane, fluoride, isodrin and various sulpher compounds.

The contamination control development effort is being conducted on a priority basis. Primary importance was placed on the north boundary due to the magnitude of contamination moving off post and the proximity of private residences. Basin F is second priority because of the potential hazards to both humans and wildlife that have been associated with this last active lagoon on RMA and due to the lead time required to eliminate the waste currently stored in the basin. The northwest boundary has become a high priority since low levels of DBCP were found migrating off post into residential drinking wells. The final priority groups the source areas of the Arsenal including the Basin A/South Plants/Lower Lakes region. A hazards ranking system is being used to prioritize any other potential sources.

Identification of the north boundary problem necessitated technology development efforts consisting of laboratory and bench scale treatment studies and investigations to develop containment techniques for contaminated groundwater. The North Boundary Pilot Facility consisted of a 1,500-foot long, 30-foot deep bentonite barrier parallel to the Arsenal boundary. The system is anchored into bedrock at the base of the alluvial aquifer. Contaminated water is withdrawn upstream of the barrier, treated for removal of organic contaminants by a granular activated carbon system and reinjected downstream from the barrier. Since its inception, the pilot system has processed over 80 MG of water to meet or exceed drinking water guidelines. Based on the success of this pilot operation, the system was expanded in 1981 to intercept the entire contaminant plume crossing the north boundary of the Arsenal. The completed system is approximately 1.5 miles long and is treating 300-400 gallons per minute.



EXPANDED CONTAINMENT/TREATMENT SYSTEM FOR NORTH BOUNDARY OF RMA

Problems encountered at Basin F established the need for additional treatment technology development. As a first step towards closure of the basin, a RCRA site, construction is underway for an enhanced evaporation system to dry the remaining liquid wastes. Completion of these construction activities are projected for late summer 1982. The basin should approach dryness in 2-3 evaporation seasons. Contaminated sewer lines leading to the basin from the manufacturing complexes have been removed and deposited in a dry portion of Basin F. They will be temporarily stored there until a final closure strategy for Basin F is implemented.

Low levels of contaminants are now appearing in two separate locations along the northwest boundary. Shell Chemical Company has constructed a 1,500-foot hydrological interceptor/treatment system on Arsenal property near the Irondale community. The system is designed to control the isolated nemagon plume which apparently originates near the Arsenal railyard. In 1984, the Army plans to construct a 2,600-foot containment/treatment system further north which will intercept contaminants eminating from Basins A, C and F. Performance of both the expanded north boundary slurry trench and Shell's hydrological system is being monitored so that optimal design for this area can be defined.

Ongoing problem definition studies, including interpretation of historical aerial photography are oriented to assure that all contaminants and potential sources have been identified. In addition, these survey activities will provide the data on the extent and rate of contaminant migration. This data is required for the selection of an Arsenal-wide contamination control strategy within the current fiscal year.

The volume of the primary sources, conservatively estimated in excess of 100 million cubic yards of contaminated source material, has forced the program to address the contamination problem in the context of an overall Arsenal control strategy rather than individual source control efforts. Since potential source control actions would stress financial and technological resources, the overall control stragegy is necessary for economy of scale in contamination containment, treatment and/or removal. This strategy is the final objective of the ongoing source control study which utilizes the expertise of a group of government and industry specialists. They are working together to define the most feasible strategies for bringing RMA into compliance with applicable state and federal regulations. Based on Army plans for retention of the Arsenal, 14 control options have been identified with cost estimates at $100 to $200 million dollars. For comparison, these options for unrestricted release of the property are costed at $800 million to one billion dollars. The source control study is in its final phase and will result in the identification of a recommended strategy for final contamination control at RMA.

In summary, a major groundwater contamination problem exists at Rocky Mountain Arsenal. This problem is being addressed by extensive geotechnical surveys and technology development. A series of containment projects over the 1980-1987 time frame are being defined to program the construction needed to bring the Arsenal into compliance with applicabale state and federal regulations. Successful completion of these containment projects will provide for the ultimate control of groundwater contamination at RMA.

AQUIFER POLLUTION AT A STRATEGIC AIR COMMAND INSTALLATION - A CASE STUDY

Hugh M. Stirts
HQ SAC/DEVQ

ABSTRACT: Groundwater contamination is a widespread problem with potentially severe consequences. Several Strategic Air Command Installations have been involved in groundwater pollution situations, and one is currently subjected to litigation. Wurtsmith AFB, Michigan, has inadvertently polluted several area aquifers with the solvent trichloroethylene. Mode of contamination appears to be leaking underground storage tanks and fuel spills. Efforts to determine the magnitude of pollution have been extensive, with costs exceeding $1.8 million. Abatement procedures include purge pumping, air stripping, and carbon filtration. However abatement efforts and ultimate acceptable levels of contaminant are issues of contention between the Air Force and state. Estimates to effect clean-up vary from 3 to 11 years or longer, with costs approaching $15 million. Information concerning aquifer pollution and abatement is lacking, and our efforts are often trial and error. This results in increased costs, and exacerbates problems dealing with local and state governments. We are currently developing a program which will result in better pollution control methodologies and reduced costs.

Groundwater contamination is a widespread problem with potentially severe consequences. Although the Strategic Air Command makes conscientious efforts to use environmentally sound practices, we have been involved in a groundwater pollution situation at Wurtsmith AFB, Michigan. The polluting substance, Trichloroethylene (TCE), was utilized on base as a degreasing solvent. TCE is a volatile organic chemical, heavier than water and with limited water solubility. When introduced into a water column, TCE sinks to the bottom.

The National Cancer Institute has determined TCE is a carcinogen in mice; however, toxicity to aquatic wildlife is relatively low. On the Air Base, TCE was collected after use, stored in an underground tank and subsequently moved off base by a licensed hauler. In fall, 1977, a base housing resident complained of unusual taste and odor in his tap water. Analysis of this water indicated the presence of TCE in concentrations of 1100 ug/L. The Air Force, realizing the immediate concern was the health of base personnel, tested all potable water sources, and provided safe drinking water for those supplied by contaminated sources. In conjunction with this search, the base immediately began a systematic review of known TCE uses and locations. The review indicated a storage tank near an aircraft maintenance facility was the probable source. A physical inspection of the tank revealed a corroded filler pipe; the tank was removed, along with a large quantity of contaminated soil. The quantity of spilled TCE was estimated to range from 1800 to 4500 gallons, and the leakage time was in excess of 5 years. Initial investigations indicated 5 of 7 major water producing facilities were contaminated, and concentrations ranged from 20 to 6700 ppb (ug/L).

It was apparent we were now involved in a groundwater pollution situation of great magnitude, with little local or national expertise available. With short-term supplies of clean water now available, our next efforts were focused on determining the extent of contamination, to include effect on off base, private wells.

Following guidance provided by SAC Bioenvironmental Engineers and the USAF Occupational and Environmental Health Lab (OEHL), test wells were installed along the base perimeter. These wells indicated off-base migration of the contaminant was possible. US EPA and Michigan Department of Natural Resources (MDNR) were contacted in Jan 78. Meetings between these agencies and HQ SAC resulted in agreement that the base would install a TCE treatment system on an interim basis. In March 1978, the base began purging at 250 gpm. The purged water was mixed, aerated, and agitated during passage from a storage reservoir, channeled through the sanitary sewage lines and sewage treatment plant, and finally disposed in the existing seepage beds. Removal efficiencies were 75-85%, and were considered inadequate. Additional purge wells and aeration facilities were installed and removal efficiencies increased. TCE migration off-base appeared halted, and base officials were confident efforts were timely and effective in minimizing TCE migration.

However, in October 1978, MDNR filed a joint Notice of Noncompliance, citing the base for ineffective handling of the problem. Knowledge was still lacking in the area of groundwater pollution abatement, and we contracted with the US Geological Survey (USGS) to provide a three dimensional model of the groundwater hydrology, contamination plume, and an estimation of the pollutant direction and rate of movement. This project, costing $275,000, was completed July 81, and included construction of 200 deep and shallow sampling wells. Their investigation revealed several areas of contamination with the largest concentration near the jet engine test shop. This pollutant "plume" encompassed a triangular area 2900 feet long and 1200 feet wide at the base, 40 feet deep, and was migrating to the east and off base. Several additional wells were threatened, and other smaller areas of contamination in the aquifer had been identified. TCE concentrations were fluctuating, but by 1980, concentrations ranged from 500 to 1200 ppb.

The Air Force continued to purge contaminated water, and in 1979 several activated carbon units were installed. USGS recommended that a 1200 gpm capacity purge well system would provide most efficient abatement of the TCE pollution. We accepted this concept, and it was included in the Consent Decree negotiated between the Air Force and Michigan. We also developed a comprehensive groundwater monitoring plan to document TCE movement in the aquifer, and initiated procedures to cap and close the landfill which had received TCE contaminated material from various operations. This 1200 gpm purging system was completed March 82, and included 5 purge wells, 6 carbon filtration units, ancillary plumbing and piping, and 2 air stripping towers. The air strippers were developed under the supervision of the Air Force Engineering and Services Center (AFESC), and are undergoing a series of calibration and configuration experiments. Initial results indicate removal efficiencies approach 97% for the air stripping columns. After flowing through the air stripper, this water is then passed through activated carbon for final purification. The treated water is ultimately drained into the storm sewers.

Several areas of confusion or contention have developed. These include eventual fate of the purged and filtered water, and acceptable levels of TCE in the aquifer and the purged, filtered water. To date, there is no federally promulgated level for TCE in surface or ground waters. EPA has recommended a range from 4.5 to 45 ug/L depending on usage, the National Academy of Sciences has suggested 270 ug/L for transient populations (appropriate for military and civilian personnel on base), and the Air Force has determined a level of 45 ug/L will provide sufficient safeguards. Michigan has stated levels should not exceed 1.5 ug/L for both drinking and groundwaters. However, several other states have accepted higher concentrations in these waters; California has an "action level" of 5 ug/L, Pennsylvania has accepted 4.5, New Hampshire tolerates levels ranging from 10 to 20 ug/L, and the New Jersey Department of Environmental Health stated 100 ug/L was acceptable. We are presently treating the purged water to a level of less than 1.5 ug/L.

Time of purging is also a consideration. Estimates of time necessary to abate the polluted water range from 3 to 30 years. Operation of the purge wells will "stress" the system and provide a more accurate determination of pumping times. However, recent studies have indicated TCE may weakly sorb on inorganic soils. Should this occur, attempts to reach 1.5 ug/L concentrations in the aquifer may be futile.

The attendant costs for our abatement efforts have exceeded 1.8 million, and purging duration may increase these costs considerably. To date, we have installed a 1200 gpm capacity purge well system with activated carbon filtration and air stripping process, we have closed and capped a large landfill, established many sampling and monitoring wells, and are providing potable water to appropriate individuals. While the abatement procedures continue, and migration of the TCE plume near the jet engine building has been arrested, several questions still remain. What are acceptable levels of TCE in surface, ground, and drinking waters? To what levels should we purge, and to what uses can the filtered water be applied? Should the ultimate use of aquifer water determine pollutant levels, or should all aquifers be considered pristine?

We have accumulated considerable experience over the past 5 years in the areas of groundwater pollution, monitoring and abatement. A principle "lesson learned" is that preventing groundwater contamination whenever possible is of paramount importance. We have recently initiated procedures to identify all potential areas of pollution (eg. underground tanks, lines, and operations), and are investigating, in conjunction with the AFESC, methodologies to prevent contamination and effectively abate aquifer pollution when it occurs. We are committed to protecting the environment at our bases, and restoring those areas which have been impacted by our activities.

CONTRACTING FOR HAZARDOUS WASTE MANAGEMENT

Thadeus J. Zagrobelny
Naval Facilities Engineering Command

Richard Seraydarian
Western Division
Naval Facilities Engineering Command

The Resource Conservation and Recovery Act has established a national program for the management of hazardous wastes, requiring generators of wastes to ensure proper identification, packaging, collection, storage, transportation, treatement, and ultimate disposal. These requirements must be met by the U.S. Navy, just as any other industry must meet these rules.

Navy Public Works Centers (PWCs) were tasked in 1980 by the Chief of Naval Operations to provide area-wide hazardous waste services in addition to other services regularly provided to their customers. A limited number of billets were allocated to selected PWCs, enabling services to be provided with in-house forces. The remaining PWCs were directed to contract for these functions. This paper summarizes the development of a standard Performance Work Statement (PWS) for contract hazardous waste management and the first use of the standard PWS at the PWC, San Francisco Bay.

The Naval Facilities Engineering Command (NAVFAC) includes a headquarters in Alexandria and six regional Engineering Field Divisions (EFDs). The EFDs provide engineering support to all shore facilities. In addition, nine PWCs service approximately one third of the shore establishment, as well as ships homeported at those facilities. Where PWCs have not been established, Navy policy encourages individual activities to group together under a lead activity for managing hazardous wastes. In all other cases, activities must individually provide for hazardous waste management. Since several EFDs were being asked by PWCs and other activities for guidance in preparing hazardous waste management service contracts, NAVFAC Headquarters decided to develop a standard guide statement of work that could be tailored to fit site specific conditions.

Most service contracts may be either for a continuing contracting effort or conversion of services under the Commercial Activities (CA) program. Since providing Hazardous Waste Management services is a new start at most activities, CA program requirements do not apply. The standard PWS package consists of: a User's Guide, the Performance Work Statement, and the Quality Assurance Guide.

The User's Guide is designed to aid the Specification Writer in understanding how the standard PWS was developed, how to tailor it to meet specific activity needs, how to prepare for contract award, how to evaluate bid proposals and the importance of checking contractor performance.

The Performance Work Statement tells the Contractor what the Government wishes to procure, but not how to do the job. The standard Performance Work Statement is tailored by the individual user and then becomes the contract document.

This Performance Work Statement requests Hazardous Waste Management, that is providing the multitude of hazardous waste services required to meet the Environmental Protection Agency's hazardous waste regulations, not just the final disposal or incinceration of a waste. The types of work included under this contract include analytical laboratory identification, containerizing, transportation, warehousing, ultimate treatment or disposal, and all the associated recordkeeping and reporting. The final treatment or disposal methods could include recycling, re-use, neutralization, chemical fixation, chemical destruction, incineration, land farming, deep well injections, or burial. The PWS allows the Contractor maximum flexibility in choosing a technique to do the job. For example, the Contractor may opt for bulk collection of liquids in a tank truck in lieu of drumming the wastes. Either method would be allowable. The Contractor may also choose a type of disposal over another, such as recycling solvents instead of incineration. Again, either method is acceptable.

The Quality Assurance Guide was prepared to assist the User in implementing a surveillance program. This Guide provides the framework for the User to develop an individual activity Quality Assurance program. The User modifies and expands upon the "standard" Quality Assurance Guide as the standard SOW is tailored. It should also be noted that the PWS also requires the Contractor to establish an internal Quality Control program.

Although the Contractor should be given a great deal of latitude, the overall intent of this contract is to fully comply with Federal and State hazardous waste regulations. Quality Assurance must be tight to provide for total compliance with the regulations and to protect personnel and the environment. Since the Environmental Protection Agency's regulations literally allow no defects, the Quality Assurance plan must be equally strict.

By the Fall of 1980, NAVFAC realized that it would not be possible to staff all PWCs to provide the new services required by CNO, so NAVFAC decided to request that PWCs located in the San Francisco Bay area, Pensacola, Great Lakes, and Guam contract for hazardous waste management. In May 1980, the Defense Logistics Agency (DLA) was given a broad charter for hazardous materials disposal. The military services were required to dispose of eight selected categories of materials and collect, identify, package, and deliver all materials that were the DLA's responsibility. Since the DLA system for hazardous materials was not yet established with the necessary manpower and funding, NAVFAC decided to prepare a broad guideline contract that could fulfill the Navy's need as well as provide disposal for items that would later be transferred to the DLA.

The first meeting to develop the standard SOW package was held in December of 1980. Representatives from NAVFAC Headquarters, EFDs, and PWCs provided ideas on the various approaches that could be taken to procure Contractor services. From February to May 1981, draft portions were reviewed by the EFDs and PWCs. The final document was released by NAVFAC Headquarters in July 1981 and sent to field divisions for trial use. In addition to hard copy, field divisions received the package on word processor diskette. Copies have also been sent to other military services and the DLA.

The PWC, San Francisco Bay, was one of several PWCs designated by the Navy as coordinators for area-wide actions to comply with Federal, State and local requirements regarding the identification, generation, storage, transportation, treatment and disposal of hazardous wastes. The San Francisco Bay Area complex includes seven major Naval activities and their tenants, the Oakland Army Base, Coast Guard facilities, and ships that are homeported in the area. The area includes major industrial complexes, weapons storage, a medical center complex, deep water port facilities, supply facilities, and family housing.

In order to assess the needs of the customers, an ad hoc committee was established in October 1980. The committee, which convened bi-monthly, was designed to provide interim solutions to hazardous waste problems until the contract could be awarded and to assess the needs of each customer. One of the first actions taken was the development of a hazardous waste inventory. The inventory for each activity was to include not only the estimated annual generation rate for each type of waste, but also an estimate of the amount and type of waste that had been stockpiled over the years and would have to be disposed of via the contract. As a part of the survey, each activity was asked to provide, in addition to the generation rate, details on the location of the waste generation, the capacity for temporary storage, type of waste containerization, and the current disposal method. Approximately 45 different types of waste were identified including asbestos, solvents, plating wastes, industrial treatment sludges, polychlorinated biphenyl liquids and transformers, paint sludge, medical wastes, sandblasting grit, spent acids, and caustics. Individual generation rates ranged from about 100 gallons per year to over 250,000 gallons per year.

Once the inventory was completed, the local EFD, Western Division, was asked to prepare the contract package using the standard SOW package being prepared by NAVFAC Headquarters. Because of the wide variability in the type and quantity of wastes generated, it was ultimately decided to prepare an indefinite quantity contract. In September of 1981, an invitation for bids on a maintenance and service contract went out. A schedule of bid items was submitted by each bidder with a unit price for each bid item and the total bid item cost based on the government estimate of the quantity generated. The contract has a guaranteed minimum value of $100,000 and a maximum value of $1,000,000.

