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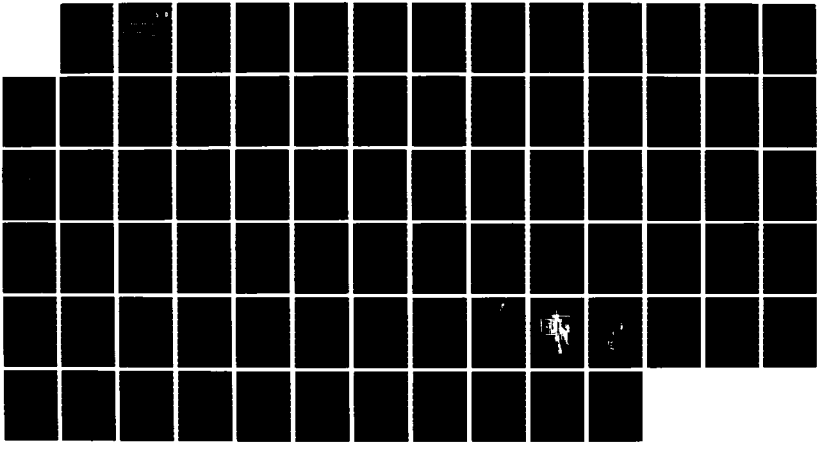

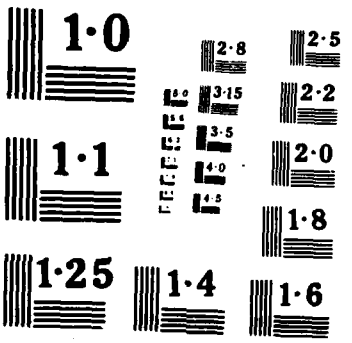
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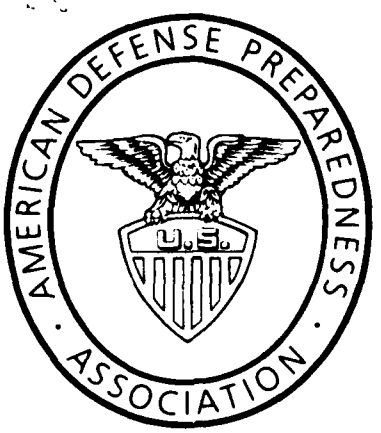

PROCEEDINGS

11th ANNUAL ENVIRONMENTAL SYSTEMS SYMPOSIUM

November 19-20, 1980
Marriott Key Bridge Hotel
Arlington, VA

American Defense Preparedness Association

National Headquarters: Rosslyn Center
Suite 900, Arlington, VA 22209

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SPEECH OF

GEORGE MARIENTHAL

DEPUTY ASSISTANT SECRETARY OF DEFENSE

(ENERGY, ENVIRONMENT AND SAFETY)

AT THE

AMERICAN DEFENSE PREPAREDNESS ASSOCIATION'S

ELEVENTH ANNUAL

ENVIRONMENTAL SYSTEMS SYMPOSIUM

MARRIOTT KEY BRIDGE MOTEL

ROSSLYN, VIRGINIA

NOVEMBER 19, 1980

- IT IS A PLEASURE TO BE HERE THIS MORNING AT THE 11TH ANNUAL ENVIRONMENTAL SYSTEMS SYMPOSIUM.

- I AM PARTICULARLY INTERESTED IN THE TOXIC AND HAZARDOUS WASTE ISSUE THAT WE ARE ADDRESSING AS A FOLLOW-ON FROM LAST YEAR.

- THAT ISSUE HAS BEEN OUR NUMBER ONE ENVIRONMENTAL PRIORITY FOR THE YEAR. IT WILL CONTINUE TO BE OUR NUMBER ONE ENVIRONMENTAL PRIORITY, IN ALL LIKELIHOOD, IN THE YEARS TO FOLLOW. I BELIEVE THAT WE HAVE MADE GREAT STRIDES IN THE MANAGEMENT OF HAZARDOUS WASTE WITHIN THE DEFENSE DEPARTMENT. WE HAVE A LONG WAY TO GO, HOWEVER.

- LAST YEAR, I PRESENTED OUR TOTAL CONCEPT OF THE CRADLE-TO-GRAVE MANAGEMENT OF HAZARDOUS MATERIALS, FROM PROCUREMENT AND PRODUCTION, THROUGH TRANSPORTATION AND USE, TO ULTIMATE RECYCLE, OR DISPOSAL.

- TODAY, I WOULD LIKE TO FOCUS ON THE END OF THAT MATERIAL MANAGEMENT STREAM, THAT IS, THE DISPOSAL OF HAZARDOUS WASTE. I WILL BREAK THE HAZARDOUS WASTE PROBLEM INTO THREE GENERAL AREAS TO DESCRIBE OUR MAJOR CONCERNS AND SOME MAJOR ACTIONS OVER THE PAST YEAR.

- FIRST, I WILL LOOK AT THE ABANDONED WASTE SITE PROBLEMS AND DISCUSS OUR PROGRAMS TO CONTROL ENVIRONMENTAL CONTAMINATION FROM PAST ACTIVITIES.

- THEN, I WILL PRESENT OUR MAJOR PROGRAM TO IMPLEMENT WITHIN THE DEPARTMENT OF DEFENSE THE RESOURCE CONSERVATION AND RECOVERY ACT HAZARDOUS WASTE MANAGEMENT REGULATIONS WHICH THE ENVIRONMENTAL PROTECTION AGENCY PUBLISHED THIS MAY.

• FINALLY, I WILL TOUCH BRIEFLY ON SOME SERIOUS PROBLEMS THAT WE FACE IN THE RADIOACTIVE WASTE DISPOSAL AREA.

• LET'S START WITH THE ABANDONED WASTE DISPOSAL SITE PROBLEM. LOVE CANAL, VALLEY OF THE DRUMS, AND ELIZABETH, NEW JERSEY, HAVE MADE THIS PROBLEM EXTREMELY VISIBLE AND HIGHLY SENSITIVE. CONGRESS HAS PROPOSED SUPERFUND LEGISLATION TO PAY FOR PROPER CLEANUP OF THOSE DUMPS EXCEPT THAT FEDERAL FACILITIES ARE NOT COVERED. THE ADMINISTRATION HAS MOVED FAMILIES FROM THE IMMEDIATE LOVE CANAL AREA. THE COURTS ARE SORTING OUT CULPABILITY AND FINANCIAL RENUMERATION.

• THE DEPARTMENT OF DEFENSE IS INVOLVED IN THIS INCREASED CONCERN. FOR EXAMPLE, LAST JUNE, I TESTIFIED BEFORE THE SENATE JUDICIARY COMMITTEE AND PRESENTED AN OVERVIEW OF DOD'S HAZARDOUS WASTE DISPOSAL PROGRAM AND OUR PROGRAM TO ABATE MIGRATION OF CONTAMINANTS FROM DEFENSE INSTALLATIONS. THE INTENSE QUESTIONS FROM THE COMMITTEE SHOWED CLEARLY THAT WE MUST REVISIT THE PAST WITH TODAY'S KNOWLEDGE TO RE-EVALUATE OUR DISPOSAL ACTIONS.

• I BELIEVE, HOWEVER, IN SPITE OF OUR PAST ACTIONS; THAT IS, WE, LIKE EVERYONE ELSE, DISPOSED OF WASTES WITHOUT TODAY'S KNOWLEDGE OF DISPOSAL TECHNIQUES, THAT WE ARE FAR AHEAD OF INDUSTRY AND MOST OF THE GOVERNMENT. SINCE 1975, DEFENSE HAS HAD ITS INSTALLATION RESTORATION PROGRAM TO ASSESS AND CONTROL ANY POSSIBLE MIGRATION OF ENVIRONMENTAL CONTAMINANTS UNDER, OVER, OR THROUGH OUR FENCES.

• THE ARMY HAS TAKEN THE LEAD AND DEVELOPED AN EXCELLENT PROGRAM WHICH THEY RECENTLY PRESENTED TO OUR NATO ALLIES AT A SEMINAR IN MUNICH, WEST GERMANY. THIS AFTERNOON, CHARLIE BARONIAN, DEPUTY

DIRECTOR OF THE US ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY, WILL DISCUSS IN SOME DETAIL THAT INSTALLATON RESTORATION PROGRAM.