There were six responses received on the bid package ranging from about $250,000 to about $450,000. The contract was awarded in November 1981 to the IT Corporation of Martinez, California. The Contractor was not authorized to begin operations until December 1981. This was necessary to insure that all previous activity contracts for disposal of hazardous wastes either expired or had their minimum guarantees satisfied.

Although the contract was awarded by Western Division, it is being administered by the PWC San Francisco Bay. A PWC employee has been given responsibility for liaison between the generators and the Contractor personnel. A local instruction was developed to inform the customers of the appropriate procedures for arranging for Contractor services. A work order is written for each service request, specifying exactly which tasks have to be performed. The Contractor invoices the PWC for each work order, who in turn bills customers for the services. That portion of the cost for transportation to disposal and disposal is eligible for reimbursement from the DLA if the appropriate turn-in document (DD Form 1348-1) has been completed and signed by the Defense Property Disposal Office. There have already been several cases where the turn-in documents were not properly completed and disposal responsibilty remained with the waste producer.

In the first three months of operation, almost $500,000 has been spent. Approximately $300,000 of that needed to dispose of backlogs that were not identified in the original inventory. A large part of this cost involved analysis for unknown wastes and repackaging of the wastes for safe transportation to the disposal site.

Although the overall operation has been relatively smooth, there have been several deficiencies with the contract capability. The major problem is the lack of flexibilty to handle contingencies, such as:

a. Ability to handle new customers or wastes not specifically identified in the bid package,

b. Clean-up of hazardous material spills not caused by the Contractor,

c. Unrealisticly short Contractor response times.

The San Francisco Bay experience with contracting for hazardous waste services will continue to be closely monitored by NAVFAC Headquarters and Western Division. After additional experience at San Francisco, the standard PWS package will be reviewed, revised as needed, and issued as a NAVFAC specification.

SAFETY AND TRAINING FOR HAZARDOUS WASTE SITE INVESTIGATION/CLEAN-UP

Anthony A. Fuscaldo
Phoenix Safety Associates, LTD

A. Introduction

The problem of disposal of hazardous materials has been present for years. Unfortunately, the problem has been mishandled for years. Now, with the realization of the dangers posed to human health and the environment, the desire to rapidly correct the errors of the past has created an attitude which has the potential for us to equal or surpass previous levels of ineptitude. A rush to action, unimpeded by thought or planning, could cause serious damage to people, the environment and to the remedial program itself. This is not to advocate delay, but only to recommend that action be planned and rational. A primary concern in this area is the safety of the individuals involved in the investigation/ clean-up of hazardous waste sites, and of individuals who reside or work in the immediate area of the site. Proper training of all personnel involved with hazardous materials, combined with a comprehensive safety program directed by an experienced professional, will greatly reduce the potential for injury or property damage. The time and money invested in a safety program will be much less than the time and money lost in a major lawsuit. A serious injury may be beyond the capabilities of money to rectify.

Many accidents are caused by a lack of knowledge and a cavalier attitude on the part of the individuals involved. If the field personnel do not understand the serious toxic effects of these chemicals, the carcinogenic potential, the increased dangers resulting from chemical synergism, and the awesome effects of chemical fires and BLEVES (Boiling Liquid Expanding Vapor Explosions), then they are not going to be serious about preventing them. An effective safety program cannot operate without trained, responsible workers. Conversely, no matter how well trained the staff, a well designed, comprehensive, and carefully monitored site specific safety program is necessary to prevent accidents or to provide a rapid coherent response in the event an unavoidable incident does occur.

B. Hazard Description

There are a variety of dangers to which personnel involved with hazardous waste sites are exposed. These include: toxicity; fire; explosion; radiation; and physical accidents. It is beyond the scope of this paper to discuss methods involved in protecting personnel against these dangers; rather, it will just describe them to illustrate the breadth of the problem.

B.1. Toxicity

There are many ways to study the toxicity of chemicals. For this discussion, the routes of exposure will be mentioned and the biological effects will be superficially discussed. The other methods of classifying toxicity are not relevant to this presentation.

B.1.1 Routes of Exposure

There are three major routes of exposure: ingestion; respiration; and dermal exposure. The ingestion route should not be a factor since exposure by that route would involve bypassing all standard, common sense safety procedures. There is, however, a significant potential hazard to personnel via the respiratory and dermal routes. Prevention requires training in all phases of respiratory protection and the use of protective clothing

B.1.2 Biological Effects

Exposure to some chemicals can cause a variety of effects in man. Some of these are easily recognized while others are not. The effects to be discussed in this presentation are: acute; allergic; chronic; carcinogenic; mutagenic and teratogenic.

B.1.2.1 Acute Toxicity

This is the toxic effect that occurs after an exposure of short duration or a single brief exposure. In most cases, toxic reactions occur within a very short time after exposure. An exposure to 270 ppm of hydrogen cyanide gas is fatal within 6 to 8 minutes after inhalation. Other acutely toxic chemicals do not react as quickly. For example, the symptoms of nitroaniline exposure are insidious and may be delayed up to four hours following exposure. The individual usually feels well and has no complaints. If the exposure is high enough, the result could be collapse, coma, and even death. Therefore, the lack of immediate symptoms or signs such as dead animals around a site, does not necessarily mean that an acutely toxic chemical is not present. In the space of four hours an animal can be far from the scene of exposure.

B.1.2.2 Allergic Reactions

A chemical allergy is a reaction to a chemical resulting from a previous exposure to that chemical or a structurally similiar one. An allergic reaction is quite dangerous. The individual in question will show no reaction to the chemical on the first exposure. However, a subsequent exposure weeks or even years later can produce an allergic effect. The effect can involve various organ systems and range from a minor skin lesion to a fatal anaphylactic shock. There is no uniform dose response relationship which makes the TLV a meaningless figure in allergic reactions. The allergic response dose is usually significantly lower than the TLV for a given chemical.

B.1.2.3 Chronic Reaction

Chronic toxicity refers to an exposure of long duration. In other words, repeated or prolonged exposure. Repeated exposures to a chemical, even in small doses, can result in accumulation of the chemical and, eventually, a serious problem. An example of this would be dinitrocresol. Toxicity here is cumulative. Excretion in humans is quite slow, so it continues to accumulate until it reaches a level where damage is done. There is a specialized problem that should be discussed at this point. That is the problem of synergistic effect. An individual exposed to two unrelated toxic chemicals can experience a variety of effects. The simplest would be an additive effect. This is where the combined effect of the two chemicals is equal to the sum of the effect of each agent given alone (for example, 4 + 5 = 9). On the other hand, there could be a synergistic effect. Here, the combined effect of the two chemicals is much greater than the sum of the effect of each chemical alone (example 5 + 5 = 25). An example of this is carbon tetrachloride and methanol, two agents which individually injure the liver, but combined causes 5 to 10 times the degree of damage. Two chemicals do not have to be given simultaneously to cause the enhanced damage. Ethanol given 24 hours before a dose of carbon tetrachloride will increase the damage done by the carbon tetrachloride by a factor of 8. Another problem is the "potentiation" of chemicals. This is a situation where one substances does not have a toxic effect on a certain organ but when added to another chemical makes the latter more toxic. This is similar to the synergistic effect. An example of this is isopropenol which is not toxic to the liver and carbon tetrachloride which is. If the ispopropenol is given 24 hours before the carbon tetrachloride, the carbon tetrachloride is now 30 times more damaging to the liver then it was without the pre-exposure to isopropanol. For the most part, there have been very few studies done on the potentiation and the synergistic effect among chemicals. The wide variety of chemicals to which hazardous waste investigators are exposed will provide a significant opportunity for the "potentiation" or "synergistic" effect to occur. Due to a greatly increased potential for toxicity of various chemical combinations, it is necessary to be extremely conservative when attempting to apply TLV values to chemicals in the field. TLVs are only calculated for long term exposures to a single chemical, not to groups of chemicals.

B.1.2.4 Carcinogens

A carcinogen is a chemical which has the potential of inducing a cancer in man. The effect of a carcinogen, i.e., production of a cancer, normally occurs long after the exposure. An example of this would be lung cancer following exposure to asbestos. Studies here have shown that twenty to thirty years following asbestos exposure, there is a greatly increased rate of lung cancer among asbestos workers. Another example would be the use of chloromethyl ether (CME). Workers manufacturing this 30 years ago are now showing extremely high rates of lung cancer. A third example would be the chemical diethylstilbestol. This chemical had been used quite often in pregnant women to prevent miscarriages. Twenty to thirty years later a significant number of cases of vaginal and uterine cancer are occuring in females exposed to that chemical in utero. Carcinogens can also act synergistically. Preliminary studies show asbestos workers who are also cigarette smokers have lung cancer rates 8 times that which would have been expected from the simple additive effect of asbestos and cigarette smoking.

B.1.2.5 Mutagenic Chemicals

A large number of chemicals have been shown to be mutagenic. A mutogenic chemical causes changes in the genetic material (DNA) of the egg or the sperm thereby producing mutations in the fetuses produced by these eggs and sperm. In most cases, these mutations will be lethal and the fetus will abort quite early. In other cases there will be permanent changes in the offspring which they will then pass on to their offspring. It is quite important to realize that the male is as susceptible, if not more so, than the female is to mutagenic damage. In the female, all of the eggs that will be available for reproduction throughout her life are present at birth. These eggs are in a quiescent mode in the female. The DNA in an individual egg is inactive until such time as that egg is ready to be released from the ovary in order to be fertilized. The eggs in a female are therefore vulnerable to the mutagenic effect of physical agents such as x-rays and chemical agents which can act on non-replicating DNA. In the male, however, sperm cells are constantly being produced. Therefore, the DNA in a male sperm is constantly dividing. When the DNA is dividing it is sensitive to chemical attack by a greater number of chemicals than DNA that is not dividing. Therefore, the male is suseptible to genetic damage from x-rays, chemicals that attack resting DNA and chemicals that attack dividing DNA. An advantage the male has is that mature sperm cells, including any with defects, are periodically removed, so that genetic damage is usually transitory rather than long-term or permanent. However, all persons in their reproductive years must be cautious about the possibility of genetic damage.

B.1.2.6 Teratogenic Effects

Here we have a special case where only pregnant women are at risk. In the first trimester of pregnancy, a developing fetus is extremely sensitive to damage. Many things can cause defects in the fetus during this time period. Biological agents such as the virus causing German Measles in pregnant women have long been known to cause birth defects. However, it is now obvious that chemicals can also cause defects. A glaring example of this was the effect of thalidomide. There are now many thousands of young adults in Europe who were born without arms or legs due to the use of thalidomide by their mothers during pregnancy. It is incumbent upon any woman to know she is pregnant before going into the field on an investigation. It is also an important responsibility on her part to inform her superiors of this problem and be removed from any potential danger.

B.2 Explosives

The definition of explosives is "materials, which under certain conditions of temperature, shock or chemical action, can decompose rapidly to evolve either large volumes of gas or so much heat that the surrounding air is forced to expand very rapidly." An explosion is probably one of the most serious and acute hazards that can occur on a hazardous chemical site. It will, at worst, kill or permanently maim and, at best, probably frighten someone to near death. There are no protective devices such as respirators or rubber suits which we can use to protect ourselves from explosions. Therefore, an awareness of potentially explosive situations and careful, precisely controlled actions on the part of the field investigation team will be the difference between an uneventful site investigation and a fiery explosion. An explosive chemical can be detonated in a number of ways: heat; shock; and reaction with other chemicals. While investigating a hazardous waste site, it is possible that one will come upon a container of a high explosive which may or may not be not be properly labelled. It is therefore, important to monitor all containers of unknown liquids with an explosimeter to determine if a possibly explosive condition exists. However, it is also quite likely that an explosive situation can occur due to decomposition of stored chemicals, changes in the physical state of chemicals, or the reaction of different chemicals. There are many examples of each of these conditions. One common chemical that is shock sensitive is benzoyl peroxide. It is sold in paper bags because a threaded bottle cap can generate enough friction to detonate it. Ethers and other peroxidizable compounds can deteriorate in prolonged storage and form shock sensitive peroxides. Picric acid is a high explosive that becomes shock sensitive as well as heat sensitive if it dries to a point where it contains less than 10% moisture. Sodium Azide, commonly used as an antibacterial agent in solutions, can react with copper or lead to form compounds that are violently explosive from thermal or mechanical shock. There are many materials which react with water, steam or solutions containing water to evolve heat, flamable gases or explosive gases. Examples of these are metallic sodium, potassium, calcium and cobalt. It is possible, therefore, that a sudden rain shower in the vicinity of some freshly opened drums could create a holocaust. Another problem would be that acids and/or acid fumes can attack structural alloys and evolve hydrogen, a highly explosive gas. It is obvious from the preceeding comments, that one must be extremely aware of the explosive potential of all chemicals on a site. In light of the shock sensitive peroxides which can form from certain chemical compounds upon drying, one must be aware that even empty drums can be lethal. FIT members should, therefore, limit contact with drums to only that which is absolutely necessary to carry out the mission at hand. Furthermore, any contact that is necessary should be carried out in such a manner as to avoid sparks, friction, heat and shock.

B.3 Fire

Fire, combustion, or burning require four things: fuel; oxygen; critical temperature or heat; and free radical reactions. Fires can range from the rather simple and relatively slow combustion of papers to the fast burning and rapidly spreading combustion of organic solvents and occasionally to the explosive combustion of volatile gases or solids. The consequences of an uncontrolled, 30-minute fire in a solvent filled tissue processor in a biological laboratory caused $1 million in damages in 1976 and required the evacuation of patients from a nine story hospital in which the laboratory was housed. If it is possible to identify the chemicals before entering a site, then it is possible to obtain enough information to prevent a fire from occuring. This information would iclude the flash point, i.e., the lowest temperature at which a liquid will give off enough flammable vapor at or near its surface so a spark can ignite it, or the auto ignition temperature which is the temperature at which the material will self ignite and sustain combustion in the absence of a spark or flame. However, in many cases, it will not be possible to identify the chemicals, so it is wise to always assume worst case and act accordingly to avoid igniting a fire. Normally fires are divided into various classes. These include class A fires which contain ordinary combustible materials, class B fires which contain flammable liquids such as oils, gasoline solvents, etc., Class C fires which occur in energized electrical equipment; and Class D fires which consist of combustible metals such as lithium, magnesium, sodium and potassium. In order to combat any type of fire requires the right equipment and sufficient training. A fire at a hazardous waste site is exceedingly dangerous due to the large volumes of unknown chemicals which could be potentially flammable or even explosive. Since, for the most part, FIT teams do not have the training, expertise, equipment, or knowledge of the prevailing conditions and compounds to effectively fight a fire, the most prudent course of action would be to withdraw to a safe area, and, if requested, provide information to local firefighters concerning possible toxic effects.

B.4 Radiation

The effects of radiation on the human body are varied and dose related. Extrememly high doses (20,000 rems) can cause death within one day. Slightly lower doses (2,000 rems) can cause death within a couple of weeks. Lower doses (below 400 rems) will probably not cause death immediately, but will cause a number of other problems. Low level or repeated low level exposure to ionizing radiation is the problem of most immediate concern to field investigation team members. The delayed effect of radiation in mammals fall in three categories: an accelerated aging process; a specific carcinogenic process; or a mutogenic event. The accelerated aging process is not well understood. In general, it seems to represent a mammalian system dying of old age before its time. This type of effect on the mammal is miminal when compared to the other two. Sources of radiation which are external to the body have been shown to be responsible for a dramatic increase in skin cancers and leukemias. Radioactive material which has been taken into the body poses an even greater danger. In this case you will have a low level radiation source incorporated into a cell or organ of the body. This cell and surrounding cells will now be continually bombarded by radiation. If the material is inhaled and deposits in the lung, and it may lead to an increased likelihood of lung cancer. If the radioactive material tends to locate in a particular organ, that organ now becomes extremely suseptible to a cancerous transformation. An example is radium ingested by persons who painted watch dials with radium so the watches would glow in the dark. These workers have a greatly increased potential for bone cancer. Once inside the body, many isotopes are difficult to remove. In fact, removal is often impractical, dangerous, or impossible to accomplish. The effects of different levels of single whole body doses of radiation are shown in Table 1. It must be remembered that radioactive damage is cumulative. That means that the effects of radiation exposure does not go away with time. The effect is permanent and the next radiation exposure adds to it.

B.5. Physical Accidents and Illnesses

In addition to the job related hazards discussed above, one must stillconsider the possibility of "ordinary" accidents, and illnesses. When on site one must be prepared to deal with a variety of events such as:

B.5.1. Physical Accidents - cuts, bruises, broken arms or legs, burns, foreign objects in the eye, concussions, electrical shock, bleeding, water hazards etc.

B.5.2. Illnesses - Heat stroke, heat exhaustion, shock, heart attack, stroke, cold exposure, stings, bites, allergic reactions etc.

C. Training Programs

Personnel involved with hazardous waste site activities require a variety of interdisciplinary skills. A training program must be designed to train inexperienced personnel in the overall concepts, principles and procedures of hazardous waste site reconnaissance, investigation and remedial action.

It should be structured to offer a balance between the theoretical and practical with lectures and "hands on" field excercises. After completion, attendees should understand the basic principles of personnel protection and safety; should be able to perform hazardous waste site activities in a safe and organized manner; should understand how to utilize state-of-the-art monitoring and sampling techniques to characterize the site; and understand the problems associated with the remedial actions necessary to restore the site to its original uncontaminated condition.

The course topics should include at a minimum: toxicology; protective clothing; respiratory protection; decontamination; safety plan development and implementation; emergency preparedness; evacuation techniques; field strategies; communications; remote survey techniques; ambient air characterization; field sampling; remedial action approaches; and first aid/CPR.

The respiratory protection portion of the course should be at least six to eight hours in duration and fulfill the requirements of 29 CFR 1910.134. Personnel who potentially are exposed to respiratory hazards must use a variety of equipment in order to provide optimum respiratory protection and still allow for the most efficient use of manpower. The course should provide instruction in basic respiratory protection along with training in the use of emergency escape packs, air purifying respirators and self contained breathing apparatus. It would be quite effective to pattern the course on the one that the USEPA utilizes in providing respiratory training for its personnel. The day is divided into a three hour lecture/demonstration on the use and limitations of various types of equipment, a two hour workshop on self contained breathing apparatus and a two hour field exercise.