- LATELY, THE NAVY AND AIR FORCE FINALIZED THEIR RESTORATION PROGRAMS, WHICH ARE VERY SIMILAR TO THE ARMY'S PROGRAM.

- I AM CONFIDENT THAT WE ARE FOCUSING ON THE MOST SERIOUS POTENTIAL PROBLEMS AND AM PLEASED WITH THE PROGRESS THAT WE ARE MAKING. WE WILL CONTINUE, HOWEVER, TO EMPHASIZE THE ABANDONED WASTE SITE PROBLEM AND TO DIRECT CONSIDERABLE ENVIRONMENTAL RESOURCES AND MANAGEMENT ATTENTION TO ASSURE THAT ENVIRONMENTAL CONTAMINANTS ARE NOT MIGRATING FROM OR CONTAMINATING GROUND WATER ON OUR INSTALLATIONS.

- WE HAVE LEARNED A LOT, PARTICULARLY FROM OUR EXPERIENCE AT REDSTONE ARSENAL WITH DDT, AT ROCKY MOUNTAIN ARSENAL WITH OTHER PESTICIDE RESIDUES AND FROM WURTSMITH WITH TCE.

- ABANDONED WASTE-DISPOSAL SITES ARE ONLY HALF OF OUR HAZARDOUS WASTE DISPOSAL PROBLEM, HOWEVER. WE ALSO MUST FACE OUR CURRENT WASTE DISPOSAL PROBLEMS. THAT PROBLEM IS, IN FACT, THE IMPLEMENTATION OF THE RESOURCE CONSERVATION RECOVERY ACT (RCRA) HAZARDOUS WASTE MANAGEMENT REGULATIONS WITHIN DEPARTMENT OF DEFENSE.

- THE SUMMER PUBLICATION OF THOSE EPA REGULATIONS PUT ALL OF US IN A NEW BALL GAME. LIFE JUST IS NOT AS SIMPLE AS IT WAS BEFORE. WE MUST FACE THIS REALITY IN OUR DEFENSE OPERATIONS AND DEVELOP A FEASIBLE APPROACH TO WASTE DISPOSAL THAT FITS WITHIN OUR EXISTING LOGISTICAL FRAMEWORK. I BELIEVE WE HAVE DONE THIS.

- WE HAVE PUBLISHED THREE SIGNIFICANT POLICIES THIS YEAR ON HAZARDOUS WASTE DISPOSAL.

- THE FIRST POLICY, WHICH IS OFTEN CALLED 80-5 AFTER OUR POLICY MEMORANDUM NUMBERING SCHEME, ASSIGNS THE RESPONSIBILITY FOR DISPOSAL OF HAZARDOUS WASTE. BASICALLY, WE HAVE DEVELOPED A SINGLE MANAGER APPROACH. THE DEFENSE LOGISTICS AGENCY'S PROPERTY DISPOSAL OFFICE IS RESPONSIBLE FOR THE DISPOSAL OF ALL HAZARDOUS MATERIAL EXCEPT FOR A FEW ITEMS THAT ARE SPECIFICALLY ASSIGNED TO THE DEFENSE COMPONENT WHICH GENERATES THE WASTE. WE ARE CURRENTLY WORKING OUT THE NITTY-GRITTY PROCEDURES TO IMPLEMENT THE SINGLE MANAGER APPROACH IN THE FIELD. TOMORROW, COLONEL HAMBLIN FROM THE DEFENSE PROPERTY DISPOSAL SERVICE WILL DISCUSS IN MORE DETAIL THAT SINGLE MANAGER ROLE OF THE DEFENSE LOGISTICS AGENCY IN DOD HAZARDOUS MATERIALS DISPOSAL.

- THE SECOND POLICY, WHICH IS REFERRED TO AS 80-8, DEALS STRICTLY WITH RCRA HAZARDOUS WASTE MANAGEMENT REGULATIONS IMPLEMENTATION. WITHIN DEFENSE, WE ARE PUTTING THE OVERSIGHT RESPONSIBILITY ON EACH INSTALLATION COMMANDER. WE HIRED HIM TO RUN THAT INSTALLATION, AND HE MUST ASSURE THAT WE ARE MEETING ALL FEDERAL, STATE, AND LOCAL LAWS ON THAT INSTALLATION. AS FAR AS THE REST OF THE WORLD IS CONCERNED, THAT INSTALLATION AS A WHOLE IS DEFENSE PROPERTY. THEY DON'T REALLY CARE, NOR SHOULD THEY, THAT WE HAVE A SHIPYARD OR AN AIR REWORK FACILITY OR A SUPPLY DEPOT WITHIN THAT FENCE. TO THEM, IT IS ONE INSTALLATION, AND THE INSTALLATION COMMANDER SPEAKS FOR THE WHOLE PLACE. IN FACT, HE (OR SHE) HOLDS THE EPA IDENTIFICATION NUMBER UNDER RCRA, SIGNS ALL RCRA PERMIT APPLICATIONS AS THE FACILITY OWNER, AND SUBMITS ANNUAL REPORTS TO EPA. OUR NEXT SPEAKER, MR. BILL

FRICK, WILL ADDRESS THE IMPACT THAT RCRA WILL HAVE ON DOD AND, THEREFORE, THAT INSTALLATION COMMANDER.

- OTHER SPEAKERS DURING THE TWO-DAY SYMPOSIUM WILL TOUCH ON MANY OTHER HAZARDOUS WASTE DISPOSAL PROBLEMS THAT FACE DEFENSE. ONE THAT IS PARTICULARLY INTERESTING IS THE DISPOSAL OF POLYCHLORINATED BIPHENYLS (PCBs). WE RECENTLY PUBLISHED POLICY MEMORANDUM 80-9 TO FOCUS ATTENTION ON THE SAFE STORAGE, MARKING, TRANSPORTATION, AND DISPOSAL OF PCBS. THAT POLICY EXPANDS THE BASIC GUIDANCE OF 80-5 FOR THAT PARTICULARLY LARGE DISPOSAL PROBLEM. BILL POWERS AND STEVE COYLE WILL PRESENT SOME NAVY AND AIR FORCE, RESPECTIVELY, COMMENTS ON THE PCB PROBLEM.

- FINALLY, I WOULD LIKE TO DISCUSS THE ISSUE OF DISPOSAL OF RADIOACTIVE WASTES. THERE ARE PRESENTLY ONLY THREE NUCLEAR REGULATORY COMMISSION LICENSED DISPOSAL SITES FOR RADIOACTIVE WASTES. THESE PRIVATELY-OPERATED SITES ARE IN BARNWELL, SOUTH CAROLINA, BEATTY, NEVADA, AND HANFORD, WASHINGTON. DEFENSE'S CONTINUED USE OF EACH OF THOSE SITES IS UNCERTAIN.

- IN MAY, 1980, SOUTH CAROLINA PASSED A LAW TO REQUIRE ANY SHIPPER OF RADIOACTIVE WASTE TO SOUTH CAROLINA TO OBTAIN A PERMIT. WE HAVE OBJECTED TO THE INDEMNIFICATION AND PROOF OF FINANCIAL RESPONSIBILITY REQUIREMENTS OF THE PERMIT.

- LAST YEAR, THE STATE OF WASHINGTON REQUIRED ALL SHIPPERS OF RADIOACTIVE WASTES TO INDEMNIFY AND HOLD HARMLESS THE STATE OF WASHINGTON. SINCE THERE IS NO AUTHORITY OR LEGAL ABILITY AT THIS JUNCTURE FOR DEFENSE TO HOLD THE STATE HARMLESS, WE HAVE STOPPED SHIPMENTS OF WASTE TO WASHINGTON. ALSO, THE PEOPLE OF THE STATE JUST RECENTLY PASSED A REFERENDUM WHICH PROHIBITS THE DISPOSAL OF

ALL RADIOACTIVE WASTE, EXCEPT FOR MEDICAL WASTES, WHICH WAS NOT GENERATED IN THE STATE.