The course should also include a "fit test" on each individual to assure that the masks being used are adequate to protect that individual from respiratory hazards. Upon completion of the respiratory protection training, the attendee sould be able to effectively perform required tasks while maintaining maximum safety in a hazardous environment.

An important part of the standard program is a section on instrumentation techniques. This portion of the presentation should prepare the personnel to utilize basic air monitoring equipment. Upon completion of the training program the personnel should also be proficient in First Aid, one and two person CPR, safety plan preparation/implementation, and emergency procedures.

It would be useful to give a select group of the field personnel an advanced instrumentation course. The course structure should offer a balance among the lecture room, the laboratory and the field, with a performance test designed to assess operator proficiency. The emphasis should be on utilizing instrumentation to quantitate site hazards; to determine levels of personnel protection; to monitor the effect of hazardous waste site activities on the surrounding community and to collect data for assessing the environmental hazard caused by the site. Students should, at a minimum, learn the operation of the following instruments: combustible gas detector; oxygen level indicator; portable photoionization detector; portable gas chromatograph; colorimetric tubes and collection media/air sampling pumps.

D. The Safety Plan

The use of a site safety plan is absolutely necessary. The preparation of this plan serves a multitude of purposes. In order to complete the plan and make the necessary evaluations, the site leader and the safety officer must institute a thorough study of the known information about the site. The safety plans include a number of important factors concerning the investigation. It names member of the work team and their specific duties on the site. The plan designates all of the equipment necessary to adequately insure the safety of the investigation team members and serves as a checklist to insure that all of the equipment is brought to the site. It serves as a ready reference for emergency information needed by the team. The information includes the name and phone number of the nearest hospital, the nearest ambulance service, the fire and police departments and any other persons or organizations needed to contend with an emergency at that facility. Finally, it has been shown to be quite useful if a detailed work plan is attached to the safety plan. A thorough understanding of what is to be done, the sequence in which it is to be done, and the individual responsible for doing it, helps avoid confusion, assures that important details are not overlooked, and helps prevent accidents.

E. Summary

Proper training of persons involved with hazardous materials is essential to safety. There are a variety of training programs available which can be presented in one to five days depending upon the needs of the students. These include the "hands on" courses for the technical personnel and the lecture/theory presentations for management. Safety planning is necessary for all onsite operations, including decontamination of personnel and equipment following site work. The investment in a proper safety program is a mere fraction of the cost of suffering to employees or bystanders from an accident or the time and dollars lost due to that accident.

Ranking System for Releases of Hazardous Substances

Kris W. Barrett
S. Steven Chang
The MITRE Corporation

Steve Caldwell
U.S. Environmental Protection Agency
Office of Emergency and Remedial Response

INTRODUCTION

In recent years, hundreds of incidents involving hazardous substances have occurred in the United States, including rail and barge spills, hazardous waste explosions, direct contact poisonings, food crop contamination, toxic air pollution, as well as ground and surface water contamination. The Environmental Protection Agency (EPA) has identified over 10,000 inactive hazardous waste sites, many of which continue to threaten the public. In addition, thousands of hazardous substance spills occur each year. A number of major rivers have become contaminated with persistent toxic pollutants, often due to poor waste handling practices long since discontinued. The large number of problems and the high costs of investigation and cleanup activities have forced those public agencies responsible for hazardous substances programs to set priorities for response. In general, this has been done at the State level, largely on the basis of professional judgment. This paper describes the status of a system currently under development for setting priorities for remedial actions to address hazardous substances releases.

In passing the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Congress recognized the need for a systematic approach to setting priorities. CERCLA Section 105(8) requires the President to include criteria for setting priorities among releases and potential releases of hazardous substances as a part of the National Contingency Plan. The criteria are to take into account population at risk, the nature of the hazardous substances, the potential for contaminating drinking water supplies, the potential for direct human contact, potential for destruction of sensitive ecosystems, State preparedness, and other appropriate factors. In addition, the Act requires the States to apply these criteria to establish priorities for remedial actions at facilities and submit them to the President. The President must then establish a National Priority List of at least 400 facilities based on the criteria and taking into consideration the States' priorities. The National Priority List is to be used in selecting the most serious hazardous substance problems for remedial action.

In response to the program needs and legal requirements for a system for setting priorities, EPA along with the MITRE Corporation undertook development of a method for ranking facilities according to risks to health and the environment. The objectives of the project are as follows:

- To develop a system for ranking facilities according to risks.

- To develop a system that would give consistent results when applied by various user organizations.

- To develop a system that could be applied by the States, with the results then used by EPA to form a national priorities list.

Several other considerations were important in shaping the development of the system. Since approximately 400 out of thousands of facilities are to be listed, the system should discriminate most accurately among the very worst problems. In the course of developing a list of at least 400, as many as several thousand facilities might be evaluated using the criteria; thus, costs to collect data and apply the criteria are a major concern. In practice that means that accuracy in results has been balanced against costs of data collection. Finally, from the outset the EPA established the general policy that public health consideration would outweigh environmental effects.

GENERAL APPROACH

Ideally, in order to evaluate the harm to public health and environment for the priorities list, investigators would simply measure all effects and convert them to some common denominator (e.g., dollars). In addition, where effects have not already happened, the potential for harm would be expressed as a quantitative risk assessment; for example, one might predict the number of increased cancers in a given population. Unfortunately, demonstration of health effects due to exposure to harmful substances is extremely costly, if not generally infeasible. Likewise, EPA studies indicate that precise quantitative risk assessments of hazardous waste facilities are not generally feasible due to uncertainties surrounding the health effects of mixtures of chemicals and the difficulties of accurately predicting migration of ground water contaminants[1]. Finally, even assuming the technical ability to perform such analyses, the costs would be entirely too high to warrant their use in implementing CERCLA. A simpler system is required.

Three existing general approaches to setting priorities were then identified: classification systems; judgment by "experts"; and scoring systems. Classification systems, used by several State and local agencies, have the distinct disadvantage that in order to be useful in setting priorities, every member of one class must be higher in the distinguishing characteristics (risk) than every member of the next lower class. The variety and combinations of hazardous substance problem types is not amenable to reduction to such a classification sytem. Judgment by "experts" has been the most widely used approach to setting priorities, and within a single organization may be the best approach. However, it is doubtful that such an approach would be consistently applied from State to State. Perhaps even more importantly, while such a system might accurately rank facilities within a State or region, it offers no mechanism for merging results from all States to create a National Priorities List. A scoring system of some sort was deemed the most desirable approach.

REVIEW OF EXISTING APPROACHES

Several models have been developed for rating the relative hazard to public health and the environment posed by various hazardous substance facilities. These include the LeGrand and Surface Impoundment Assessment (SIA) models, the EPA Solid and Hazardous Waste Research Division (SHWRD) Predictive Method (SPM), and the Rating Methodology Model. The first two of these are concerned only with ground water contamination, whereas the SPM might be applicable to a variety of routes and the Rating Methodology Model addresses both ground and surface water contamination. The characteristics of these models are outlined in the following sections.

The LeGrand Model[2]

The LeGrand Model describes the potential for contamination of water wells by waste disposal sources. The final rating reflects the potential hazard of the wastes, the likelihood of the wastes reaching the ground water, and the vulnerability of the ground water to contamination. However, the model does not address air or surface water pollution problems.

The Surface Impoundment Assessment (SIA) Model[3]

The SIA Model expands on the scope of the LeGrand Model to evaluate the potential threat of contamination to ground water itself, rather than the potential threat of contamination of wells. However, the model does not address surface water pollution, air pollution or other types of risks caused by hazardous substances.

The SIA Model has been adapted in a modified form by the State of Michigan Department of Natural Resources to rank hazardous waste sites within the State. The toxicity factor has been revised, and factors have been added for considering the number and proximity of drinking water wells and of people using these wells in the immediate proximity of the site.

SHWRD Predictive Method[4]

The SHWRD Predictive Method involves the application of multivariate analysis to perform two functions:

- Evaluate the relative importance of various rating factors (e.g., distance to ground water).
- Classify sites into 2 or more categories as to their potential for an impact (e.g., 3 categories such as "good", "minimal", and "bad", according to compliance with accepted environmental standards).

Classifying facilities into a number of classes would probably not provide adequate discrimination among them to effectively implement the priority list requirements of CERCLA. In addition, constructing a representative mathematical function resembling a regression equation to deal with multiple routes and an infinite classification (i.e., no pre-established cut-off points) would require more information than would generally be available at each facility. The approach of the method might be very useful in refining rating factors and weights once a number of sites have been scored and data on the sites is available for multivariate analysis.

The Rating Methodology Model[5]

The Rating Methodology Model was developed primarily to assess landfills, surface impoundments and other types of land-based storage and disposal facilities for the purpose of setting priorities for technical investigations. The hazard is rated in terms of four general areas:

- receptors
- pathways
- waste characteristics
- waste management practices

"Receptors" are humans and other living beings and their environment that may be affected adversely by the hazardous wastes. "Pathways" are the routes or media (e.g., ground water, air) that the waste is likely to traverse in reaching the receptors. "Waste characteristics" are the hazardous properties of the waste including mobility, toxicity, and ignitability. "Waste management practices" refers to the designs and procedures that have been used in managing and containing the waste.

Thirty-one factors were identified as a means of rating, on a scale of 0 to 3, the potential contribution of the four areas of the overall hazard. If factors do not apply to a specific site or cannot be evaluated due to lack of data, they may be omitted. Alternatively, extra factors may be added to account for special considerations that are not addressed by the 31 factors. A fixed multiplier associated with each factor serves to weight that factor's relative importance. The final score is obtained by adding the products of all the factors and their corresponding multipliers and by normalizing the result on a scale of 0 to 100.

The State of New Jersey Department of Environmental Protection has adopted the Rating Methodology Model and converted it into a classification system. All of the sites in the State are grouped into one of three priority classes, and there is no distinction drawn within each class when assigning the remedial action priority to a site.

Hazard Ranking System

The Hazard Ranking System is a scoring system designed to address the full range of problems resulting from releases of hazardous substances. Unlike the four approaches previously discussed, it is designed to address surface water, air, fire and explosion, and direct contact, in addition to ground water contamination. The system applies a structured value analysis approach, similar to the Rating Methodology Model. Three migration routes of exposure, ground water, surface water, and air, are evaluated and their scores are combined to derive a score representing the relative risk posed by the facility. Two additional routes of exposure, fire and explosion and direct contact, are measures of the need for emergency response.

The system differs from the Rating Methodology Model primarily in that the routes are scored independently and the dependent nature of the variables is reflected by multiplying where appropriate rather than simply adding. Also, unlike the Ranking Methodology Model, the Hazard Ranking System was designed specifically for the purpose of ranking facilities for remedial action. The system therefore requires a greater amount of more detailed information.

Description

Application of the Hazard Ranking System results in three scores for a hazardous waste facility. One score, S_M, reflects the potential for harm to humans or the environment as a result of migration of a hazardous substance away from the facility by routes involving ground water, surface water or air. S_M is a composite of separate scores for each of the three routes. Another score, S_{FE}, reflects the potential for harm from materials that can explode or cause fires. The third, S_{DC}, reflects the potential for harm as a result of direct human contact with hazardous materials at the facility (i.e., no migration need be involved).

The score for each hazard mode (migration, fire and explosion and direct contact) or route is obtained by considering a set of factors that characterize the hazardous potential of the facility. A comprehensive listing of factors for all of the hazard modes is given in Table 1.

Each factor is assigned a numerical value (generally on a scale of 0 to 3, 5 or 8) according to prescribed guidelines. This value is then multiplied by a weighting factor yielding the factor score. The factor scores are then combined by following established guidelines; scores within a factor category are additive, but the factor category scores are multiplicative.

In computing S_{FE} or S_{DC}, or an individual migration route score, the product of its factor category scores is divided by the maximum value the product can have, and the resulting ratio is multiplied by 100, thus normalizing scores to a 100-point scale.

Computation of S_M is slightly more complex since S_M is a composite of the scores for the three possible routes: ground water (S_{gw}), surface water (S_{sw}) and air (S_a). S_M is obtained from the equation:

$$S_M = \frac{1}{1.73} \sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$$

The factor 1/1.73 arises from the vector addition of the three route scores after the individual scores are normalized to a common denominator. This means of combining them gives added weight to routes with higher scores.

The Hazard Ranking System does not result in quantitative estimates of the probability of harm from a facility, or the magnitude of the harm that could result. It is a device for rank-ordering facilities in terms of the potential hazard they present. Risks are generally considered to be a function of the probability of an event occurring and the magnitude or severity should the event occur. Applying this approach to hazardous substance facilities, the probability and magnitude of a release are generally functions of the following areas:

- the manner in which the hazardous material is contained,
- the route by which its release would occur,
- the characteristics of the harmful substance,
- the amount of hazardous substance, and
- the likely targets.

These areas have been examined, and representative factors were chosen to address each.

The scoring guidelines for each factor and the weight accorded to each factor were developed based on judgment initially. The weights and guidelines were then adjusted based on tests using data from 43 facilities.

Using the Hazard Ranking System

Use of the Hazard Ranking System requires considerable information about the facility, its hazardous substances content, its surroundings for distances up to three miles, and the geological character of the area down to the depth of aquifers that may be at risk. Complete data may not be available and the individual assigning scores may have to use some judgment in applying the guidance provided. Geology, hydrology, chemistry and the ecological sciences are the most relevant disciplines and scoring is best accomplished using a team of individuals knowledgeable in these disciplines. Figure 1, gives a format for recording general information regarding the facility being evaluated. It can also serve as a cover sheet for the work sheets used in the evaluation. Sample work sheets are shown in Figures 2 through 7.

Where data for a factor are unavailable, the factor should be assigned a value of zero. However, if the factor for which the data are missing is the only factor in a category (e.g., containment or waste quantity), then the factor is given a score of 1. If data are lacking for more than one factor in connection with the evaluation of S_{gw}, S_{sw}, S_a, S_{FE} or S_{DC}, that score is automatically set at zero.

Detailed instructions and guidance are provided in the guidance manual for using the Hazard Ranking System. As mentioned previously, if sufficient data are available, three scores are computed, S_M, S_{FE} and S_{DC}; S_M being a composite of separate scores for three release routes: ground water, surface water and air. It is this composite migration score that is used to rank facilities for remedial action priorities.

SYSTEM TESTING

The equations and factors described above were settled on after a comprehensive review and selective testing was performed on previous drafts. The review included EPA regional personnel, contractors and industry representatives. Major anomalies were pointed out, particularly in the case of a city of 50,000 population with a threatened drinking water supply and a composite migration score of 28. The results of preliminary testing are shown in Figure 8. The ideal distribution for maximum discrimination is a straight line with a slope of 1.0. The preliminary data was skewed toward the higher values because the 45 test facilities were not chosen randomly, but were generally those sites considered "bad" by the EPA regional offices. This trend would be expected even under ideal conditions since it is unlikely that individuals would spend time and money to score facilities that are apparently a very low priority.

A sensitivity analysis was done to analyze the sensitivity of the final ranking score to changes in individual factor scores. This analysis showed that the hazardous waste quantity score had the greatest effect on the final ranking score. A change of 1 point in a factor value could, under worst case, effect the final score by 5.7%. The sensitivity analysis assumed that individuals assigning values according to the guidelines would not err more than 1 point on any factor.

As a result of the review comments received, the preliminary test results and the sensitivity analysis, major changes were made in the original Hazard Ranking System. Among these were:

- elimination of fire and explosion and direct contact as routes to be considered for facility ranking
- a reduction in the number of factors

- revision of the population factors to increase the system sensitivity to human populations

- revision of the hazardous waste quantity factor

FUTURE DEVELOPMENT

Development and testing of the system is continuing, and some revision is expected prior to implementing the National Priorities List of 400 facilities. Areas of development include:

- cost of securing data
- anomalies
- testing
- quality assurance

The cost of securing data is of concern because of the quantity of detailed sampling and analysis that is required to score a facility. A method is needed to screen sites before spending funds to collect extensive data for a site that will not rank above a given level.

Anomalies, facilities that have extreme characteristics outside the scope of the system will occur regardless of the complexity or detail required by the Hazard Ranking System. Where a class of anomalies can be identified, the system can be modified to more accurately rank facilities according to risk.

Field testing is required to measure the ability of the system to discriminate and rank sites with independent judgment. A method has been proposed to use an independent panel of experts to rank a selected group of sites and then compare these results with the Hazard Ranking System scores. The two ranking lists would then be analyzed for a statistical correlation.

Quality assurance is necessary to ensure that there is consistency in the application of the Hazard Ranking System among the individuals assigning scores.

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TABLE 1

COMPREHENSIVE LIST OF RATING FACTORS

HAZARD MODE	FACTOR CATEGORY	FACTORS: Ground Water Route	FACTORS: Surface Water Route	FACTORS: Air Route
Migration	Containment	• Containment	• Containment	
	Route Characteristics	• Depth to aquifer of concern • Net precipitation • Permeability of unsaturated zone	• Site slope and intervening terrain • 1 Year 24 hour rainfall • Distance to nearest surface water • Flood potential	
	Waste Characteristics	• Physical State • Persistence • Toxicity	• Physical State • Persistence • Toxicity	• Volatility/Physical State • Reactivity • Incompatibility • Toxicity
	Hazardous Waste Quantity	• Total waste quantity	• Total waste quantity	• Total waste quantity
	Targets	• Ground water use • Distance to nearest well down gradient • Population served by ground water drawn with 3 mile radius	• Surface water use • Distance to a sensitive environment • Population served by surface water drawn within 3 mile radius	• Distance to nearest human population • Population within 1 mile radius • Distance to sensitive environment • Land use
Fire and Explosion	Containment	• Containment		
	Waste Characteristics	• Direct evidence of ignitibility or explosivity • Ignitibility • Reactivity • Incompatibility		
	Hazardous Waste Quantity	• Total waste quantity		
	Targets	• Distance to nearest human population • Distance to nearest building • Distance to sensitive environment • Land use • Population within 2 mile radius • Number of buildings within 2 mile radius		
Direct Contact	Accessibility	• Accessibility		
	Containment	• Containment		
	Waste Characteristics	• Toxicity		
	Targets	• Population within a 1 mile radius • Distance to a critical habitat		

Facility Name: ______________________
Location: ______________________
EPA Region: ______________________
Person(s) in Charge of the Facility: ______________________
____
____
Name of Reviewer: ______________________
General Description of the Facility
(For example: landfill, surface impoundment, pile, container; types of wastes; location of the site; contamination route of major concern; types of information needed for rating; agency action, etc.)
____
Scores: S_M = (S_{gw} = + S_{sw} = + S_a =)
S_{fe} =
S_{dc} =

Figure 1

MODEL COVER SHEET

GROUNDWATER ROUTE WORKSHEET				
Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max. Score
[1] Observed Release	0 45	1		45
If observed release is given a score of 45, proceed to line [4]. If observed release is given a score of 0, proceed to line [2].				
[2] Route Characteristics				
Depth to aquifer of concern	0 1 2 3	2		6
Net Precipitation	0 1 2 3	1		3
Permeability of unsaturated zone	0 1 2 3	2		6
Total Route Characteristics Score				15
[3] Containment	0 1 2 3	1		3
[4] Waste Characteristics				
Physical State	0 1 2 3	1		3
Persistence	0 1 2 3	2		6
Toxicity	0 1 2 3	2		6
Total Waste Characteristics Score				15
[5] Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8
[6] Targets				
Groundwater use	0 1 2 3	3		9
Distance to nearest well downgradient	0 1 2 3	3		9
Population served	0 1 2 3 4 5	6		30
Total Targets Score				48
[7] If line [1] is 45, multiply [1] x [4] x [5] x [6]; If line [1] is 0, multiply [2] x [3] x [4] x [5] x [6]				259,200
[8] Divide [7] by 259,200 and multiply by 100			S_{gw} =	

Figure 2

SURFACE WATER ROUTE WORK SHEET				
Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max Score
[1] Observed Release	0 45	1		45
If observed release is given a value of 45, proceed to line [4]. If observed release is given a value of 0, proceed to line [2].				
[2] Route Characteristics				
Site Slope and Intervening Terrain	0 1 2 3	1		3
1-yr 24-hr. Rainfall	0 1 2 3	1		3
Distance to Nearest Surface Water	0 1 2 3	1		3
Flood Potential	0 1 2 3	2		6
Total Route Characteristics Score				15
[3] Containment	0 1 2 3	1		3
[4] Waste Characteristics				
Physical State	0 1 2 3	1		3
Persistence	0 1 2 3	2		6
Toxicity	0 1 2 3	2		6
Total Waste Characteristics Score				15
[5] Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8
[6] Targets				
Surface Water Use	0 1 2 3	3		9
Distance to a Sensitive Environment	0 1 2 3	2		6
Population Served	0 1 2 3 4 5	6		30
Total Targets Score				45
[7] If line [1] is 45, multiply [1] x [4] x [5] x [6]; If line [1] is 0, multiply [2] x [3] x [4] x [5] x [6]				243,000
[8] Divide [7] by 243,000 and multiply by 100			S_{sw} =	

Figure 3

AIR ROUTE WORK SHEET				
Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max. Score
[1] Observed Release	0 45	1 1		45
If line [1] is 0, then S_a = 0. Enter on line [6]. If line [1] is 45, then proceed to line [2].				
[2] Volatility/physical State	0 1 2 3	1 1		3
Reactivity	0 1 2 3	1 1		3
Incompatibility	0 1 2 3	1 1		3
Toxicity	0 1 2 3	2 2		6
Total Waste Characteristics Score				15
[3] Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8
[4] Distance to Nearest Human Population	0 1 2 3	2		6
Population Within 1-Mile Radius	0 1 2 3 4 5	5		25
Distance to Sensitive Environment	0 1 2 3	2		6
Land Use	0 1 2 3	1		3
Total Targets Score				40
[5] Multiply [1] x [2] x [3] x [4]				216,000
[6] Divide [5] by 216,000 and multiply by 100			S_a =	

Figure 4

	S	S^2
Groundwater Route Score (S_{gw})		
Surface Water Route Score (S_{sw})		
Air Route Score (S_a)	//////	
$S_{gw}^2 + S_{sw}^2 + S_a^2$	//////	
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$	//////	
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2} / 1.73$	//////	$S_M =$

WORKSHEET FOR COMPUTING S_M

Figure 5

FIRE AND EXPLOSION WORKSHEET				
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score
1 Containment	1 3	1		3
2 Waste Characteristics				
Direct Evidence	0 3	1		3
Ignitability	0 1 2 3	1		3
Reactivity	0 1 2 3	1		3
Incompatibility	0 1 2 3	1		3
Total Waste Characteristics Score				12
3 Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8
4 Targets				
Distance to Nearest Population	0 1 2 3 4 5	1		5
Distance to Nearest Building	0 1 2 3	1		3
Distance to Sensitive Environment	0 1 2 3	1		3
Land Use	0 1 2 3	1		3
Population Within 2 Mile Radius	0 1 2 3 4 5	1		5
Buildings Within 2 Mile Radius	0 1 2 3 4 5	1		5
Total Targets Score				24
5 Multiply 1 x 2 x 3 x 4				6912
6 Divide 5 by 6912 and multiply by 100			$S_{fe} =$	

Figure 6

DIRECT CONTACT WORKSHEET				
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score
1 Observed Incident	0 45	1		45
If line 1 is 45, proceed to line 4 If line 1 is 0, proceed to line 2				
2 Route Characteristics Accessibility	0 1 2 3	1		3
3 Containment	0 15	1		15
4 Waste Characteristics Toxicity	0 1 2 3	5		15
5 Targets				
Population within a 1-mile radius	0 1 2 3 4 5	4		20
Distance to a critical habitat	0 1 2 3	4		12
Total Targets Score				32
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5				21,600
7 Divide line 6 by 21,600 and multiply by 100			$S_{dc} =$	

Figure 7

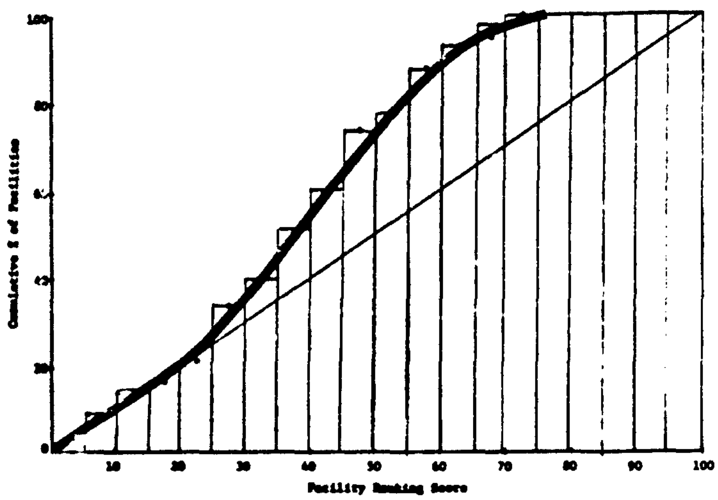

Figure 8

Frequency Distribution of Facility Ranking Scores for 43 Preliminary Test Facilities (April 1981)

NAVY ASSESSMENT AND CONTROL OF INSTALLATION POLLUTANT (NAICP) CONFIRMATION STUDY RANKING MODEL

Elizabeth B. Luecker
Civil Engineers, U.S. Navy

Background

With the passage of "Superfund," or CERCLA, in December 1980, the need for a systematic approach toward the cleanup of old hazardous waste disposal sites became apparent. The Department of Defense (DOD), anticipating "Superfund," established the Installation Restoration (IR) program. The Navy's part of this program is the Navy Assessment and Control of Installation Pollutants (NACIP) program.

The NACIP program consists of three phases: (1) Initial Assessment Study (IAS), (2) Confirmation, and (3) Corrective Measures. One of the most important steps in the program is the decision to go from the IAS, based on record searches, interviews, and minimal sampling, to the Confirmation Study, which involves extensive sampling. Another aspect of proceeding to Confirmation from the IAS is the IR program requirement to "develop and maintain a priority listing of contaminated installations and facilities for remedial action" (DEQPPM 81-5, 11 December 1981).

Over time, several other reasons for using a ranking model have developed in addition to the IR requirement of a priority listing. Because the Navy and all of DOD are an extremely vulnerable target for protests of all types, a defendable criterion for recommending or not recommending further study was needed. Standard guidelines were needed to rate sites Navywide, so that a minimum amount of grumbling would be heard from the local activities. This Navywide rating was also needed to establish funding priorities.

A new ranking system was developed, rather than using an existing ranking model, because of a combination of Navy and DOD unique problems. One of these was the difficulty in sufficiently differentiating sites on one base. Many bases, due to their age and location, have a large number of potential sites with essentially the same basic hydrogeology. Because of this, the pathways must be more site specific than most models. This large number of sites per base also has a wide range of waste types--everything from oil and ordnance to plating, paints, and pesticides. Another problem was the need to show a definite standard reasoning for dropping sites from further study. Many of the existing models also require detailed sampling data; little or no data of this type is available for most of the Navy sites. Last, because the Navy's model would be used in-house and by at least five different contractors, it had to be as simple and straightforward as possible. As a result, a two-step decision process has been designed specifically for the NACIP program.

Description

The first step is a "yes-no" flowchart based on easily determined facts found during the IAS. These facts include type of waste, type of containment (spills, ponds, dumps, barrels, etc.), and hydrogeology. The flowchart tells whether to go to the Confirmation phase, to consider immediate mitigating action, such as restricting access to the site, or to do nothing if the site is basically innocuous. If the flowchart indicates that the Confirmation phase should be implemented, the user proceeds to step two.

In step two, the site is given a numerical ranking by going through the Confirmation Study Rating (CSR) Model. Ranking is also based on information obtained during the IAS and is the "priority listing" of sites. The model is based on the system used by the Air Force, which in turn is based on a model developed for EPA by JRB Associates.

As with these previous models, the CSR Model assesses the different characteristics of each hazardous waste site including areas of potential impact or possible receptors of contamination, pathways that the contamination may take to reach the receptors, and waste characteristics and containment. Each of these categories contains several weighted rating factors as shown in Table 1. The factors are used to calculate a category subscore. These category subscores are then used to calculate the overall hazard rating.

The receptors rating is based on the JRB Model and is calculated by scoring each factor, multiplying by a weighting constant, and adding the weighted scores to obtain a total score for the receptors category.

The pathways rating is taken from the Air Force Hazard Assessment Rating Methodology (HARM) model. This rating is based on direct evidence of contamination migration, or on one of three pathways with the highest contamination migration potential. If direct evidence of contamination exists, the pathways category is given a subscore of 1. If no evidence is found, the highest score from three possible pathways is used. The pathways are surface water migration, flooding, and ground water migration.

The waste characteristics category is similar in format to the receptors category. The waste characteristics rating is obtained by scoring each factor, multiplying by a weighting constant, then multiplying and adding these weighted factors as indicated to obtain a total score for the category. An unusual aspect of this model is that the waste quantity score is based on 40 CFR 117 (Reportable Spill Quantities); and that the quantity is then multiplied by other Waste Characteristics before the category is scored. The CSR Model differs from the other two models mentioned due to differences in the waste characteristics section, and minor changes in the other sections. The major difference, however, lies in the final scoring of the sites. These previous models have based their rankings on the idea that factors, such as pathways of possible migration, location of receptors, and waste characteristics are additive as indicated by the formula:

$$U_{site} = \sum_{i=1}^{n} \left[k_i U_i (x_i) \right]$$

$$= Up + Ur + Uw$$

Ui = the Rating factor (1.0 is the worst, 0.0 is the best condition)

Up = the total Pathways factor

Ur = the total Receptors factor

Uw = the total Waste Characteristics factor

k = weighing constant = 1 in this instance

U_{site} = the score or rating of the site

TABLE 1

List of Rating Factors

Category	Rating Factor
Receptors	o Population within 1000 ft of site o Distance to nearest down gradient well o Land use/zoning within 1 mile radius o Distance to reservation boundary o Critical Environments within 1 mile radius o Water quality/use of nearest surface water body o Ground water use of the aquifer of concern o Population served by surface water supply within 3 miles downstream o Population served by ground water supply within 3 miles
Pathways	o Direct Evidence of Contamination

or

1--Surface Water Migration Potential,	2--Flooding Potential, or	3--Ground Water Migration Potential
o Distance to nearest down gradient surface water o Net precipitation o Surface erosion o Soil permeability o Rainfall intensity	o Floodplain	o Depth to ground water o Net precipitation o Soil permeability o Subsurface flows o Direct access to ground water

Category	Rating Factor
Waste Characteristics	o Waste Quantity o Acute Toxicity o Chronic Toxicity o Persistency o Flammability o Reactivity o Incompatibility o Corrosiveness o Solubility o Bioaccumulation o Physical State o Years site was in use o Years since site closed
Waste Management	o Waste Containment

This additive model is only theoretically correct if the factors considered (Pathways, Receptors, and Waste Characteristics) are completely independent of one another. However, these factors are not independent of each other. For example, an innocuous waste such as paper (low Uw) may be found in an area that has a hydrogeology conducive to migration (high Up) and be close to a large population (high Ur). If this site somehow slips into the above rating model, it will have a high priority due to the Up and Ur.

The CSR Model uses instead a multiplicative approach as indicated by the formula:

$$U_{site} = k\left[\prod_{i=1}^{n} Kk_i(1-U_i)+1)-1\right]$$

$$= (Ur)(Up)(Uw)$$

This formula reflects the dependent nature of the factors involved. These formulas have been included to show the mathematical approach to the rating problem. The multiplicative approach is rescaled from 0 to 100 and used in the CSR Model as:

$$U_{site} = 100\ (Ur)(Up)(Uw)$$

This score is then multiplied by a waste management or containment factor. However, in most cases so far, there has been no effort at containment so that the factor for waste management is 1, and the U_{site} is actually the final score.

By using the multiplicative model, sites with a low UR, Up, or Uw, such as the site previously mentioned, will have a lower rating than would be expected using an additive model.

Use of the System

All sites found will be put through the Confirmation Study Ranking Flowchart This flowchart will tell the user to go to the CSR Model if further study is required. The CSR Model is divided into subsections or rating categories: I is Receptors, II is Pathways, III is Waste Characteristics, and IV is Waste Management and Final Score.

The Confirmation Study Ranking System was designed to use information readily available from interviews and records. The existing EPA models Models were designed to rank sites after a NACIP confirmation type of investigation. Because the purpose of the System is to rank sites before a full field investigation of sampling is done, this model differs from the models EPA has used. Ranking sites before the expensive Phase II is done will enable the Navy to investigate most cost effectively as soon as possible those sites that pose the greatest potential hazard.

References

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TECHNICAL AND ECONOMIC FACTORS THAT AFFECT THE SELECTION OF GROUNDWATER TREATMENT TECHNOLOGIES

Robert D. Allan, Charles S. Parmele
IT Enviroscience

I. INTRODUCTION

The problem of groundwater contamination has become the subject of a great deal of discussion in recent years. Efforts to protect groundwater from future contamination are being made through proper design of hazardous waste disposal facilities and monitoring of disposal and storage sites, but serious problems already exist and will require development of aquifer restoration programs.

In a recent article in Chemical Engineering magazine, EPA officials state that aquifer restoration can be done, but not at a reasonable cost.[1] It will have to be done in many cases, however, and the key to putting together a cost-effective aquifer restoration program is to have a clear understanding of each site's individual conditions, constraints, and options. The goal of this paper is to identify those parameters that are important in defining the goals of the cleanup operation and assessing the impacts of those parameters on the selection of an appropriate treatment technology.

II. PROBLEM DEFINITION

Unfortunately, no single treatment technology is going to be universally applicable for all aquifer restoration programs. A thorough evaluation of the site-specific parameters involved is necessary in order to choose the most cost-effective treatment technology for the job. Because major aquifer restorations are likely to take several years to accomplish, the investment of time and effort to properly evaluate the situation initially will more than pay for itself in the long run.

Among the major site-specific parameters that should be defined are:

A. CONTAMINANT COMPOSITION AND CONCENTRATION

An accurate analysis of the aquifer contamination is important. The contamination could be a single component from an underground storage tank leak or a wide variety of components from a disposal site leachate. The level of contamination could range from low parts per billion to several parts per million. The treatment cost of technologies such as carbon adsorption and oxidation are dependent on concentration and type of compound, while costs for air and steam stripping are more closely related to the treatment rate.

B. DESIRED EFFLUENT QUALITY AND EFFLUENT DISPOSITION

A requirement that effluent quality meet drinking water standards will eliminate some technologies from consideration immediately, but that level of effluent quality is likely to be required for most aquifer restoration programs. The ultimate disposition of the effluent will have some bearing on the required effluent quality. If the treated groundwater can be discharged to the sewer for further treatment by a municipal waste facility, effluent guidelines may be less strict. However, if the groundwater is to be recharged or discharged directly to surface water, requirements are likely to be more stringent.

C. VOLUME TO BE TREATED

Treatment volumes for aquifer restoration can range from a few thousand to billions of gallons. A small volume may be best treated by a technology with low capital costs and high operating costs, while economic restoration of a large aquifer is more likely to be accomplished utilizing a technology with low operating costs. An evaluation of treatment options should also include consideration of leasing equipment to treat small volume sources.

D. FATE OF TREATMENT BY-PRODUCTS

Local requirements for disposition of treatment by-products will have a major impact on the economics and viability of various treatment technologies. Air stripping can be an extremely cost-effective technology if the organic-laden air can be emitted directly to the environment, but strict air emissions standards would require that air stripping be followed by a vapor-phase adsorption system, significantly increasing treatment costs. Similar considerations exist with the generation of potentially toxic by-products from chemical oxidation processes, and the possible need for nutrient removal (phosphorus and nitrogen) from the effluent of biological oxidation processes. The economics of activated carbon adsorption (especially on a throwaway carbon basis) can be affected by the accessibility of an approved disposal site for the contaminated carbon.

E. UTILITIES AVAILABILITY AND COST

The selection of technologies such as steam stripping and activated carbon adsorption with nondestructive regeneration will be influenced by the availability of steam at the treatment site. Likewise, energy-intensive processes such as UV-catalyzed oxidation require a substantial source of electrical power. The energy-intensive processes are also likely to be more attractive in the southern part of the country where electrical costs are approximately $0.05/kWh than on the west cost where costs can approach $0.10/kWh.