- IN SEPTEMBER, 1980, THE NUCLEAR ENGINEERING COMPANY, WHICH OWNS AND OPERATES THE NEVADA SITE, DENIED A DOD COMPONENT FURTHER USE OF THAT SITE BECAUSE OF UNSAFE SHIPMENTS OF RADIOACTIVE WASTE.

- OUR CONTRACTORS ARE ALSO TROUBLED WITH THE DISPOSAL OF RADIOACTIVE WASTES. FOR EXAMPLE, DURING THE PRODUCTION OF CERTAIN MILITARY AMMUNITION, SUCH AS THE PENETRATOR WHICH CONTAINS DEPLETED URANIUM, LARGE QUANTITIES OF VERY LOW LEVEL RADIOACTIVE WASTE ARE GENERATED. THE ABILITY OF OUR CONTRACTOR TO PRODUCE THE ESSENTIAL AMMUNITION OBVIOUSLY HINGES UPON THE AVAILABILITY OF A SUITABLE WASTE DISPOSAL SITE.

- IN EACH OF THE SITUATIONS MENTIONED, WE ARE WORKING WITH THE STATES, AND THE DEPARTMENTS OF ENERGY AND JUSTICE, TO FIND SOLUTIONS.

- LET ME CONCLUDE THIS MORNING BY REITERATING THE IMPORTANCE OF THE HAZARDOUS WASTE DISPOSAL ISSUE IN THE ENVIRONMENTAL ARENA. IT IS THE ENVIRONMENTAL PROBLEM OF THE 1980s. DEFENSE IS COMMITTED TO FACE SQUARELY THIS PROBLEM AS WE DID THE AIR AND WATER POLLUTION PROBLEMS IN THE 1970s. WE NOT ONLY WILL FACE THEM, BUT I KNOW WE WILL CONTINUE TO BE A LEADER IN THE ENVIRONMENTAL COMMUNITY.

- THROUGH THE DEDICATION, FORESIGHT, AND INITIATIVE OF OUR PEOPLE AT ALL LEVELS, AND PARTICULARLY AT EACH INSTALLATION, WE WILL SOLVE THIS PROBLEM.

- THANK YOU FOR YOUR SUPPORT BY BEING HERE THIS MORNING. THANK YOU ALSO FOR THE OPPORTUNITY TO JOIN YOU FOR THIS MOST IMPORTANT ENVIRONMENTAL SYSTEMS SYMPOSIUM.

- IF THERE ARE ANY QUESTIONS, I WILL BE HAPPY TO TRY TO ANSWER THEM.

ASSESSMENT AND CONTROL OF POLYCHLORINATED BIPHENYLS (PCBs)

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NAVYWIDE APPROACH

The Naval Energy and Environmental Support Activity (NEESA), as part of its hazardous materials program, has developed a Navywide approach for managing PCBs. The Navy's approach is detailed in the PCB Compliance, Assessment and Spill Control Guide (NESO 20.2-028) developed for use by Navy activities for complying with EPA's complex PCB regulations. The guide was designed to be used as part of an activity's overall PCB awareness program and contains the following information:

- Summary of EPA's PCB regulations
- Major compliance dates
- Methods for evaluating and assessing activity compliance.
- Procedures for determining project priorities
- Spill prevention and control procedures
- Spill prevention control and countermeasures (SPCC) planning requirements
- Standard inventory report forms
- Alternative and substitutes for PCBs

ACTIVITY SURVEY

Regardless of the size, location, or mission of an activity, a one-time PCB survey must be conducted. The survey should include an activity compliance evaluation and a general risk assessment of all PCB transformers located at the facility.

A. Compliance Evaluation

An evaluation of an activity's current compliance status with EPAs PCB regulation must be conducted by inspecting all PCB items and operations.

B. Risk Assessment

Initially, all PCB transformers must be visually inspected, using the transformer risk assessment form and assessment schedule provided in the NEESA Guide. Pertinent questions provided on the assessment form relating to transformer contents, location, and conditions are all critical factors that must be addressed in order to adequately assess PCB transformers. Answers to all questions are weighted, and points are assigned for determining relative priorities. These points, when totaled, are also used to assess the general risk by using the risk factor schedule developed.

C. Hazard Ranking System

A transformer hazard ranking system, which incorporates information gathered during the initial risk assessment, is used to determine the specific priority group from one of three groups and the hazard category, which is selected from one of 13 categories. This is done for each PCB transformer inspected. The specific number of

points assigned to a given transformer during the initial risk assessment (inspection) is used to rank specific transformers against others within the same group and category. For example, a leaking PCB transformer located in a food handling area, accumulating 314 points, would have the following hazard ranking

Group	Category	Risk Assessment
I	B	314 Points
(leaking)	(food handling area)	

Most of the information concerning an activity survey and assessment can be gathered by electrical technicians as a part of their normal inspection visits or during required maintenance. Additional information can be collected as a part of the activity's Environmental Engineering Survey.

When discovered during the activity evaluation and risk assessment, the following items require immediate action on the part of the activity.

- Leaking PCB transformers resulting in ground/surface water contamination or contamination of food handling or storage areas.
- Improper storage of PCBs.
- Improper disposal of PCBs.
- Lack of or improper use of personnel protective equipment.
- Improper labeling of PCB transformers, equipment, capacitors, or containers.
- Improper recordkeeping.

A more detailed explanation of the hazard ranking system and risk assessment procedures can be found in the NEESA PCB Guide.

SPILL CONTROL

EPA requires the development of both spill prevention control and countermeasures (SPCC) plans, (describing berms, dikes, and other equipment installed to control spills) and a spill contingency (response) plan for PCB storage areas. EPA, however, only requires that spill contingency plans be developed for power sub-stations and other areas using PCB transformers in outdoor locations. Activities storing PCBs, or operating equipment containing PCBs, must be prepared for handling spill emergencies. These activities should properly train employees to handle PCB spills.

Being properly prepared for handling PCB spill emergencies requires prior preparation of a PCB spill kit and understanding the steps to be followed when a spill occurs. A PCB spill kit should contain needed cleanup equipment and an emergency spill procedures sheet and must be labeled and designated for use in handling PCB spills. Most items required for spill response can be obtained through the Federal supply system or local manufacturers and suppliers.

The exact size, content, and location of each spill kit will vary with the amount of PCBs and the location and type of equipment used at the activity. Each vehicle that transports PCBs should also have a spill kit for cleaning up and decontaminating spills that may occur during transport. The exact content of each spill kit should be tailored to the needs of the individual activity.

Personnel working with PCBs or in areas containing PCB equipment should be adequately trained in quick evacuation and proper spill prevention and emergency procedures, as follows:

1. Safety and First Aid

All persons working with equipment containing PCBs should be well trained in basic first aid and safety procedures. It must be emphasized that, when handling any spill, the most immediate concern is for the health and well-being of persons in and around the immediate spill area.

2. Identification

If possible, determine the quantity of PCB and type of equipment involved in the spill incident. Information, such as the trade name of dielectric spilled and the equipment manufacturer's name and address, should be obtained.

3. Site Security

The spill site must be adequately secured against entrance by unauthorized personnel by roping off the area and posting warning signs. If necessary, assistance should be obtained from police or fire department personnel.

4. Spill Reporting

Not all PCB spills warrant reporting to EPA or the Coast Guard. However, spills threatening/entering waterways or involving PCBs in quantities equal to or exceeding the 10 pounds (4.54 Kg) designated reportable quantity (RQ) specified in EPA's Clean Water Act (CWA) must be reported.

5. Containment and Control

Spilled PCBs must be contained on site where the spill occurs. PCBs must be kept from entering storm drains, wells, water systems, and navigable waterways.

6. Cleanup

Adequate cleanup of spilled PCB is essential in order to remove any health or environmental hazards. When cleaning up PCB spills, it is advisable NOT TO WORK ALONE and to make sure the area is properly ventilated and that appropriate safety equipment is used. The activity's safety office should be contacted concerning proper safety equipment.

7. Decontamination

Depending on the location of the spill, appropriate solvents, such as kerosene, trichloroethane, trichlorobenzene, etc., can be used to effectively decontaminate most spill areas after cleaning up the bulk material.