A clear definition of the goals of an aquifer restoration program along with an understanding of the above site-specific parameters and the technical limitations of the technologies under consideration will allow selection of the most cost-effective treatment option.

III. TECHNICAL EVALUATION

A number of technologies are potentially applicable to decontamination of groundwater. Some are best suited for specific applications and others may be eliminated from widespread consideration because of the inability to meet stringent discharge standards or other technical limitations. In this section, the authors will attempt to identify those technologies with the greatest potential for groundwater decontamination and discuss the major advantages and disadvantages of each technology.

For purposes of discussion, the technologies are divided into three basic categories:

- Conventional chemical engineering unit operations
- Oxidation technologies
- Carbon adsorption options

A. CONVENTIONAL CHEMICAL ENGINEERING UNIT OPERATIONS

1. Solvent Extraction

Solvent extraction usually finds application as a primary treatment technology for at-the-source treatment of grossly contaminated industrial wastewaters. Operating costs associated with solvent losses can be high, but the ability to recover product from concentrated waste streams helps to offset that high operating cost. When dealing with dilute waste streams such as contaminated groundwater, however, the high operating costs cannot be offset by product recovery, and the overall treatment cost for solvent extraction becomes prohibitively expensive.

Another problem with solvent extraction is its inability to meet stringent effluent discharge standards. Discussion of solvent extraction as a pollution control technology deals with the fact that most extraction solvents cannot reduce the organic concentration in the wastewater to acceptable discharge levels, often necessitating a polishing treatment step.[2] In addition, most solvents that would be considered for use are environmentally unacceptable and therefore require a raffinate stripping step. The steam requirements associated with raffinate stripping and solvent recovery demand that a source of steam be available at the treatment site. For the above reasons, solvent extraction will not receive further consideration as a groundwater decontamination technology in this paper.

2. Steam Stripping

Steam stripping is a specialized form of distillation in which heat is provided by the direct introduction of steam in a stripping tower. Its application is limited to the removal of volatile organics or organics where the activity coefficient is high. Like solvent extraction, it is better suited to treatment of concentrated waste streams, where product recovery can help to offset relatively high operating costs, but unlike solvent extraction, it can be competitive in the treatment of dilute streams.

The major advantages of steam stripping are its relatively low capital requirement and its simplicity of operation. It does, however, demand a source of steam at the treatment site. The capital involved in providing a grass-roots steam generation facility will approximately double the treatment cost for this option.

The major disadvantages associated with steam stripping are its questionable ability to meet effluent discharge requirements and its relatively high operating costs. Because it is a technology normally applied to higher concentration waste streams, its efficiency in treating dilute streams is not well defined.

3. Air Stripping

Air stripping is a contaminant removal technique based on concentration differentials between a liquid phase and a contacting gas phase. As air is contacted with a wastewater stream in a stripping tower, the concentration differential drives the organic contaminant from the liquid to the gas phase.

The major advantage of air stripping is its low overall treatment cost. Both capital and operating cost requirements are low compared to most other technologies. Also, like steam stripping, it is a relatively simple technology to operate.

The key to air stripping's low overall treatment cost is the assumption that it can stand alone as a treatment technology. In many cases, however, air emission standards will require that air stripping be used in conjunction with a vapor-phase adsorption unit, significantly affecting the cost-effectiveness of this option.

Another major disadvantage of air stripping is the fact that it is temperature-sensitive. The literature states that decreasing temperature will increase the air to water ratios required for efficient operation.[3] Since groundwater is normally in the range of 10 to 15°C, extremely high air-to-water ratios may be required.

Still another problem associated with air stripping is the potential presence of scale-producing compounds in the groundwater which may result in scale buildup in the stripping column, eventually interfering with efficient column operation.

B. OXIDATION TECHNOLOGIES

Oxidation technologies use biological or chemical means to completely oxidize organic contaminants to CO_2 and H_2O, or partially oxidize them to non-toxic intermediates. A general oxidation flow sheet is presented in Fig. 1. Most of the oxidation options are best suited to specific applications, and the effluent from uncatalyzed oxidation technologies is not likely to meet drinking water standards.

1. Biological Oxidation

Biological oxidation uses active microorganisms to biodegrade organics to acceptable forms. The two major forms of biological treatment are aerobic which produces CO_2 and H_2O, and anaerobic which produces CO_2 and CH_4.

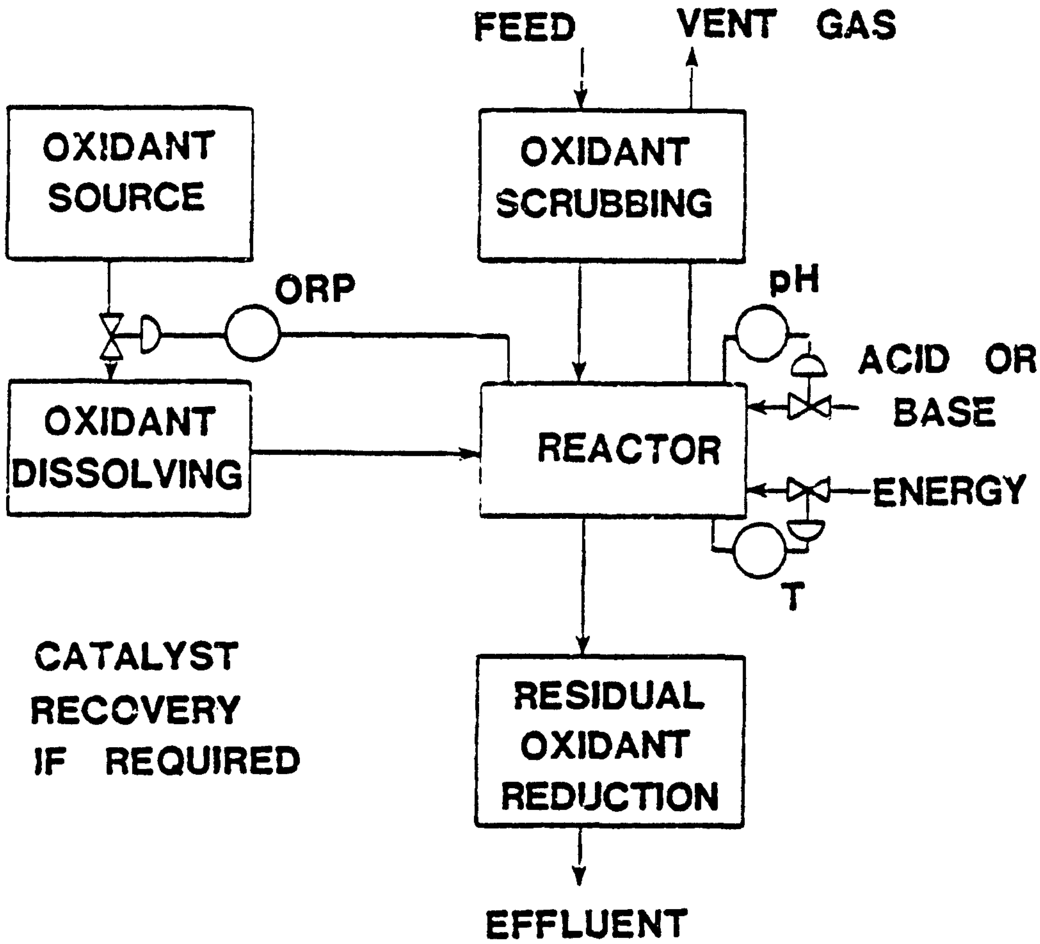

FIGURE I

GENERAL PROCESS FLOWSHEET FOR CHEMICAL OXIDATION

A number of considerations make biological treatment an unlikely candidate for groundwater decontamination. Removal efficiencies of 9[illegible]% for BOD and 75 to 80% for COD are typical for biological treatment. These percentages would not be sufficient to provide acceptable effluent quality. Literature sources on wastewater treatment point out that a number of toxic organic chemicals, especially those which are halogenated, are resistant to biodegradation.[4] In addition, groundwater applications may require the addition of nutrients such as phosphorus or nitrogen. Stringent effluent requirements will necessitate the removal of these nutrients, increasing the overall treatment costs. Biological treatment is very sensitive to temperature and exposure to chemicals that may be toxic to the system's microorganisms.

2. Uncatalyzed Chemical Oxidation

Chemical oxidation accomplishes detoxification of waste streams through the addition of chemical oxidation agents. Nearly all chemical oxidation processes use either chlorine or oxygen as the oxidizing agent. Chlorine oxidation is of questionable value because of the difficulty in assessing the impact of potentially toxic chlorinated by-products.[4] Oxygen itself has very limited effectiveness, but may be of use in the form of ozone or hydrogen peroxide.

None of the uncatalyzed chemical oxidation technologies are likely to be effective for groundwater treatment. If they were, they would already be in use throughout the country. Without catalysis the reaction kinetics are simply not sufficient to provide the required destruction efficiency in a reasonable amount of time. For purposes of economic evaluation, this paper will address only those oxidation technologies catalyzed by ultraviolet light.

3. UV-Catalyzed Oxidation

The application of ultraviolet light enhances oxidation by photodecomposition of the organics, creating more reactive "free radical" species.[5] There is even evidence that the effect of UV-catalysis is greater at the low concentrations likely to be associated with groundwater contamination than in applications to more concentrated waste streams.[6] For the purpose of this paper, the relative advantages and disadvantages of UV-ozonation and UV-peroxide treatment systems will be discussed. UV-chlorination will not be considered because of the potential for toxic chlorinated by-products.

Because the half-life of ozone is very short, use of UV-ozonation will require an on-site ozone generator. This ozone generator can utilize either oxygen or air as feed, but if air is used, it must be dried. The need for the ozone generator significantly impacts both capital and operating cost requirements. Additional costs associated with continuously stirred reactors (CSTRs) and UV lamps combine to make UV-ozonation the most expensive of the potential aquifer restoration technologies discussed in this paper. Another disadvantage is the high maintenance level associated with the UV lights and ozone generator.

The major advantage of UV-ozonation is that it probably can meet effluent quality requirements, although two or three CSTRs in series may be needed to economically achieve the desired destruction efficiency. In addition, by-products from the ozonation process are often environmentally acceptable.

Many of the comments that apply to UV-ozonation also apply to UV-peroxide treatment. With proper design of the system, effluent guidelines can probably be met, and reaction by-products are likely to be environmentally acceptable. Like UV-ozonation, capital and operating cost requirements are relatively high, but the absence of an ozone generator makes the treatment cost significantly less than for UV-ozonation.

C. CARBON ADSORPTION OPTIONS

Perhaps the most widely applicable technology for aquifer restoration is adsorption. For purposes of this paper's evaluation, discussion will be limited to the use of activated carbon as the adsorptive media. Numerous literature sources state that synthetic adsorbents are both specific in their application and expensive compared to activated carbon.[3,7]

The use of activated carbon adsorption for aquifer restoration programs has drawn widespread attention. Several literature sources point to its ability to achieve exceptionally good effluent quality, and the EPA has endorsed it as the preferred treatment method for meeting drinking water standards.[3,7,8] A major aquifer restoration program underway at the Rocky Mountain Arsenal in Colorado is utilizing activated carbon adsorption as its chosen treatment technology.[9,10,11] This paper will discuss three basic ways in which carbon can be used.

- Throwaway carbon basis
- Thermal regeneration basis
- Nondestructive regeneration basis

1. Throwaway Carbon

One way to consistently ensure good eff'uent quality is to use activated carbon adsorption on a once-through carbon basis. Virgin carbon is capable of removing a broad range of organic contaminants to low parts per billion levels. A once-through carbon adsorption system is easy to operate, requiring a minimum of operator attention, and the capital cost requirements are relatively low.

Unfortunately, carbon replacement costs associated with once-through carbon adsorption systems are very high. The large treatment volumes and high flow-rates usually associated with aquifer restoration programs result in a high carbon consumption rate. In addition, hazardous substances loaded onto activated carbon make the carbon a hazardous substance, requiring disposal in an approved hazardous waste facility.

2. Thermal Regeneration

The most common regeneration technique for activated carbon is thermal oxidation, usually accomplished in a multiple hearth, fluidized-bed, or rotary-kiln furnace. A thermal regeneration unit can be built at the treatment site, but the level of carbon consumption associated with groundwater decontamination usually makes it more economical to utilize a thermal regeneration service.[12]

The advantages of activated carbon adsorption with a thermal regeneration service are low capital requirement and ease of operation, as with throwaway carbon. But the disadvantages of thermal regeneration are numerous. Using a thermal regeneration service basically amounts to "renting" the carbon, and in many cases, the cost per pound of carbon for thermal regeneration is only slightly less than that for purchasing virgin carbon. Additionally, carbon losses associated with thermal regeneration are typically 5 to 10% per cycle due to handling losses and carbon that is destroyed during the regeneration process. Thermally regenerated carbon can be expected to have different performance characteristics and removal efficiency from virgin carbon.

A major problem associated with thermal regeneration is that many hazardous substances cannot be thermally regenerated for one reason or another. Because the hazardous substances are literally burned off the carbon during thermal regeneration, air emissions from the regeneration furnaces can be a problem. Consequently, thermal regenerators often refuse to deal with carbon that has been used to adsorb toxic materials such as PCBs. Other hazardous substances, such as RDX and TNT, normally are not thermally regenerated because of safety concerns.

3. Nondestructive Regeneration

There are three basic ways that granular activated carbon can be nondestructively regenerated:

- Using pH shift for weak acids or bases
- Using steam for volatile organics
- Using a solvent for a wider variety of organics

The use of supercritical fluids has also received some attention as a nondestructive regeneration technology, but its application is limited by economics to those cases where other solvents will not work. The concept of nondestructive regeneration is the subject of several papers and articles,[13-16] but this paper will concentrate on the steam regeneration of volatile organics, an approach that can be used in many groundwater applications.

Steam regeneration, which has been used for decades with vapor-phase adsorbers, is accomplished by passing steam through a spent adsorber to a condenser, then to a decanter where the condensate and immiscible organics are separated. Carbon losses associated with nondestructive regeneration are significantly less than those associated with thermal regeneration. The carbon is not physically altered by the nondestructive regeneration process, and if the carbon adsorbers are made of the proper material, the regeneration can be accomplished in-situ, eliminating carbon handling losses. The process is relatively easy to operate, and the nondestructive nature of the process allows organic recovery if desired. Even if recovery is not desired, the disposal requirements are reduced from several thousand pounds of contaminated carbon to a few gallons of organic material.

There is some question as to whether regenerated carbon will be able to meet effluent guidelines. IT Enviroscience is involved in studies to verify that this technology, which has been demonstrated for process applications, is effective for groundwater. These studies will determine the effect that operating at low inlet concentration has on carbon life-time and adsorptive capacity.

IV. ECONOMIC EVALUATION

Based on the technical factors discussed in the previous section, the following treatment technologies were chosen for economic evaluation:

- Steam stripping
- Air stripping
- UV-catalyzed peroxide oxidation
- UV-catalyzed ozone oxidation
- Carbon adsorption with throwaway carbon
- Carbon adsorption with thermal regeneration
- Carbon adsorption with nondestructive regeneration

All the above technologies were evaluated for their cost in treating 500,000 gallons per day (350 gpm) of groundwater contaminated with either 5 parts per million or 0.5 parts per million of organic material.

Major equipment costs were estimated using standard literature sources.[19,20] The equipment considered for each technology is summarized in Table 1 and was sized according to the design parameters also listed in Table 1. Operating costs include utilities and raw materials costs, but do not include labor. The operating costs were calculated based on the design parameters listed in Table 1 and the cost factors summarized in Table 2. The equipment and operating costs for each of the technologies are summarized in Table 3.

The overall treatment cost, in dollars per thousand gallons of treated groundwater, is summarized for all of the technologies in Table 4. The treatment cost is a composite of the operating cost plus 30% of the installed equipment cost to cover depreciation, maintenance, and overhead. The installed equipment cost is defined as four times the equipment purchase cost listed in Table 3.

The costs presented are estimates for comparison of technologies on a common basis only. Evaluation of any technology for a specific application requires consideration of all the site-specific factors.

Table 1. Economic Evaluation Input

Treatment Technology	Major Equipment Requirements	Utility Requirements[a] 5 ppm	Utility Requirements[a] 0.5 ppm	Design Parameters 5 ppm	Design Parameters 0.5 ppm
Steam stripping	Packed column	68.5$\bar{M}$ lb steam/yr	68.5$\bar{M}$ lb steam/yr	30 gpm/ft^2	30 gpm/ft^2
				0.05 lb steam/lb feed	0.05 lb steam/lb feed
Air stripping	Packed column	885M kWh/yr	885M kWh/yr	30 gpm/ft^2	30 gpm/ft^2
	Blower			20 cfm air/gpm feed	20 cfm air/gpm feed
UV-peroxide	Reactors w/UV lamps	535M kWh/yr	355M kWh/yr	5 lb H_2O_2/lb org	5 lb H_2O_2/lb org
	H_2O_2 storage tank	36 lamps/yr	24 lamps/yr		
		33M lb H_2O_2/yr	33M lb H_2O_2/yr		
UV-ozonation	Reactors w/UV lamps	1.1$\bar{M}$ kWh/yr	625M kWh/yr	8 lb O_3/lb org	8 lb O_3/lb org
	Ozone generator	19.0$\bar{M}$ gal cw/yr	2.4$\bar{M}$ gal cw/yr		
		36 lamps/yr	24 lamps/yr		
Carbon-throwaway	Column	140M lb carbon/yr	70M lb carbon/yr	4 gpm/ft^2	4 gpm/ft^2
	Carbon handling equipment			0.05 lb org/lb carbon	0.01 lb org/lb carbon
Carbon-thermal service	Column	150M lb carbon/yr	75M lb carbon/yr	4 gpm/ft^2	4 gpm/ft^2
	Carbon handling equipment			0.05 lb org/lb carbon	0.01 lb org/lb carbon
Carbon-nondestructive	Column	7M lb carbon/yr (makeup)	3.5M lb carbon/yr (makeup)	4 gpm/ft^2	4 gpm/ft^2
	Carbon handling equipment	700M lb steam/yr	350M lb steam/yr	0.05 lb org/lb carbon	0.01 lb org/lb carbon
		6.0$\bar{M}$ gal cw/yr	3.0$\bar{M}$ gal cw/yr		
	Condenser				
	Decanter				

[a] Based on treating 0.5$\bar{M}$ gpd (350 gpm).