Appropriate solvents should be used in conjunction with absorbent materials to decontaminate concrete floors, transformer pads, and tools.

8. Disposal

Soil and debris, considered to be contaminated, require cleanup and proper disposal in specially approved EPA disposal sites. Contract laboratory services are available for sampling and testing to help determine if PCB concentrations in soil, water, or other materials has reached a contaminated level.

DESTRUCTION OF POLYCHLORINATED BIPHENYLS

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McClellan Air Force Base, an Air Force Logistics Command (AFLC) installation located in Sacramento CA, is attempting to conduct a trial incineration of Polychlorinated Biphenyls, which, to our knowledge, no other public agency has ever attempted. In this paper, we will examine the technical aspects, political realities, and lessons learned from an attempt to contribute to pioneering efforts in hazardous waste destruction.

PCB is a class of nonflammable chlorinated hydrocarbons which is very stable chemically. PCB was a commercially attractive substance because of its numerous desirable characteristics which made it an excellent dielectric fluid for use in electrical devices. Unfortunately, these properties, such as resistance to degradation, contribute to PCB's basic harmful effects. After 50 years of being manufactured, PCB has now gained the reputation of being one of the most difficult chemicals to properly handle, rather than as the excellent dielectric fluid it is. By direction of Congress, as stipulated in Section 6 (e) of the Toxic Substances Control Act, EPA essentially banned PCB from further production, processing, and distribution. The controls placed on disposal of PCB items or liquids are categorized by PCB concentration or contamination level. The strictest control applies to liquids containing more than 500 ppm; only high temperature incineration is allowed. But presently there are no EPA approved incinerators available to the public for commercial use.

A logical question to be answered is why McClellan AFB is attempting to burn PCB? McClellan generates large amounts of PCB due to their mission as a maintenance, repair, and storage center for communication and electronic equipment. Located at McClellan's industrial waste treatment area is a hazardous waste incinerator adaptable to burn PCB. Since the national disposal situation dictated that PCB remain in storage, McClellan viewed the incinerator as a logical and relatively inexpensive way of handling its PCB. In addition, McClellan had developed an expertise in handling PCB. Finally, there were prospects of great benefit being derived from the demonstration. As a minumum, the public could utilize the technological data for future attempts to incinerate PCB or other tightly controlled hazardous wastes.

The project was initiated in September 1976 by McClellan personnel and the AF Occupational and Environmental Health Laboratory (OEHL) located at McClellan at that time. The initial Air Force tests involved burning various fuels, including JP-4, a high BTU content jet fuel, then two chlorinated hydrocarbons mixed with JP-4. In accordance with procedures in 40 CFR, Part 761, McClellan initially filed in February 1978 for trial burn approval. Based on Air Force's test results and EPA data from laboratory testing and modeling studies, Region IX EPA approved a program for McClellan to demonstrate the destruction capability of the incinerator.

The program consisted of:

a. Testing the incinerator using chlorinated hydrocarbon compounds;

b. If step one proved successful, test burn a small amount of PCB to demonstrate

complete and safe destruction;

c. And concurrent use of extensive monitoring and analysis procedures.

Having successfully completed the first step, McClellan was granted permission for the second part in December 1979. Under the regulations, a trial burn is optional at the discretion of the Regional EPA administrator. Partly because McClellan was not attempting to incinerate under the exact conditions specified in the regulations, a trial burn was mandated. Trial burns, by the way, have been required for all other attempts to get PCB incineration permits.

The public was kept fully aware of all aspects of the potential incineration at McClellan. The base and the EPA requested comments from appropriate public agencies at several points in the permitting process. No objections to the burn were received from the agencies. An environmental assessment, meeting all National Environmental Policy Act requirements, was prepared and a Finding of No Significant Impact was concluded. This conclusion was based on the premise that the trial burn involved only a small quantity of PCB, and extensive precautions were being taken. These findings and details of the burn were released to the public.

As steps were taken to accomplish the trial burn, AFLC continued to evaluate other PCB disposal methods. A panacea for the PCB problem might have persuaded us to postpone the trial. A detoxification technique, using sodium naphthalide, has been demonstrated lately in Canada and by Goodyear Corporation. Unfortunately, the process, which has been known for decades, has the potential for explosion and has not been attempted on a production basis or with high PCB concentrations. EPA approval of the process is expected to be lengthy and not at all certain. Other destruction techniques, such as Sunohio's process and diesel incineration, were also investigated. At this point based on available data, it appears that incineration is the most logical disposal technique.

Other incineration operations have been monitored, but primarily to glean data relevant to the success of McClellan's trial burn. The feasibility of incineration is illustrated by the operating incinerator in Waterford NY, owned by General Electric and used only for the facility's waste. Ensco's rotary kiln in Eldorado AR, and Rollin's high temperature incinerator in Deer Park TX, were approved for trial burns and completed their tests in 1979. As part of the elaborate monitoring procedures, air emissions were checked for PCB and the related compounds, Polychlorinated Dibenzo-Furans, which sometimes are by-products of PCB breakdown. No detectable amounts were found. Polychlorinated Dibenzo-Dioxins (Dioxins), which are also possible by-products, were not checked at either site. Both tests and their results were considered valid by EPA, but uncertainty as to the testing procedures or actual test results arose when Dibenzo-Furans (Furans) were found in the residual ash of the Arkansas rotary kiln. Therefore, EPA required a retest at both sites. McClellan decided to wait for the retesting results (particularly from the similar Texas incinerator) before conducting the trial. But we anticipate favorable results, because tests have shown Furans and Dioxins to be destroyed at temperatures between 600-720^{o}C which is much lower than PCB incinerator temperatures.

In granting the trial burn approval, EPA stipulated certain requirements. Some of the key criteria of our burn are (1) The burn must be completed by 31 December 1980 (2) The demonstration is to be broken into three two-hour burns over a three-day period, (3) Only about 125 gallons of PCB is authorized to be burned, and we plan to burn only 65 gallons, (4) PCB will be mixed with JP4 at a 20% PCB, 80% JP4 mix, (5) The EPA requires a 99.9% combustion and destruction efficiency. Based on previous test data and modeling results,

we expect a destruction efficiency of 99.9999%. In 1979, Deer Park TX, and El Dorado AR, obtained destruction efficiencies in excess of 99.9999%. Both of these incinerators are operating with similar temperature, dwell time and excess oxygen characteristics we will use. Modifications are under way at McClellan to increase the dwell time, and maintain the temperature and excess oxygen so that these conditions meet or exceed those published in the 31 May 1979 Federal Register.

The incinerator's combustion chamber is preheated to 1200°C using natural gas, then the PCB/JP4 mixture is injected. The chamber is equipped with redundant temperature sensitive shutdown and alarm systems set to activate if the temperature in the chamber drops. This action would terminate the waste fed to the incinerator. Additionally, combustion efficiency is monitored continuously in the chamber to ensure we obtain the 99.9% required by the EPA. If it falls below this percentage, the incinerator will be immediately shut down. From the chamber, the combustion gases travel through the venturi scrubber system, and then out the stack. The water from the scrubber will be stored in an imperviously lined lagoon and evaporated. The impurities, now solid waste, will be disposed of at a chemical landfill. The gases that are discharged out the stack will be monitored both at the stack and at strategic locations upwind and downwind.

The discharged gases as well as the scrubber water will be analyzed for PCBs, Dioxins, Furans, and other possible pollutants. McClellan has performed computer modeling of potential PCB concentrations going out the stack at a relatively low destruction efficiency of 99.9%. They found no adverse health or environmental impacts on the surrounding community. There is no ambient air standard for PCB; however, they have based this determination on the strictest occupational and safety health standards. For the minimum acceptable destruction efficiency - 99.9% - and assuming normal weather characteristics, the maximum ambient air concentration of PCB would be over 300 times less than this OSHA 8-hour daily exposure limit. The area adjacent to this part of the base is sparsely populated. The nearest resident is almost one kilometer away--the distance at which the PCB concentration would be at least 3000 times less than the OSHA standard. In neither of the 1979 demonstration burns, in Texas or Arkansas, were PCBs or Furans detected in the ambient air. Dioxins have never been detected as by-products of PCB incineration.