Table 2. Utilities and Raw Materials Costs

Item	Cost ($)
Electricity	0.05/kWh
Steam	6.00/1000 lb
Cooling water	0.20/1000 gal
Virgin carbon	1.05/lb[a]
Thermal regeneration service	0.75/lb carbon[b]
Peroxide	0.40/lb 50% H_2O_2
UV lamps	1000/7.5 kw lamp

[a]Includes shipping and disposal costs.

[b]Includes shipping costs.

Table 3. Purchased Equipment and Operating Cost Comparison[a]

	5 ppm		0.5 ppm	
Treatment Technology	Purchased Equipment ($M)	Operating[b] ($M/yr)	Purchased Equipment ($M)	Operating[b] ($M/yr)
Steam stripping	20	411	20	411
Air stripping	41	44	41	44
UV-peroxide	296	92	195	45
UV-ozonation	454	95	236	45
Carbon-throwaway	56	145	56	73
Carbon-thermal service	56	104	56	52
Carbon-nondestructive	98	14	98	7

[a]Basis: treatment of 0.5$\bar{M}$ GPD (350 gpm).

[b]Not including labor.

Table 4. Treatment Cost Comparison[a]

Treatment Technology	Treatment Cost[b] ($/1000 gal) 5 ppm	0.5 ppm
Steam stripping	2.64	2.64
Air stripping	0.56	0.56
UV-peroxide	2.71	1.69
UV-ozonation	3.88	1.99
Carbon-throwaway	1.29	0.85
Carbon-thermal service	1.04	0.72
Carbon-nondestructive	0.80	0.76

[a]Basis: treatment of 0.5$\bar{M}$ GPD (350 gpm).

[b]Includes 30% of installed equipment cost for depreciation, maintenance, and overhead.

A. STEAM STRIPPING

Table 3 indicates that steam stripping has a very low capital requirement, but operating costs are the highest of any of the technologies considered, resulting in an overall treatment cost of $2.64/1000 gal, a relatively high cost technology for this application. Because capital and operating costs are both based on throughput for this technology, the treatment cost is the same for the 5 ppm and 0.5 ppm cases. The calculations assume that steam is available at the treatment site.

B. AIR STRIPPING

Table 4 indicates that, at $0.56/1000 gal, air stripping is the least expensive of the treatment technologies considered. Both capital and operating cost requirements are relatively low. It should be re-emphasized, however, that air stripping only succeeds in transferring the contaminant from the groundwater to the air, and that if vapor-phase emission control is required, treatment cost for this option will be significantly increased.

As with steam stripping, the costs for this technology are throughput-dependent and are therefore the same for 5 ppm and 0.5 ppm cases.

C. UV-CATALYZED PEROXIDE OXIDATION

The UV-peroxide treatment method has one of the highest overall treatment costs ($2.71/1000 gal for 5 ppm feed; $1.69/1000 gal for 0.5 ppm feed). This is primarily due to very high equipment capital requirements of almost $300,000 for 5 ppm feed and $200,000 for 0.5 ppm feed. Both capital and operating cost requirements are concentration- and throughput-dependent, resulting in the UV-catalyzed oxidation technologies being more expensive than steam stripping at 5 ppm feed but less expensive at 0.5 ppm feed. For the purposes of this evaluation, it was assumed that 5 ppm feed would require three reactors in series and that 0.5 ppm would require two reactors in series to achieve the desired destruction efficiency.

D. UV-CATALYZED OZONE OXIDATION

Like UV-peroxide, the UV-ozonation option is among the highest cost treatment technologies. The overall treatment cost of \$3.88/1000 gal for 5 ppm feed and \$1.99/1000 gal for 0.5 ppm feed is most heavily influenced by the very high capital requirement associated with the series operation of the UV-equipped reactors and requirement of an ozone generator. Even though other literature sources do not specify reactors in series for this type of application, overall equipment costs are comparable or even less for the series operation.[21]

E. CARBON ADSORPTION

The carbon adsorption options demonstrate the best combination of technical capability and cost-effectiveness. Table 4 indicates that the overall treatment cost for the carbon options is higher than for air stripping, but there is a much higher degree of confidence that carbon adsorption can meet all environmental standards as a stand-alone technology.

As Table 4 indicates, carbon adsorption treatment costs are heavily dependent on concentration. Capital requirements are the same for the throwaway and thermal regeneration systems, but slightly more for the nondestructive regeneration system due to material of construction requirements and steam condensation equipment. The primary source of variable treatment costs for carbon adsorption systems is the amount of carbon consumed, which is a function of the feed concentration and its associated loading value, and the relative costs for treating or purchasing the carbon. As Table 2 indicates, virgin carbon costs total about \$1.05/lb carbon, while thermal regeneration costs are about \$0.75/lb carbon. On-site nondestructive regeneration can be accomplished for approximately \$0.05/lb carbon.

The carbon adsorption options are the least likely technologies to be affected by site-specific parameters. Carbon treatment can handle a wide range of contaminants at varying concentrations and provide good effluent quality. It is capable of treating virtually any treatment volume at whatever rate is desired, and throwaway carbon is the only treatment by-product to cause a concern. Although this paper assumes steam is available for nondestructive regeneration, it is not a requirement. The infrequent regeneration requirements make leasing of steam generation equipment both practical and economically attractive.

V. SUMMARY

Treatment cost data developed in this paper indicate that air stripping and carbon adsorption options are among the least expensive treatment technologies for aquifer restoration programs. The least expensive option is not always the most cost-effective, however. In order to have a well designed aquifer restoration program, it is important to evaluate the site-specific parameters involved and to fully understand the constraints, options, and goals of the program.

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U.S. AIR FORCE INSTALLATION RESTORATION PROGRAM (PHASE I)

W. Gary Christopher
John R. Absalon

Engineering-Science
Atlanta, Georgia

ABSTRACT

In accordance with Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, the U.S. Air Force has implemented the Department of Defense Installation Restoration (IR) Program, a comprehensive effort to identify and evaluate past USAF hazardous material disposal sites located on USAF property and to control the migration of hazardous environmental contamination that may result from such sites. The IR program consists of four broad phases:

(a) Installation Assessment (IA) - A case-by-case evaluation of individual USAF bases to select those installations that possess hazardous waste disposal sites requiring control of contaminant migration.

(b) Confirmation - A comprehensive environmental and/or ecological survey designed to define the presence of contamination.

(c) Technical Base Development - Development of a sound data base upon which contaminant migration control plans may be formulated.

(d) Operations - Execution of the contaminant control plan (an actual site isolation or clean-up).

Technical assistance for implementing the IR Program is provided to the Air Force by qualified consultant organizations such as Engineering-Science. Contract management is provided by Headquarters, Air Force Engineering and Services Center, Directorate of Environmental Planning, Tyndall AFB, Florida, and technical guidance is provided by the USAF Occupational and Environmental Health Laboratory, Brooks AFB, Texas. Project coordination is furnished by major commands within the Air Force.

The IR Program commences with the Installation Assessment, the most critical phase of the study process. A general overview of the

Installation Assessment is presented by defining the major objectives. These objectives include:

1. Identify hazardous, potentially hazardous or non-hazardous waste generating processes.
2. Prepare a waste inventory by facility (shop, test range, etc.)
   - o Hazardous material usage
   - o Waste characterization evaluation
   - o Waste classification
3. Identify and evaluate past waste handling, storage, treatment and disposal practices.
4. Determine base waste disposal facilities having actual or suspected contamination.
5. Characterize the regional setting with respect to (disposal) site-specific conditions:
   - o Review regional geology
   - o Review site-specific soils/geology/hydrology for potential contaminant migration patnways
   - o Establish environmental setting of facility
   - o Define potential contaminant migration pathways
6. Evaluate individual disposal facilities with respect to contaminant migration potential.
7. Rank sites according to hazard priority, utilizing a system compatible with EPA requirements.
8. Provide recommendations outlining scope of additional studies designed to define the presence, concentration, and extent of contamination migration (Confirmation).

In order to achieve these numerous and complex goals, the performance of an Installation Assessment is organized into major tasks as follows:

a. Pre-performance meeting with all interested parties
b. Project team organized to be compatible with individual base characteristics/operations
c. Site inspection, records search and data collection
d. Off-base literature review/technical interviews
e. Data compilation

f. Base disposal facility rankings

g. Report preparation

The major tasks are discussed in terms of a typical base evaluation. Generalized examples of major assessment tasks are presented.

CONCEPTUAL PLANS UNDER SUPERFUND FOR REVEGETATING THE BURNT FLY BOG HAZARDOUS WASTE DUMP IN MARLBORO TOWNSHIP, NEW JERSEY

by B. William Garland and J. Rogers

The Burnt Fly Bog abandoned toxic waste dump in Marlboro Township, New Jersey is ranked as the number one toxic site in the State needing cleanup. This site is known to contain a variety of toxic substances, including PCBs, lead, trichlorethylene, chloroform, and benzene. An investigation under Superfund was initiated in early 1982 to develop a cleanup plan for the bog. One aspect of this cleanup program is the creation of a revegetation plan that is directed to re-establishing a plant community that blends into existing vegetation surrounding the site. Efforts in the investigation, therefore, concentrated on selecting species of native vegetation currently growing on surrounding areas that would be suitable for planting on the site. There are, however, a number of environmental factors that must be given consideration before a specific revegetation plan can be developed.

There are two basic approaches that may prove useful in developing a revegetation plan for Burnt Fly Bog. A soil lift can either be applied to the surface of capped areas and contaminated soils, or attempts can be made to directly seed denuded areas when soil is shown to be free of contaminants. The approach to establishing a plant cover will depend, to a large extent, on the technique recommended for securing the hazardous waste site. Basically, these techniques are expected to either involve the installation of a relatively impermeable cover over contaminated unexcavated soils, or the removal of contaminated soils from the site. Since the final cleanup plan is unknown at this stage of the investigation, the advantages and disadvantages of various conceptual plans were evaluated. If plants are to be grown on soils containing low levels of contamination and exhibiting poor soil structure, then care must be taken to select species for planting that are able to withstand these environmental stresses. Further consideration must also include the possible uptake of contaminants by plants and their deposition on the soil surface, and subsequent entrance into the biological food chain. The establishment of a ground cover over an impermeable cap provides additional environmental factors that must be investigated. The depth of plant rooting over this cap may at sometime in the future threaten the integrity of the cap.

The initial step of this investigation involved the review of soil tests and aerial photographs depicting vegetation coverage. A field survey then allowed comparisons to be made concerning contaminant levels and the extent of natural plant coverage. The initial survey of the facility revealed several factors that have inhibited the establishment of vegetation under natural conditions: 1) possible acid conditions due to elevated concentrations of pyrite in soils; 2) severe erosion; and 3) the probable occurrence of harmful concentrations of contaminants. These site specific environmental factors must be included in the formulation of the final revegetative plan.

A DESCRIPTIVE SUMMARY OF THE

ENDECO[R] TYPE 2100 SEPTIC-SNOOPER[TM] SYSTEM

Robert F. Skinder
ENDECO, Inc.

What is the SEPTIC-SNOOPER?

This unique monitoring system was developed by Environmental Devices Corporation in response to a need for an economical means of locating areas of septic system and sewage effluent discharges entering streams, lakes, rivers, reservoirs and harbors. It is a portable field unit that can be operated continuously to scan expansive shorelines in a comparatively short period of time. Real time feedback provides on-site determination of problem areas.

How does the system work?

The SEPTIC-SNOOPER System monitors two parameters, fluorescence (organic channel) and conductivity (inorganic channel). This unique system is based on the theory that a stable ratio exists between fluorescence and conductivity in typical septic leachate outfalls. Readings for each channel appear visually on panel meters while the information is recorded on a self-contained strip chart recorder. Recording modes include individual channel outputs or a combined output.

The submersible lift pump in the probe draws water from the bottom and passes it through the fluorometer unit which is sensitive to fluorescing organic molecules from laundry whiteners and septic wastes. The water then passes through a graphite electrode type conductivity cell sensitive to inorganic ionic components such as chloride (Cl^-) and sodium ($Na+$). Fluorescence and conductivity signals are generated and sent to an analog computer circuit that compares the signals against the background to which the instrument was calibrated. The resultant output is expressed as a percentage of the background and is continuously documented on the strip chart recorder. Full scale recorder output is provided for less than 1% septic leachate concentration. When higher than normal readings are encountered, discrete water samples can be taken directly from the instrument's discharge for later analysis of actual water quality. The system is powered by a standard 12 volt automobile battery or a portable generator. The system can be operated from a small boat moving at walking pace along shorelines or in fixed locations for static monitoring applications. The entire system is completely portable.

What are the system's applications?

The SEPTIC-SNOOPER System has a number of applications which include:

- assistance for regulatory agencies in monitoring the condition of shoreline septic systems and enforcing public health regulations

- determination of the presence of septic leachate in potable or recreational waters

- assistance in determining optimum lake levels and other facets of in-lake management programs

- help in planning future property development

- identification of the direction and relative amplitude of groundwater inflows

- monitoring of groundwater resources

- monitoring downstream effects of municipal waste treatment outfalls

- on-line monitoring of sewage effluent discharges

How does this method compare to other techniques?

Conventional methods of leachate detection are primarily dye studies and in-depth water sampling programs. Simple visual observation is also used. All of these methods have their advantages as well as their disadvantages The following matrix compares the characteristics of these methods with respect to accurate location of problem areas:

Technique	Survey Time Involved	Access Problems	Ease of Operation	Effectiveness	Total Cost
dye studies	extensive	yes	complex	good	high
water sampling	extensive	no	complex	fair	high
observation	minimal	no	simple	poor	low
SEPTIC-SNOOPER	minimal	no	simple	excellent	low**

What is the system's track record to date?

The SEPTIC-SNOOPER System was originally developed in 1976 through the combined efforts of Environmental Management Institute and Environmental Devices Corporation. The system has been used in a number of water quality surveys to help determine the extent of faulty septic systems allowing excessive amounts of nutrient concentrations to reach lake waters.

**The purchase cost of one complete SEPTIC-SNOOPER unit is far less than the cost of a single leachate outfall survey done by most other techniques. The system's flexibility to meet a number of applications and its continued use as a periodic check on existing conditions allows long term amortization which further reduces overall cost.

A Descriptive Summary of The
ENDECO[R] Type 2100 SEPTIC-SNOOPER[TM] System

Studies have shown that septic leachate is now a major cause of lake eutrophication. The introduction of excessive amounts of dissolved nitrate, ammonia, phosphate and organic substances results in an abundance of bacteria and algae growth that can have serious effects on recreational and potable waters, including groundwater reserves.

The SEPTIC-SNOOPER System has been used in a number of surveys to determine the extent of septic leachate discharges and to locate their sources. Major surveys in New Hampshire have been conducted during comprehensive studies of Ossipee and Squam Lakes as well as Lake Winona and Lake Winnepesaukee. An in-depth study of Johns Pond in Mashpee, Massachusetts resulted in the location of a number of malfunctioning septic systems. The data derived from the study served as the basis for sound pond management and planning for future development of shoreline property.

A number of studies have subsequently been scheduled, further emphasizing the awareness by various governmental agencies and private consulting and environmental organizations that a serious health hazard can result from sewage and septic system pollution of wetlands.

In terms of cost and long term environmental impact, the most effective cure for sewage and septic leachate problems is generally regarded as prevention of them or at lease the arresting of them at early stages. Water resources planning and management programs must address the need for periodic septic system monitoring as an integral part of overall water quality assessment. The SEPTIC-SNOOPER System is designed to meet that need in various applications which include lakes, rivers, harbors, groundwater reserves and municipal waste treatment facilities. Water resources management programs that incorporate the periodic use of the SEPTIC-SNOOPER System should realize tremendous cost savings and long term environmental benefits. The only real alternative is to wait until a major environmental problem becomes plainly evident, at which time, costly research, evaluation and corrective measures must be undertaken.

Who could benefit from the use of this system?

Users of this unique method of leachate detection can best be categorized as having a continuous need or an occasional need.

Continuous users include those who have developed effective water resources management programs at the municipal or regional level of government, state and county regulatory agencies concerned with the preservation of water quality standards, private consulting firms engaged in water quality evaluation programs.

Occasional users include those who are not directly involved in comprehensive assessment programs but who wish to determine the exact nature and extent of localized problems. Local and regional lake management associations, environmental groups and private consulting firms can benefit from the results of SEPTIC-SNOOPER surveys that verify and quantify actual conditions in recreational areas and potable waters where septic leachate is suspected.

<u>For additional information contact:</u>

Environmental `evices Corporation
Tower Building
Marion, MA 02738

Telephone: 617/748-0366
Telex: 929451

GROUND-WATER QUALITY PROTECTION

Dana C. Larson
UOP, Inc.

Ground water is the source of base flow of all perennial streams and accounts for over 90 percent of the world's fresh water resources and 50 percent of the drinking water of the United States, but has received only token scientific attention.

Recent environmental legislation has emphasized the importance of ground-water quality protection and the stresses that man's activities place on this vital national resource. To provide a realistic assessment of current and potential pollution problems and a rational basis for ground-water quality protection, it is necessary to collect representative samples from this remote and relatively inaccessible environment. This paper presents procedures currently utilized to sample ground water for inorganic and organic chemical parameters.

In selecting a sampling procedure, considerations are described based on the objectives of the sampling program, characteristics of pollutants, nature of pollution source, and hydrogeology of the area. Various techniques for constructing sample wells and for withdrawing samples are described with advantages and disadvantages of each method listed.

The procedures described provide a basic discussion of sampling subsurface environments.