Other precautions to assure a quality burn include:

a. Prenco, the manufacturer, and our Air Force experts inspected the incinerator, finding it in excellent condition. Also Prenco will operate the incinerator;

b. OEHL will supervise the monitoring and analysis to be performed by a contractor;

c. and, every step of the burn will be documented. The records will be open to the public, allowing the data to assist others who have the PCB waste problem.

Due to increased public awareness of the burn, many issues, such as dwell time, air emissions, burn residues, and safety features became points of contention. The base diligently tried to address all these points, but the conditions for the burn have changed in part due to this concern. For example:

a. Some regulatory agencies in California have recently contemplated requiring McClellan apply for air and water permits as prerequisites for the burn. However, the only permit required for the demonstration burn per se is granted by Federal EPA.

b. One benefit of the demonstration was to ascertain whether EPA's incineration

criteria can be modified with minimal effect on combustion efficiency. A concession to satisfy some parties was to alter the incinerator to comply with EPA's published criteria.

After approaching the PCB incineration idea with caution, informing the public at numerous points, and assuring proper technological considerations, our incineration attempt has been delayed by recent developments. But the experience has its positive side that will prove beneficial in the future. While AFLC is not planning to production burn PCB, we hope that a spin off of this demonstration will be to open new doors to more cost effective PCB disposal. Also, McClellan, AFLC, and DOD are learning new lessons or reconfirming old ones from this situation. The nation has a definite need for a hazardous waste disposal capability, and DOD has shown again that it has the know-how and the desire to assist in developing new disposal technology. Unfortunately, we have seen that not all of our attempts are viewed in a positive light. DOD must assist in educating the public about hazardous waste problems and about the available and/or feasible means of dealing with the problems. Siting of hazardous waste facilities is a sensitive issue that will find many political entities at odds and the public confused and angry, if we do not learn from situations such as these.

SOLIDIFICATION/STABILIZATION OF MILITARY WASTES

by

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In activities related to building and maintaining a defense capability, the military generates many waste products which are classed as hazardous or toxic. The development of techniques for the safe disposal of these materials in a way that poses a minimum threat to human health or the environment is a requirement now mandated by Federal Regulations. The military and all other Federal Agencies that are responsible for hazardous waste have been ordered to meet all requirements placed on civilian waste disposal activities.

Hazardous waste produced by many Army arsenals and Army depots characteristically are closely related to hazardous waste from comparable civilian activities. For example, Army depots involved in vehicle recovery and maintenance or rebuilding of small arms typically have wastes associated with metal surface cleaning, paint stripping and metal plating such as an automobile assembly facility might produce. Arsenals working with explosives and propellants produce wastes comparable to those from some sectors of the civilian chemical industry. Solutions to hazardous waste disposal problems posed for waste from civilian activities can, in many cases, be adapted to military wastes.

In almost any disposal program, whether it involves thermal treatment, precipitation, or incineration some solid waste residue that cannot be further degraded will be produced. The usual solution in such cases is land disposal in a landfill suitable for hazardous waste. New regulations on hazardous waste landfills make it desirable to treat waste prior to landfilling to assure that the material is in an inert immobilized form. The major technology involved in pretreating waste for landfilling is referred to as solidification/stabilization and usually involves converting the waste to an insoluble form and incorporating the material into a solid, monolithic mass.

The process of solidification/stabilization proceeds in three steps: a) production of the solid or semi-solid waste product; b) addition of a material that will produce binding or cementation in the waste material; c) curing or hardening of the treated wastemass to produce a material of low permeability and high chemical stability. An additional step that involves the production of a layer of jacketing material can also be used to further ensure that the waste is isolated from the environment.

Solidification/stabilization systems can be classified on a basis of the types of binders employed. These include materials such as: a) lime/pozzolan cement; b) plaster-like products; c) portland cement; d) thermoplastic materials; and e) organic polymers. The long-term success of solidification/stabilization in immobilizing hazardous waste is directly related to the concentration of the waste in the surface of the waste material, the rate of diffusion of groundwater or precipitation through the waste, and the impermeability and durability of the treated product. Generally, the lower the degree of containment provided by the solidification/stabilization process, the greater the degree of containment required from the landfill design. An impermeable, highly insoluble, treated waste can be placed in a landfill in the humid eastern United States with some assurance that no contamination of the surrounding area will occur. Untreated waste, on the other hand, might be disposed of safely only in a secure landfill in the arid western United States.

Each major solidification/stabilization system offers advantages and disadvantages. Lime/pozzolan systems utilize the least expensive binder material--lime and fly ash, or slag; but tend to produce solids of low strength and having moderate leach loss rates. Plaster-like products produced from reactions with calcium sulfate tend to exhibit similar characteristics. Products produced with portland cement can be made stronger and less leachable but are more expensive to produce than lime/pozzolan treated wastes. Incorporating waste into heated thermoplastic materials such as asphalt or polyethylene can greatly reduce leach losses because of the hydrophobic nature of these binders. Additional costs arise from the requirement that the waste be dried prior to incorporation and from the relatively high cost of asphalt or scrap polyethylene. Other problems arise from the flammable nature of the binders.

Organic resins, particularly organic resins that can be produced in an aqueous mediem such as polyester or urea-formaldehyde materials, have been useful in producing solids from waste. Organic binders do not usually form bonds with the waste but simply form a polymermatrix that traps the waste particles and excess liquid. Leach rates are reported to be low, but in some of these products the entrapped water slowly leaks out to produce a "weeping" solid.

The cost of waste solidification/stabilization is variable depending on the nature of the waste and the transportation of the necessary [illegible]. Cost for cement or lime/pozzolan systems can be roughly estimated from the cost of lime and cement. The processes could be expected to cost $50.00 to $70.00 per metric ton. Thermoplastic materials are more expensive and cost could reach $300.00 to $400.00 per metric ton. Organic polymer systems could cost approximately $600.00 per metric ton.

Any hazardous waste disposal system used in Army operations can be expected to add to the cost. The goal for the Army is to obtain the surest waste contaminent with minimum cost. The expenses involved in cleaning up a hazardous waste site after toxic materials have moved into surrounding soil and water are so great that this risk alone justifies cost incurred in solidification/stabilization of toxic waste.

DETECTION AND IDENTIFICATION OF BURIED WASTE AND MUNITIONS

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INTRODUCTION

The successful decommissioning and decontamination (D&D) of sites containing obsolete, unidentified, and ofttimes buried munitions depends on the ability to perform a series of challenging technical tasks. In the more general case, the following sequence must be accomplished:

1) Locate buried objects that may correspond to munitions
2) Characterize targets in terms of composition, size, shape, and depth to identify possible or probable munitions
3) Excavate, deactivate, and/or dispose of the munitions.

These tasks are analytical in nature and involve the application of sophisticated equipment and methods developed for a variety of related activities, but only recently directed to military problems. The latter task generally requires that the fill of the munition be identified in order that appropriate disposal methods are employed. The following discussion presents background information on some of the approaches available to conduct these analytical tasks. It also includes results of recent work performed under contract for the army.

DETECTION OF BURIED MUNITIONS

Metal Detection

Metal detection is the most widely known of the six survey techniques employed. It has long been used as a means of locating land mines in wartime. More recently, commercial units have been marketed for use by "treasure hunters" and coin collectors.

Evaluation of commercially available, hand-held metal detectors proved them to be useful for locating various metal objects including large masses of scrap, barrels, and pipes positioned vertically or horizontally in the soil. The detectors were found to be insensitive to elongated objects of small cross section (e.g., metal rods) even at short range. While detection range varies in a complex manner with several factors, it was concluded that objects could be detected at a depth of two to four times the object's diameter, width, or other representative dimension.

Magnetometry

Magnetic field measurements can be used to locate buried ferromagnetic objects such as munitions, steel containers, steel scrap, etc. This method is based on the fact that an induced magnetization is produced in any magnetic material within the earth's magnetic field. The induced field is superimposed on the earth's magnetic field and, if sufficiently large, can be detected as an anomaly or an aberration in the ambient field. Surveys are normally performed on a uniform grid with spacings determined by the expected size and depth of the objects sought.

The induced magnetic field of a buried object depends on the size, shape, depth of burial, orientation and susceptibility of the object, as well as on the direction and intensity of the earth's field. Analytical solutions for induced magnetic fields can be obtained for special object shapes, such as spheres and cylinders, and it is generally possible to compute fields due to complex shapes by digital computer methods. However, in the inverse calculation, which is the case of primary interest in geomagnetic surveys, no unique set of parameters can be determined from a measurement of the magnetic field patterns. In other words, an indefinitely large number of combinations of parameter values can produce the observed magnetic anomaly.

Ground-Penetrating Radar

Many aspects of radar technology have become highly advanced and sophisticated. Recent developments in electronics and data processing equipment have enhanced the reliability, power and flexibility of radar systems. However, these remarks apply primarily to radar systems designed for above-ground applications. There has not been the same intensity of effort to develop downward-looking systems, although substantial progress has been made in recent years.

In applications which involve the detection and characteriztion of discrete objects or underground structures, resolution requirements demand the use of short radar wavelengths, generally less than 5 meters. Unfortunately, many ground materials are strong absorbers of electromagnetic energy at short wavelengths. Strong absorption by the ground usually requires the use of radar wavelengths greater than about 0.5 meter.

The water content of the soil is the most important factor affecting electromagnetic absorption loss, and thus the magnitude of the effect depends on the composition and porosity of the ground material.

Additional loss factors which affect the performance or effectiveness of a given ground-penetrating radar system include reflective losses at the air-ground interface, geometrical spreading of the transmitted radar beam, the effective backscattering cross section of the reflective target, and the spreading of the reflected signal. A positive factor is a refractive gain due to the focusing effect of the dielectric medium. Field experience suggests that these factors usually limit vertical penetration to less than 40 feet in dry sandy soils and perhaps 5-10 feet in saturated clays. Specific range data must be calibrated on for each particular site.

An important attribute of ground-penetrating radar is that it can detect a wide variety of materials, both

metallic and nonmetallic. Because a radar signal is reflected by any surface or interface that corresponds to an abrupt change in dielectric constant, ground-penetrating radar can detect voids, rocks, wood, and many other materials as well as metals. However, the present state of the art is such that under the conditions commonly experienced in field surveys, it is often difficult or impossible to determine the composition (or even size and shape) of a buried reflective object from radar measurements alone. Research and development efforts will undoubtedly result in improved ground-penetrating radar system capabilities and data analysis procedures in the future. At the present time, measurement devices such as metal detectors and magnetometers can provide useful supplementary information about objects or materials detected and mapped by available radar systems.

Infrared Imaging

Changes in soil properties and moisture content can, under favorable conditions, cause distinctive temperature, thermal emissivity, or thermal inertia patterns. When these changes are associated with buried materials and backfill in disposal trenches, thermal infrared imaging by means of opto-mechanical aerial scanners is a potentially effective mapping technique. Exploratory aerial surveys have been conducted during various times of the day to test this approach. The observed thermal patterns were found to largely reflect differences in surface materials and vegetation density, although a series of buried vertical pipes was located. It was postulated that surface effects would be minimized by repeated use of thermal infrared surveys over a period of time which would allow one to characterize the thermal inertia of the ground.

In some cases, the standard methods of infrared aerial photography may be effective. Those cases would generally involve burial sites where trenches or pits have been excavated and backfilled or where there is chemical contamination in the soil. The observable effect would be variations in vegetation density, type or vigor in the excavated or contaminated areas. Often, the reflectance spectrum of plants in the near infrared band is a sensitive indicator of plant stress which can occur in chemically contaminated soils.

Acoustic Reflection Profiling

Acoustic survey techniques are best suited to the detection and mapping of large objects or masses or buried materials. At least five methods are potentially applicable: reflection (or pulse-echo) profiling, refraction profiling, travel time measurements, acoustic holography, and mechanical impedance mapping. While all five approaches present problems in dry sand and gravel, the first approach was considered to be the most promising and the most easily implemented. The principle involves interpretation of sound waves reflected from interfaces or objects in the ground.

The field experiments involved a pattern of detection devices (geophones) and an acoustic source (a steel plate struck with a sledge hammer). The most effective procedure involved the use of coincidence detectors (geophones positioned equidistant on either side of the source), selecting only reflections reaching the detectors simultaneously.

Although the coincidence measurements provided useful data, the overall results have not been promising in dry, homogenous sediments. On the other hand, an acoustic refraction survey at Love Canal in Niagara Falls, New York proved to be very successful. The tight, saturated clay in the area which hampers radar transmission provided good acoustic propagation characteristics.

Acoustic Holography

Acoustic holography utilizes principles similar to those of acoustic reflection and refraction. In a field experiment, geophones were emplaced at depth in observations holes and the sound source was moved across a surface grid. By Fourier methods it was possible to construct a three-dimensional image of the subsurface volume being investigated and to obtain an outline of a burial trench. Like other acoustic methods, this method is best suited to the detection of large objects, masses, or structures and requires a favorable propagating medium such as clay or solid rock.

Electrical Resistivity

Electrical resistivity is an indirect survey technique applicable to mapping of subsurface areas much the same as acoustic and radar methods. Depth is limited only by the voltage available and safety considerations. However, these practical constraints typically restrict use to relatively shallow investigations. The technique is based on the detection of changes in the electrical conductivity (or resistivity) in the ground due to the presence of buried objects. As such, the technique is most useful in areas with a relatively homogeneous native soil structure, and when applied to the detection of large objects or masses.

Comparative Analysis

As a result of the comparative studies that have been conducted, the relative advantages and disadvantages of the seven means of source assessment are presented in the tabulation following.

Based on the findings of the Hanford evaluation, researchers at Battelle have selected metal detection, magnetometry, and ground-penetrating radar for inclusion in an integrated survey unit for burial ground investigations. The radar unit was developed by Geophysical Survey Systems, Inc. and operates at a frequency of approximately 300 MHz. The vehicle was specially constructed of nonferrous materials to facilitate the use of a magnetometer mounted alongside the radar unit. In addition to transporting the radar and magnetometer, the vehicle contains a microcomputer and a telemetry system which acquires, preprocesses, and transmits radar magnetic data to a larger computer at the survey site.

Technique	Advantages-Applications	Disadvantages-Limitations
Metal Detector	Easy to apply, inexpensive, good for larger metal objects at shallow to moderate depth.	Provides limited quantitative data on size or depth of target, misses small diameter and deep objects. Requires presence of metals in buried waste.
Magnetometer	Sensitive to iron and steel objects, can detect large deeply buried objects, may be used to detect large nonferrous objects in areas of high natural ferromagnetic minerals content.	Cannot definitively determine depths or distributions of buried objects, mainly limited to iron and steel, often requires detailed grid measurements and extensive data processing.
Ground-Penetrating Radar	Provides good estimate of location and depth, sometimes indicates composition, shows great promise for field interpretations with more development.	Penetration and resolution affected by composition and moisture content of soil, requires computer data processing for best results.
Thermal Imaging	Used in overflight mode, can cover large areas rapidly, may provide means of locating vegetation damage due to chemical migration.	Ground cover and soil type changes confuse output analysis, may not identify many types of buried material.
Acoustic Reflection	Applicable in tight or moist soils, not restricted to metallic targets.	Performance deteriorates in dry, coarse soils, poor resolution.
Acoustic Holography	Can provide three-dimensional view of buried objects. Possible to interpret composition from travel time data.	Performance deteriorates in dry, coarse soils, poor resolution, may require drilled holes.
Electrical Resistivity	Works well in moist soils, clays, possible deep penetration if sufficient voltage can be safely applied.	Loses resolution in dry, porous soils, output may be difficult to interpret.

FIELD SURVEYS

A subsurface survey is accomplished in four steps:

1) A grid covering the study area is marked on the ground surface to guide subsequent measurements and to provide location coordinates. This step can be eliminated if automatic positioning equipment is employed and if the computer is used to label data accordingly.