MATERIALS SELECTION FOR GROUNDWATER MONITORING WELLS

I. Drilling Methods for Monitoring Wells

A. Hollow Stem Auger
B. Mud Rotary
C. Air Rotary
D. Cable Tool

II. Well Casing and Screen Materials

A. PVC
B. Polypropylene
C. Teflon
D. Kynar
E. Mild Steel
F. Stainless Steel

III. Well Screen Types

A. Field Slotted Pipe
B. Factory Slotted Pipe
C. Wire-Wound, Continuous-Slot Screen

IV. Fitting Types

A. Plain Square Ends
B. Threads and Couplings
C. Flush Threads

V. Filter Packs

A. Naturally Developed Wells
B. Filter Packed Wells

VI. Grouting Materials for Monitoring Wells

A. Bentonite
B. Cement
C. Polymers

VII. Water Quality Sampling Devices for Monitoring Wells

A. Bailer
B. Suction Lift Pump
C. Air Lift Samplers
D. Gas-Operated Squeeze Pump
E. Submersible Pumps
E_1. Johnson-Keck Submersible Pump

TYPE	ADVANTAGES	DISADVANTAGES
A. Hollow Stem Auger	* No drilling fluid is used, minimizing contamination problems * Formation waters can be sampled during drilling by using a screened lead auger or advancing a well point ahead of the augers * Natural gamma-ray logging can be done with augers in place * Hole caving can be overcome by implacing screen and casing before augers are removed * Fast * High mobility rigs can reach most sites * Equipment generally readily available throughout the U.S. * Usually less expensive than rotary or cable tool drilling	* Can be used only in unconsolidated materials * Limited to depths of 100-150 ft. * Formation samples may not be completely accurate, depending upon how they are taken * Possible problems in heaving sand situations
B. Mud Rotary	* Can be used in both unconsolidated and consolidated formations * Capable of drilling to any depth * Core samples can be collected * Casing not required during drilling * Can run a complete suite of geophysical logs in the open hole * Flexibility in well construction * Fast * Smaller rigs can reach most sites * Equipment generally readily available throughout the U.S.	* Drilling fluid is required - contaminants are circulated with the fluid - the fluid mixes with the formation water and invades the formation and is sometimes very difficult to remove - Bentonite fluids may adsorb metals and may interfere with some other parameters - organic fluids may interfere with bacterial analyses and/or organic-related parameters

TABLE 1 -- DRILLING METHODS FOR MONITORING WELLS

TYPE	ADVANTAGES	DISADVANTAGES
B. Mud Rotary (Continued)	* Relatively inexpensive	* No information on location of the water table and only limited information on water-producing zones, is directly available during drilling * Formation samples may not be accurate
C. Air Rotary	* No drilling fluid is used, minimizing contamination problems * Can be used in both unconsolidated and consolidated formations * Capable of drilling to any depth * Formation sampling ranges from excellent in hard, dry formations to nothing when circulation is lost in formations with cavities * Formation water is blown out of the hole along with cuttings making it possible to determine when the first water-bearing zone is encountered * Collection and field analysis of water blown from the hole can provide enough information regarding changes in water quality for parameters such as chlorides for which only large concentration changes are significant * Fast * Equipment available throughout most of the U.S.	* Casing is required to keep the hole open when drilling in soft, caving formations below the water table * When more than one water-bearing zone is encountered and hydrostatic pressures are different, flow between zones occurs between the time drilling is completed and the hole can be properly cased and grouted off * May not be economical for small jobs
D. Cable Tool	* Only small amounts of drilling fluid (generally water with no additives) are required	* Potential contamination by drilling fluid

TABLE 1 -- DRILLING METHODS FOR MONITORING WELLS (CONTINUED)

TYPE	ADVANTAGES	DISADVANTAGES
D. Cable Tool (Continued)	* Can be used in both unconsolidated and consolidated formations; well suited for caving, large gravel type formations with large cavities above the water table * Wide depth range * Formation samples can be excellent with a skilled driller * When water is encountered, changes in potentiometric levels are observable * Relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators * Good seal between casing and formation if flush jointed casing is used * Rigs can reach most sites * Equipment readily available throughout the U.S. * Relatively inexpensive	* Relatively large diameters are required (minimum 4-inch casing) * Steel drive pipe must be used * Cannot run a complete suite of geophysical logs * Usually a screen must be set before a water sample can be taken * Potential difficulty in pulling casing back * Slow

TABLE 1 -- DRILLING METHODS FOR MONITORING WELLS (CONTINUED)

12/81

TYPE	ADVANTAGES	DISADVANTAGES
A. PVC (Polyvinylchloride)	* Lightweight * Excellent chemical resistance to weak alkalies, alcohols, aliphatic hydrocarbons, and oils * Good chemical resistance to strong mineral acids, concentrated oxidizing acids, and strong alkalies * Readily available * Low Priced [1] - $1.50 per ft. for 2-inch diameter schedule 40 pipe, plain square ends - $1.75 per ft. for 2-inch diameter schedule 80 pipe, plain square ends - $3.30 per ft. for 2-inch diameter schedule 40 slotted pipe, plain square ends - $3.50 per ft. for 2-inch diameter schedule 80 slotted pipe, plain square ends - $12.60 per ft. for 2-inch diameter wire-wound continuous-slot screen	* Weaker, less rigid, and more temperature sensitive than metallic materials * May adsorb some constituents from ground water * May react with and leach some constituents into ground water * Poor chemical resistance to ketones, esters, and aromatic hydrocarbons
B. Polypropylene	* Lightweight * Excellent chemical resistance to mineral acids * Good to excellent chemical resistance to alkalies, alcohols, ketones, and esters * Good chemical resistance to oils [1] All prices are 1931 list prices and may vary somewhat depending upon manufacturer.	* Weaker, less rigid, and more temperature sensitive than metallic materials * May react with and leach some constituents into ground water * Poor machinability - it cannot be slotted because it melts rather than cuts

TABLE 2 -- WELL CASING AND SCREEN MATERIALS

TYPE	ADVANTAGES	DISADVANTAGES
B. Polypropylene (Continued)	* Fair chemical resistance to concentrated oxidizing acids, aliphatic hydrocarbons, and aromatic hydrocarbons * Low priced [1] - $1.80 per ft. for 2-inch diameter schedule 40 pipe, plain square ends - $1.90 per ft. for 2-inch diameter schedule 80 pipe, plain square ends	
C. Teflon (Teflon is a registered trademark of DuPont, Inc.)	* Lightweight * High impact strength * Outstanding resistance to chemical attack; insoluble in all organics except a few exotic fluorinated solvents	* Tensile strength and wear resistance low in comparison to other engineering plastics * Not readily available * Expensive[1] - $47.00 per ft. for 2-inch diameter schedule 40 pipe, plain square ends - $62.00 per ft. for 2-inch diameter schedule 40 slotted pipe, plain square ends
D. Kynar	* Greater strength and wear resistance than Teflon * Resistant to most chemicals and solvents * Lower priced than Teflon [1] - $13.95 per ft. for 2-inch diameter schedule 40 pipe, plain square ends - $18.70 per ft. for 2-inch diameter schedule 80 pipe, plain square ends [1] All prices are 1981 list prices and may vary somewhat depending upon manufacturer	* Not readily available

TABLE 2 -- WELL CASING AND SCREEN MATERIALS (CONTINUED)

TYPE	ADVANTAGES	DISADVANTAGES
E. Mild Steel	* Strong, rigid, temperature sensitivity not a problem * Readily available * Low price [1] - $2.50 per ft. for 2-inch diameter schedule 40 pipe, plain square ends - $17.75 per ft. for 2-inch diameter wire-wound continuous-slot screen	* Heavier than the plastics * May react with and leach some constituents into ground water * Not as chemically resistant as stainless steel
F. Stainless Steel	* High strength at an exceedingly great range of temperatures * Excellent resistance to corrosion and oxidation * Readily available * Moderate price [1] - $5.00 per ft. for 2-inch diameter special monitoring pipe - $33.00 per ft. for 2-inch diameter wire-wound continuous-slot screen [1] All prices are 1981 list prices and may vary somewhat depending on manufacturer	* Heavier than plastics * May corrode and leach some chromium in very acidic waters * May act as a catalyst in some organic reactions

TABLE 2 -- WELL CASING AND SCREEN MATERIALS (CONTINUED)

TYPE	ADVANTAGES	DISADVANTAGES
A. Field Slotted Pipe	* Readily available * Very inexpensive	* Very low amount of open area making development difficult to impossible; ground water may in turn not flow through the well causing stagnant water conditions and unrepresentative samples * Poor slot control; slots generally cut too large causing an excessive amount of material to enter the well unless the screen is cloth wrapped (making development absolutely impossible)
B. Factory Slotted Pipe	* Good slot control * Readily available * Inexpensive	* Low amount of open area, making development difficult
C. Wire-Wound, Continuous-Slot Screen (Not pipe based)	* Very good slot control, very wide range of slots available * High amount of open area, making good development possible and therefore, best possible samples can be obtained	* Higher priced than slotted pipe, but still moderately priced

TABLE 3 -- WELL SCREEN TYPES

12/81

TYPE	ADVANTAGES	DISADVANTAGES
A. Plain Square Ends (No fittings-to weld)	* Readily available in pipe and screen * No need to purchase threads and couplings	* Special equipment and skills needed to weld metals * Plastics are welded using solvent cement - cementing procedures are very temperature and moisture sensitive - cements must be cured after application - cements may interfere with ground water quality * Time spent welding may cause this type of fitting to actually cost more than threads
B. Threads and Couplings	* No solvents needed * Lengths of pipe and screen joined quickly * Readily available * Reasonably priced	* May be difficult to get filter pack and/or grout past the lip of couplings * May need to wrap threads with Teflon tape to make connections watertight
C. Flush Threads	* No solvents needed * No couplings needed; filter packing and grouting simplified * Lengths of pipe and screen joined quickly * Readily available * Reasonably priced	* May need to wrap threads with Teflon tape to make connections watertight * Threads generally not compatible from manufacturer to manufacturer

TABLE 4 -- FITTING TYPES

12/81

NATURALLY DEVELOPED WELLS	FILTER PACKED WELLS
Whether wells are naturally developed or filter packed, objectives are to - Retain the formation and keep the water entering the well as sediment-free as possible - Allow good well development so ground water can flow freely into the well so representative samples can be taken - Avoid placing foreign material into the borehole that will cause water quality interference	
* No material foreign to the formation is introduced * Screen slot opening should be selected on the basis of a log and samples of the formation to be screened; the screen should hold out 35% to 60% of the formation material, depending on formation uniformity and stratification and overlying materials	* An envelope of filter pack (having the following characteristics) is inserted around the screen - size graded so that it will stabilize the formation as well as permit effective development of the surface where the formation and filter pack meet - thin to allow effective development - well-rounded grains - clean, made up of material that will not cause interference with ground-water quality * Screen slot size should hold back not less than 85% of the filter pack

TABLE 5 -- FILTER PACKS

TYPE	ADVANTAGES	DISADVANTAGES
A. Bentonite	* Readily available * Inexpensive (about $6 per 50 lb.)	* May cause constituent interference due to ionic exchange * May not give complete seal - there is a limit to the amount of solids that can be pumped in a slurry (can't pump when percent of solids exceeds about 14), so there are very little solids in the seal; theoretically should wait for liquid to bleed off so solids will settle - pellets may bridge; they may wet and swell before reaching destination, sticking to formation or casing - cannot determine how effectively material has been placed - cannot assure complete bond to casing - if set alongside permeable material, water may flow around
B. Cement	* Readily available * Inexpensive (about $6 per 100 lb.) * Can use sand and/or gravel filler * Possible to determine how well cement has been placed by means of geothermal logs or sonic bond logs	* May cause constituent interference * Mixer, pump, and tremie line are required; generally more cleanup therefore than with Bentonite * May be problems getting the material to set up * Shrinks when it does set - complete bond to formation and casing not assured

TABLE 6 -- GROUTING MATERIALS FOR MONITORING WELLS

TYPE	ADVANTAGES	DISADVANTAGES
C. Polymers	* Very good formation penetration and bonding * Very low permeability	* May cause constituent interference * Hold a very high percentage of water (92-95%) * Very flexible and pliable below the water table, but will dry out above the water table * No assurance of complete bonding to casing * Very expensive

TABLE 6 -- GROUTING MATERIALS FOR MONITORING WELLS (CONTINUED)

TYPE	ADVANTAGES	DISADVANTAGES
A. Bailer	* Can be constructed in a wide variety of diameters * Can be constructed from a wide variety of materials * No external power source required * Extremely portable * Low surface area to volume ratio, resulting in a very small amount of outgassing of volatile organics while sample is contained in bailer * Easy to clean * Readily available * Inexpensive	* Time consuming sampling; sometimes impractical to properly evacuate casing before taking actual samples * Transfer of water to sample bottle may result in aeration
B. Suction Lift Pump	* Relatively portable * Readily available * Inexpensive	* Sampling is limited to situations where water levels are within about 20 ft. from ground surface * Vacuum effect can cause the water to lose some dissolved gas
C. Air Lift Samplers	* Relatively portable * Readily available * Inexpensive * Very suitable for well development	* Not an appropriate method for acquisition of water samples for detailed chemical studies owing to degassing * Changes in CO_2 concentrations make this method unsuitable for sampling for pH sensitive parameters * Oxygenation is impossible to avoid unless elaborate precautions are taken (only a very small amount of oxygen is required to cause a water sample to attain saturation with respect to oxygen)

TABLE 7 -- WATER QUALITY SAMPLING DEVICES FOR MONITORING WELLS

TYPE	ADVANTAGES	DISADVANTAGES
D. Gas-Operated Squeeze Pump (Middelburg Type)	* Can be constructed in diameters as small as one inch * Can be constructed from a wide variety of materials * Relatively portable * Fair range in pumping rates are possible * Driving gas does not contact water sample, eliminating possible contamination or gas stripping	* Gas source required * Large gas volumes and long cycles are necessary for deep operation * Pumping rates are not as great as with suction or jet pumps (rates about equal to Johnson-Keck submersible pump) * Commercial units are relatively expensive -about $2,500 for a fully equipped unit
E. Submersible Pumps	* Wide range in diameters * Various materials are available * Fairly portable * Depending upon size of pump and pumping depths, relatively large pumping rates are possible * Readily available	* Before 1981, no submersible pump was small enough in diameter for use in 2-inch wells * Conventional units are unable to pump sediment-laden water without incurring damage to the pump
E_1. Johnson-Keck Submersible Pump	* 1.75 inch outside diameter allows sampling of 2-inch wells * Construction materials meet the needs of parameters of interest * Highly portable; powered by 12-volt rechargeable battery pack * Rotor and stator construction permits pumping of fine-grained materials without damage to the pump * Easily cleaned	* Present unit delivers low pumping rates at high heads * Relatively expensive - about $3,500 for a fully equipped unit

TABLE 7 -- WATER QUALITY SAMPLING DEVICES FOR MONITORING WELLS (CONTINUED)

12/81

EPA Using Aerial Photography to Assist Army Installation Assessment

By

Kristen K. Stout, Chief Scientist
*The Bionetics Corporation

Executive Order 12316 which delegates Superfund responsibility for DOD facilities to each DOD component, requires identification and cleanup of abandoned hazardous waste sites. DOD's ongoing Installation Restoration Program (IRP), initiated in 1976, fulfills these responsibilities.

Although each component of DOD is conducting an independent IRP, the overall approaches used do not vary significantly. Each begins with an initial installation assessment or records search phase, where potential hazardous sites are identified and initially evaluated. This has been done primarily by querying installation records and long-term or retired installation personnel. Because information obtained in this manner may be sketchy and incomplete, the Department of Army's Toxic and Hazardous Materials Agency (USATHAMA), which is responsible for the Army's IRP, has enlisted the services of EPA's field office, the Environmental Photographic Interpretation Center (EPIC), to fill this information void through analysis of aerial photography.

Visual analysis of historical black and white and current color or color infrared aerial photography to locate suspected areas of past use, storage, treatment and disposal of toxic and hazardous materials has proven extremely effective in USATHAMA's Installation Assessment Project. An interagency agreement between EPIC and USATHAMA was initiated in 1980 which allowed the Army to tap into existing EPA expertise in the field of environmental imagery

*On Site Support Contractor to U.S. E.P.A. Environmental Photographic Interpretation Center.

analysis, specifically in the analysis of active and abandoned hazardous waste sites.

Studies using historical photography allow the investigator to go back in time to locate and study sites that now appear significantly changed or that were abandoned long ago. Aerial photography taken in 5-to 10-year intervals over a 30 to 35-year period (1940's to 1970's) gives a synoptic, time-sequential picture of the installation and allows the analyst to document the changes that take place throughout the life of each site.

As an installation assessment study moves into the field survey phase, acquisition of current color infrared and/or color imagery may be desired to update the historical study and to detect evidence of contaminant migration.

Color infrared aerial photography, flown during the appropriate time of year, facilitates the identification of vegetation stress and damage, which may be the result of migrating contaminants. In addition, leachate springs associated with dumps and landfills exhibit a characteristic signature on color or color infrared photography.

To date, EPIC has completed historical analyses of 36 Army installations, and an additional 12 are planned. An initial 16 installations have been analyzed with current color/color infrared photography to support ongoing field investigations.

<u>Historical Analysis</u>

The historical installation analysis is comprised of the following three phases:

1. Imagery acquisition.
2. Site discovery/inventory.
3. Individual site analysis.

Historical Imagery Acquisition. Various government agencies maintain imagery libraries that house historical aerial photography covering most of the Unites States. The Agricultural Stabilization and Conservation Service (ASCS) is the repository for photography flown for the Department of Agriculture in roughly 5 to 10-year intervals starting in the 1940's. Aerial photography dating back to the 1920's and 1930's is located in the National Archives and Records Service. Coverage of this photography is spotty and the quality is generally less than optimal for detail detection. Aerial photography flown for the U.S. Geological Survey, NASA, US Air Force and several bureaus of the Department of the Interior is maintained at the EROS Data Center in Sioux Falls, SD. Other federal agencies that routinely acquire imagery covering portions of the country are the Army Corps of Engineers and the National Oceanographic Survey. The primary sources for photography for historical installation analyses have been U.S.G.S. and ASCS, with the other sources used less frequently.

Most of the federal film repositories can be accessed through the National Cartographic Information Center (NCIC), Reston, Va. NCIC maintains listings of photo coverage of a particular area held by the aforementioned agencies. The photography must then be purchased directly from the holding agency.