2) Manual survey of the grid using hand-held metal detectors, marking all identified targets and transferring locations to an overlay map.

3) Operation of the survey vehicle over the same grid, transmitting data directly into the computer.

4) Data superposition and analysis. This is done largely by a unique software package created to filter and enhance output. Graphic display devices are used first to provide vertical profiles of each radar survey run. The profiles are then combined in digital form and sliced horizontally to generate a map view of a selected depth interval in the area surveyed. When specialized enhancement programs are applied, the output appears as color photographs with specific hues depicting buried targets.

This system has bee applied to surveys conducted in Idaho, Washington, New York, and Virginia. It has proven to be effective in mapping burial trenches and individual buried objects, such as munitions and artifacts. Two cannonball fragments were located at depths of 3 to 4 feet. In addition, many other buried objects were located including pieces of pierced steel planking, cans, burlap bags, cables, pipes, and pieces of wood. The distribution of contacts detected by radar and magnetometry clearly shows such features as underground pipes and cables and an old baseball diamond now covered by sod. With further development efforts, it is anticipated that data analysis will allow increased discrimination between targets by means of shape and composition.

MUNITION FILL DETERMINATION

In a related study for the U.S. Army, nondestructive methods for determining the internal structure and fill of highly deteriorated munitions were evaluated. The results of this survey are presented in Table 1.

ACKNOWLEDGMENT

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TABLE 1. SUMMARY OF FILL ID METHODS

Method	Information Obtained	Reliability	Field Adaptability	Current Development Status	Technical Risk	Support Requirements	Capital Cost	Operating Cost	Demonstration and Development Cost
Ultrasonic Transmission	Phases, density	Moderate	Good	Test fixture required	Low	Trained personnel	Low-moderate	Low	Low
Ultrasonic Pulse-Echo Scanning	Internal structure and phases	Unknown	Poor	Experimental	High	1) Special developed equipment 2) Professionals	High	High	Very high
X-Ray Tomography	Phases, internal structure and dimensions	High	Poor	Medical and industrial applications fielded	Moderate	1) Special equipment 2) Professionals	High	High	High
Neutron Radiography	Phases, internal structure	Moderate	Fair	Experimental	Moderate	Special equipment and personnel	Moderate	Moderate	High
X-Ray Radiography vs. Tilt	Phases, burster ID	High	Good	1) Navy EOD w/fluoroscope 2) DPG w/film	Low	Moderate	Low-moderate	Low	Low
Calorimetry	Chemical ID, melting point, degree of fill	High	Good	Conceptualized	Moderate	Test chamber	Low-moderate	Low	Low
Moment of Inertia	Phases, density	Unknown	Fair	Conceptualized	Moderate	Precise fixture required	Moderate	Moderate	Low
Neutron Activation/ Backscatter	Elemental analysis	Unknown	Poor	Conceptual in this application	High	Very significant	High	High	High
Acoustic Spectrum on Impact	Interfaces, phases, condition of fill	Moderate	Good	Conceptual in this application	Moderate	Insignificant	Low-moderate	Low	Low
X-Ray Radiography with Digital Processing	Phases, internal structure	High	Good	Industrial applications	Moderate	High	Moderate	Moderate	Moderate-high

SAMPLING SOILS AND GROUNDWATERS CONTAMINATED BY HALOGENATED ORGANICS

by

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This paper presents methods of sampling and monitoring shallow soils and groundwaters contaminated by halogenated organics. These methods may be submitted to government regulatory agencies as protocols for contaminant sampling and are suitable for use at sites where contaminants are petroleum fuels, lubricants, solvents, waste dielectric fluids, herbicides and pesticides. The proposed methods were developed and used for determining the distribution of waste dielectric fluids and unspecified oils in consolidated alluvial deposits that are saturated with water below about 10 feet.

A sampling protocol includes methods for collecting, retrieving, and transporting soil and groundwater samples. Sampling protocols should fulfill the following requirements:

1. Data are reproducible and reliable
2. Data adequately represent actual distribution of contaminants and hydraulic parameters on site
3. Uncontaminated soil and groundwater on site are not contaminated during the investigation
4. Field personnel are adequately protected

Soil Sampling

Soil sampling permits mapping of the distribution of contaminants in both the saturated and unsaturated zones to maximum depths of about 150 feet. In alluvial soils, we recommend a truck-mounted auger drilling rig for soil sampling. Advantages of the auger rig include greater mobility, shorter set-up and take-down time, fewer tools to clean, cheaper operation, and avoidance of drilling fluids. The auger rig and conventional sampling tools shown on Figure 1 can be adapted to sampling for organics if the following special precautions are taken to ensure sample integrity:

1. Collect samples with clean, solvent-rinsed soil tubes and drive samplers.

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2. Insert the drive rod and sampler down the inside of a hollow stem auger string to prevent sample contamination by caving soils.

3. Cover the end of the sampler with a plastic bag when it must pass through borehole fluids that may contaminate the soil tubes and drive sampler.

4. Steam clean the augers after each boring.

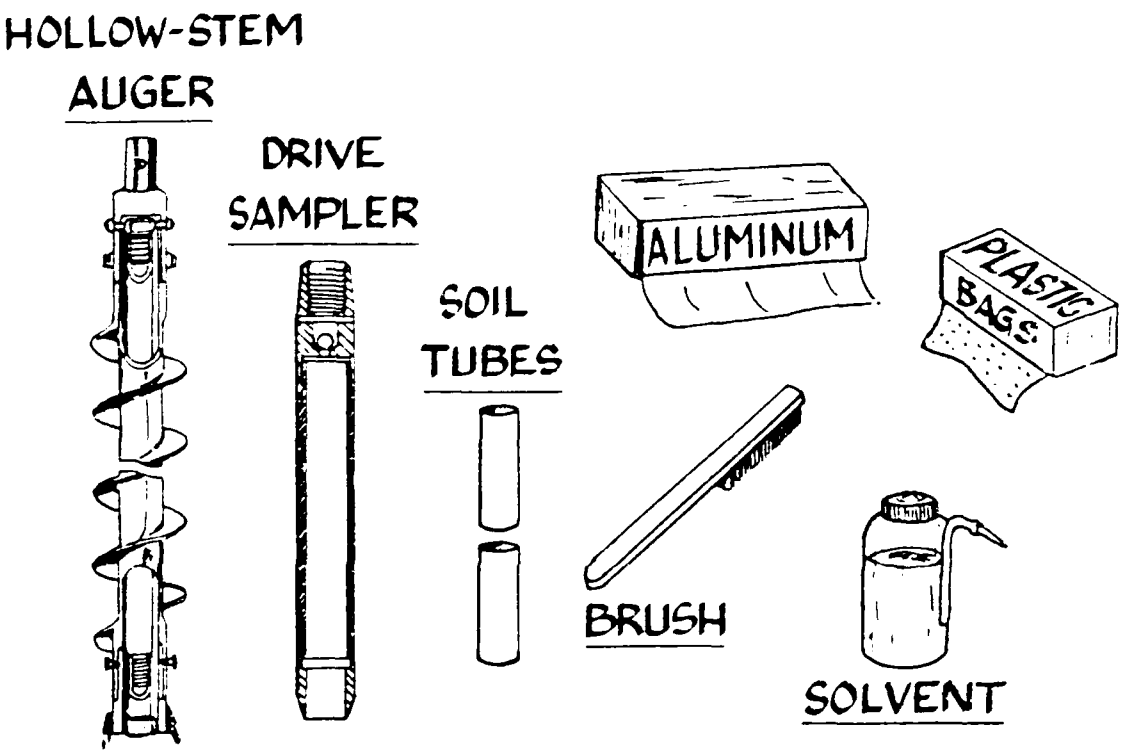

Figure 1. Soil Sampling Tools

Soil grab samples should also be collected with solvent-rinsed tools from surficial soils and backhoe trenches. We recommend the digging of trenches with a backhoe to provide supportive data on groundwater and contaminant distribution and on soil stratigraphy.