Aerial photography of each installation is selected to provide five years of coverage spanning an approximately 30-year period from the late 1940's to the early 1970's. Most of the depots and ammunition plants studied were built during World War II; therefore, there is little need to obtain photography dating back past the 1940's.

Photography is selected to maximize photo detail and data extraction. Since imagery resolution is a function of scale, only large- to medium-scale photography (1:20,000 to 1:40,000) can be used. Seasonal variations are also a consideration. Aerial photography flown during the winter months may not be very useful, especially in the more northern states, due to snow cover.

The entire acquisition process may take up to three months, especially if photo indexes have to be ordered first.

Site Discovery/Inventory. Each year of photography for a given installation is studied in sequence from the earliest to the most recent to obtain an overview of installation activities and to trace the physical changes that have taken place during the study period. During this initial scanning, potential hazardous sites and activities are located and identified. These include solid and liquid waste disposal sites (e.g, landfills, dumps, burial trenches, lagoons, and pits) and specific military-related activities such as munitions and chemical agent manufacturing, demilitarization operations, washout facilities, demolition and burning grounds, industrial workshops, wood dipping operations, test sites, and open storage of uncontained or poorly contained material. These sites and activities are labeled or numbered and drawn to scale on a photo mosaic of the installation and surrounding area or, in the case of very large installations, on U.S.G.S. topographic maps. Other features of environmental concern, such as large ground scars, excavations, scars indicating underground lines, storage tanks, wash racks, stacks, outfalls and reserve ore piles, are also identified and delineated on the photo mosaic.

Individual Site Analysis. Once potential sites or activities are identified, they are studied in detail through magnified stereoscopic viewing of the aerial imagery. This allows the analyst to see a three-dimensional image of the site, which aids greatly in the identification of objects and features, and shows changes in topography and terrain. A description of each site and the changes that take place during each imagery interval is compiled.

Photo enlargements are made of those sites that appear to be the most hazardous or that change significantly over time. The enlargements are annotated to show detailed surface drainage, the areal extent of the site, access routes and the location on site of waste or potentially hazardous materials such as drums, tanks or transformers which are leaking, piles of debris or fill material, standing liquid or ground stains indicating spills or liquid discharges; and trenches, pits or lagoons containing liquid or solid material. In addition, any features or evidence that would indicate migration off site are noted. These include stained erosion trails, liquid in ditches leading from production, demilitarization or industrial areas, breaches in berms or revetments, vegetation damage, and trails or roads leading off site into the woods.

Figures 1 through 4 show the changes that take place at four sites from 1954 to 1970.

A series of aerial photographs showing the evolution of a particular site can be extremely useful when collateral data on the site is sketchy or nonexistent. This is particularly evident when a site is inactive or abandoned such as trenches or pits that have been covered, a landfill or dump that has revegetated, or a facility that has been dismantled.

Current Analysis

If the results of the record search and historical photo analysis indicate a potential for ground or surface water contamination, USATHAMA initiates a field survey. Since the most recent photography used in the historical analysis dates from the early 1970's; field teams may find that many of the potentially hazardous sites have changed significantly. To assess current installation conditions, large scale (1:10,000) color infrared and/or color aerial photography is acquired and analyzed.

Color infrared imagery is generally used for the detection of vegetation stress. Healthy deciduous vegetation exhibits a magenta hue on color infrared film. Vegetation exhibiting anomalous hues must be carefully studied to cull out species and seasonal variations from actual stress. Although vegetation stress can be used as an indicator of soil and water contamination, other possible causes such as air pollution, insect infestation or changes in soil moisture must be considered.

Leachate springs associated with dumps, landfills and burial sites are another indicator of contaminant migration. They are easily detected on color or color infrared aerial photography unless obscurred by tree canopy.

The photo analyst follows the same procedures for site discovery and analysis with current photography as with historical photography. Data on the previously existing sites is updated and any new sites, activities, or evidence of migration are noted. Photo enlargements of these new areas of concern and the present condition of the "old" sites are annotated to show significant features. The location and precise outline of obscured or removed features (e.g., covered trenches, filled lagoons, landfill boundaries, etc.) are drawn to scale on the photo overlays. This aids field teams in precisely locating these areas.

Applying Photo Analyses to USATHAMA's Needs

EPIC's analysis of aerial photography has become an integral part of USATHAMA's Installation Assessment Project.

The historical photo studies expedite the records search by augmenting and filling the gaps of information obtained from installation records. They are also used to trigger the memories of long-term and retired personnel concerning past activities and old disposal sites. In addition, the historical photo studies are used to corroborate questionable or vague information obtained from these other sources. The field survey teams use both the historical and current photo analyses to aid in the selection of sampling sites and monitoring wells. By showing the boundaries of abandoned sites, historical photographs facilitate proper placement and reduce the number of monitoring wells needed. The current photo analyses alert field teams to possible hazards they might encounter on site, and pinpoint areas of concern that are not easily discernible or accessible from the ground.

USATHAMA and EPIC have worked together to develop a successful, cost effective method for collecting valuable information on potentially hazardous past and present installation activities.

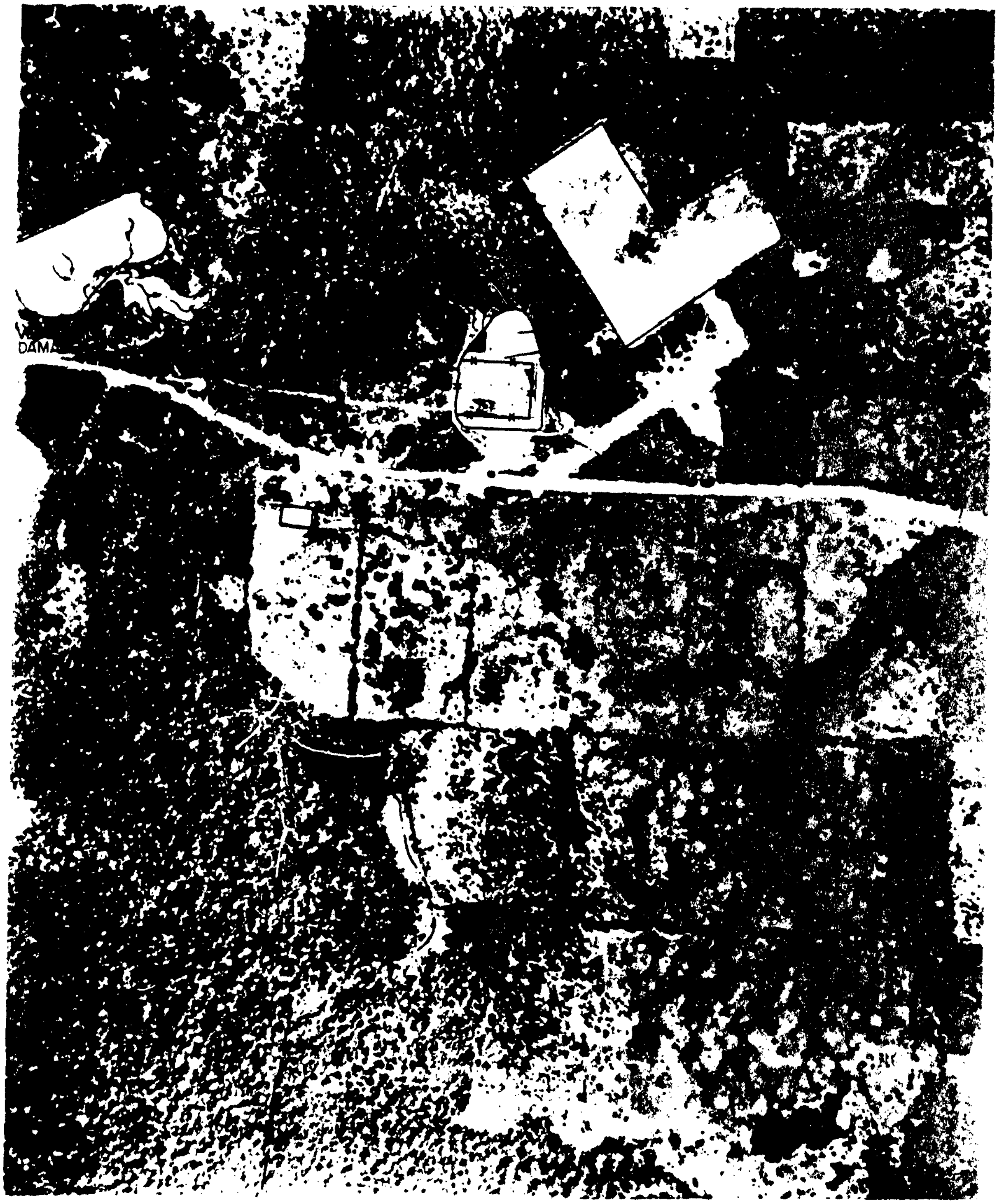

Figure 1: 1954 aerial photograph of a portion of an Army ammunition plant.

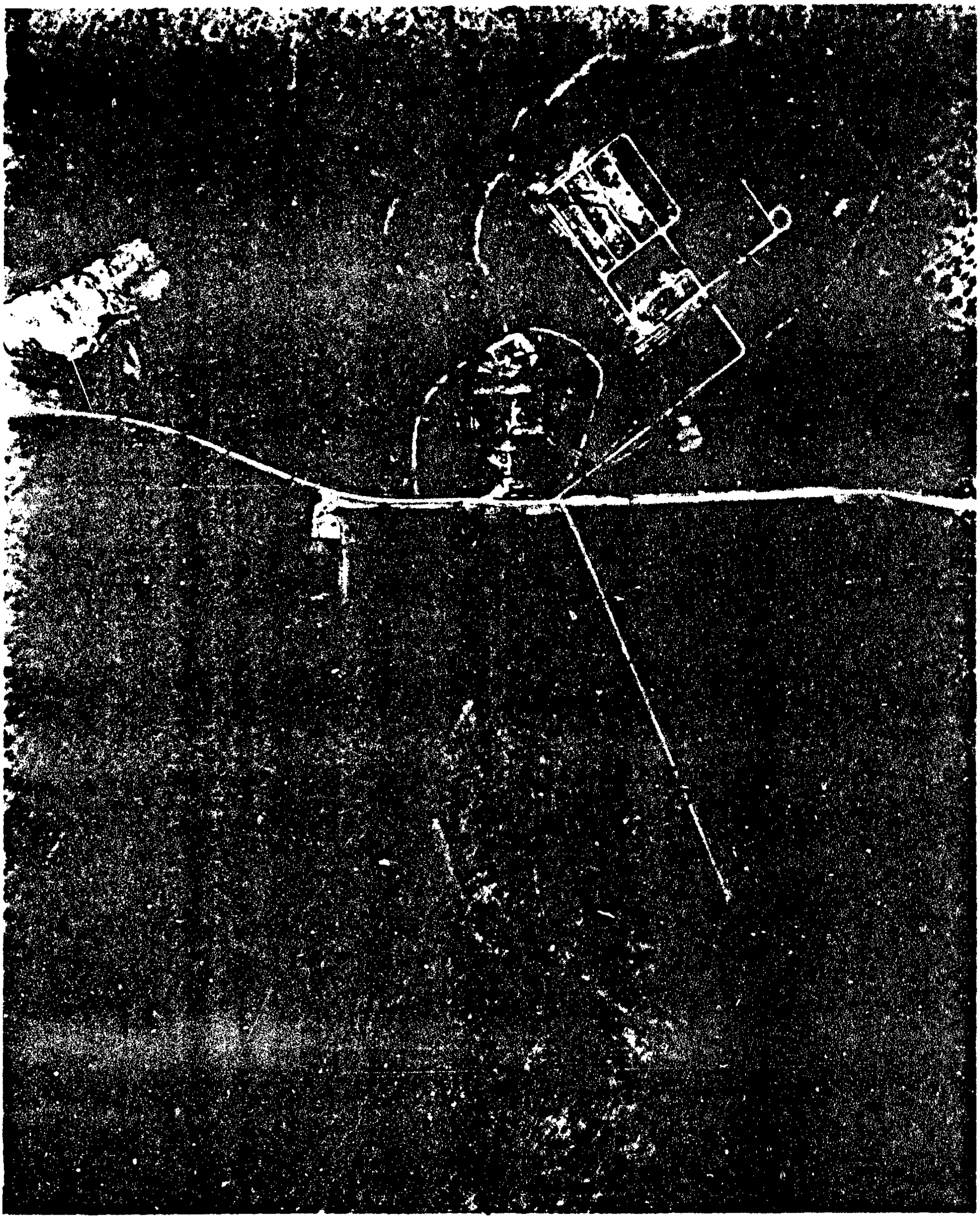

Figure 2: 1958 aerial photograph showing the same area.

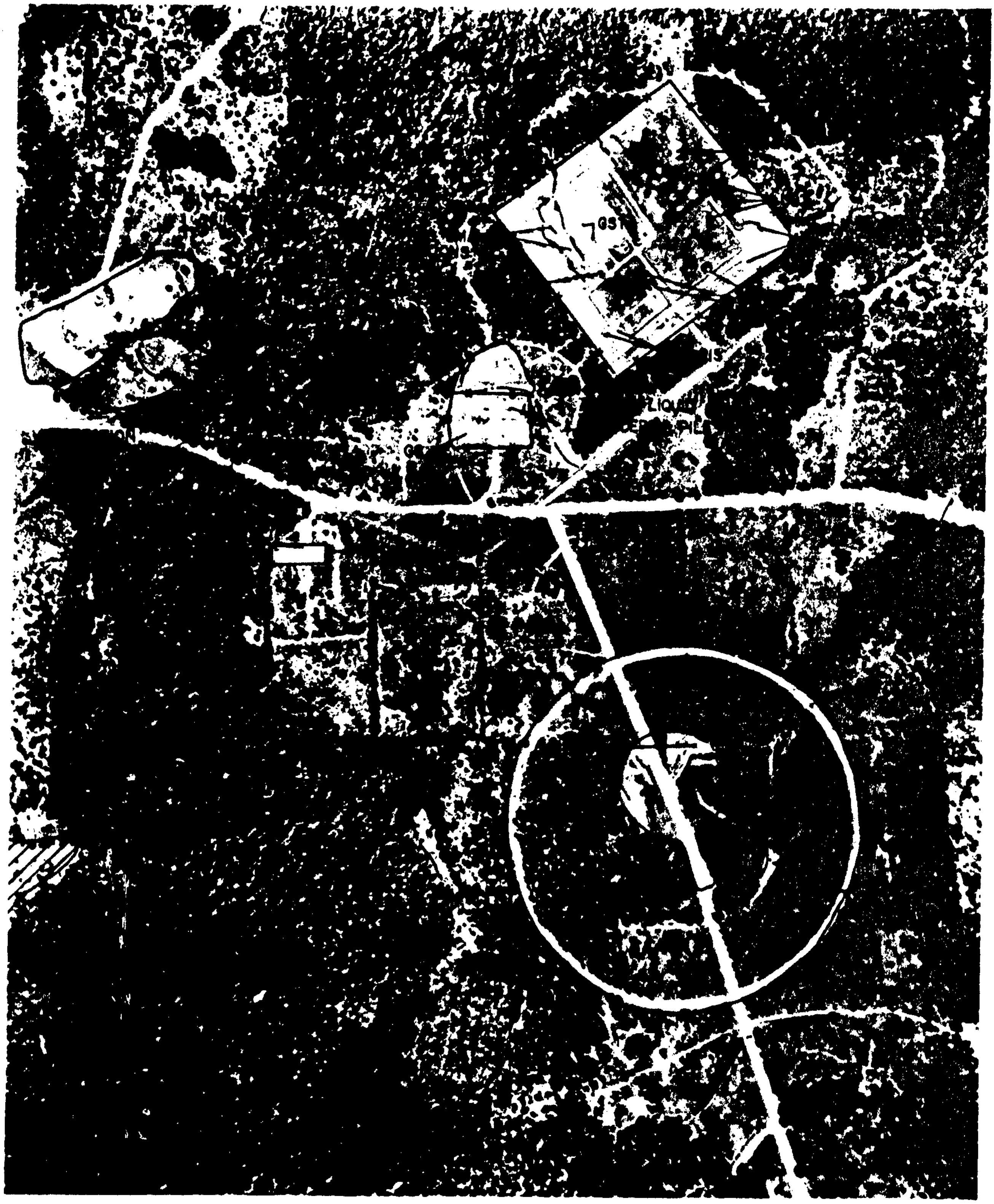

Figure 3: 1963 Aerial photograph showing the same area.

Figure 4: 1970 aerial photograph showing the same area.

LIST OF ATTENDEES

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THE BIONETICS CORPORATION

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USARMY CORPS OF ENGINEERS

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US ARMY CORPS OF ENGINEERS

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US NAVAL WEAPONS SUPPORT CNTR

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RESEARCH TRIANGLE INSTITUTE

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S-CUBED

S. CALDWELL
U.S. EPA

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US ARMY, USAMERADCOM

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HQ, AFESC/DEVP

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USATHAMA

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ENGINEERING-SCIENCE

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DEFENSE TECHNICAL INFO. CNTR.

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DAEN-MPO-U, DIRECTORATE OF

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UNIVERSITY OF MISSOURI

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ARMY ENVIRONMENTAL OFFICE

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I T ENVIRO SCIENCES

EDWARD P. PARRY
ROCKWELL INTERNATIONAL

KEVIN D. PLEDGER
THE BIONETICS CORPORATION

WILLIAM J POWERS
NAVAL ENVIRONMENTAL PROTECTION

C. DALLAS REACH, JR.
UNIVERSITY OF MISSOURI

MS. MARCIA READ
DAEN-MPO-U, EPA

HENRY RICCI
US ARMY ARRADCOM

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AMER. DEFENSE PREPARE. ASSOC.

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SVERDRUP & PARCEL & ASSOC.

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DYNAMAC CORP.

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INTEROX AMERICA

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ENGINEERING SCIENCE INC

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BATTELLE

MARY L. SCHURGER
IIT RESEARCH INSTITUTE

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NAVAL FACILITIES ENGNG. CMD

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1ST CSG/CC

JERRY STEINBERG
WATER & AIR RESEARCH

DAVID G. STENSBY
WISCONSIN DEPT. OF NATURAL

HUGH M. STIRTS
HQ SAC/DEVQ

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THE BIONETICS CORPORATION

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