Groundwater Sampling

Monitor wells must be designed and located to produce groundwater samples from specified parts of the flow system. Steam-cleaned and solvent-rinsed galvanized steel pipe is recommended for casing and screen. Pipes are joined by welding or with Teflon tape and threaded couplings. Gravel pack material installed next to the well screen must be tested for the contaminants in question. A bentonite or bentonite-cement grout seal is installed immediately above the gravel pack. Installing these

materials from inside a large diameter, hollow-stem auger string can prevent contaminated shallow soils from entering the gravel pack or well screen.

Protocol for well development should include plans for proper storage of all discharged fluids in labeled drums. Record of fluid volumes discharged, fluid levels, thickness of floating oil or emulsions, and sampling events should be maintained. Fluid levels should be monitored to control the timing of well discharges and to help design a rigorous well-testing program to determine horizontal permeabilities of saturated strata.

Figure 2 shows monitor well sampling tools currently recommended by the federal Environmental Protection Agency. Protocol for water sample collection is governed by:

1. Rate at which a well recovers
2. Vertical pumping lift
3. Density stratification of water standing inside a well

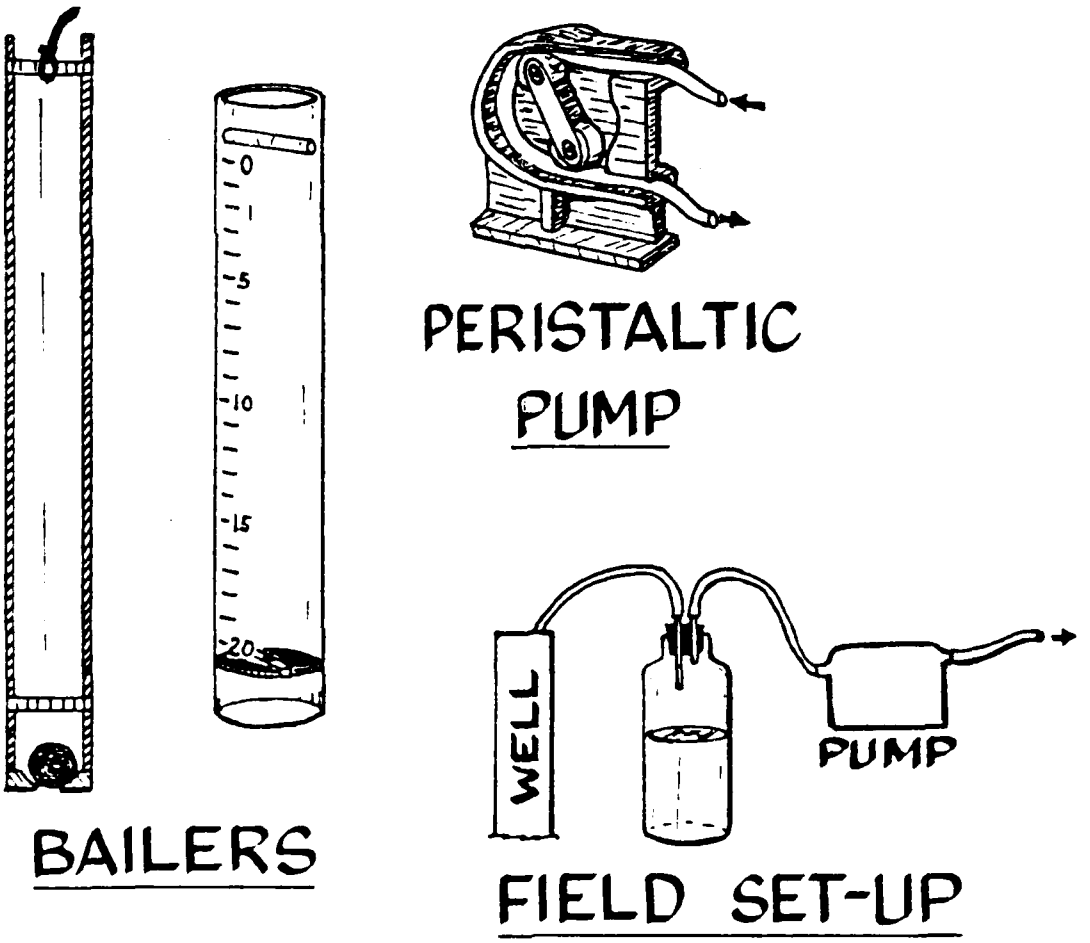

Figure 2. Monitor Well Sampling Tools

To ensure collection of a fresh sample of groundwater, a well must first be pumped to remove unrepresentative stagnant fluids above the screen. Wells having static water levels deeper than about 25 feet can be bailed to prepare the well for sampling. Wells with water levels above 25 feet can be pumped with a suction lift pump. We recommend using a peristaltic pump with Teflon suction hose as shown on Figure 2. Fluid samples from the upper part of the stratified water column in a well should be collected with a stainless steel or Teflon bailer. A separate bailer should be assigned to each well to prevent cross contamination. Grab samples of fluids lighter than water are collected from the upper part of the well screen. Fluids that are heavier than water are collected from the lower part of the well screen.

Conclusion

The procedures described here permit successful sampling for organic contaminants with conventional tools. An auger drill rig and commonly used tools can easily be adapted for sampling soils with halogenated organics if special precautions are taken to preserve sample integrity. Monitor wells should be made of inert materials, installed to prevent down-hole transport of contaminants, and sampled with EPA-recommended tools according to a protocol similar to the one described herein.

GROUNDWATER CONTAMINATION CONTROL AND TREATMENT ROCKY MOUNTAIN ARSENAL COLORADO

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ABSTRACT

Groundwater contamination has been identified at the 17,000 acre Rocky Mountain Arsenal installation located immediately north of Denver, Colorado. The general groundwater pattern beneath the production and waste disposal areas on the Arsenal has resulted in the movement of a variety of chemical contaminants through the aquifers of the region. Extensive analyses and engineering studies performed since the mid-seventies have culminated in the design of a groundwater barrier, dewatering, treatment, and recharge system for one boundary at the Arsenal. The following paper discusses the background and design of this rather unique groundwater contamination control measure.

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PROJECT DESCRIPTION

General

Contaminated groundwater at Rocky Mountain Arsenal, Figures 1 and 2, will be contained, removed from two aquifers, treated, and returned to an alluvial aquifer by this project. The Black & Veatch Special Projects and Civil-Environmental Divisions, with geotechnical consultant services from Earth Sciences Associates (ESA), Palo Alto, California and Ft. Collins, Colorado, designed this innovative system for the U.S. Army Corps of Engineers, Omaha District. Major components of the system are: (1) 54 dewatering wells valved and manifolded to selectively intercept and permit separate treatment of three identified zones of contamination; (2) a 6,740-foot length of groundwater barrier keyed into bedrock; (3) granular activated carbon filters for organic contaminant removal (designed by others); (4) activated alumina columns for fluoride removal; (5) 38 groundwater recharge wells downgradient of the barrier to reinject treated water into an alluvial aquifer; and (6) an arrangement of monitoring wells, located on Arsenal property, designed to provide water quality and groundwater level data to permit optimization of system effectiveness.

INTRODUCTION

Groundwater contamination has apparently been occurring at the Rocky Mountain Arsenal (RMA) since its inception as a facility for producing chemical and incendiary munitions in 1942. In 1946, a major segment of the centrally located manufacturing facility at RMA (Figure 2) was leased to industry. Liquid wastes generated by the industries were discharged into several unlined holding lagoons. In 1954, several farmers north (downgradient) of the Arsenal, using shallow alluvial aquifers as a source of irrigation water, complained about the loss of crops. It was thought at that time that seepage from unlined waste holding ponds was the principal source of groundwater contamination; so in 1957, the government designed and constructed an asphaltic-lined waste lagoon (Basin "F") to hold liquid wastes. Storage of liquid wastes in unlined lagoons was discontinued with the completion of the Basin F facility and ponding areas previously used were breached following the transfer of their contents to Basin F. These areas were then allowed to revert back to natural conditions.

In 1974, water quality samples were taken at a man-made bog area located in the proximity of RMA's north boundary; the samples proved that diisopropylmethylphosphonate (DIMP) and dicyclopentadiene (DCPD) were present in the bog's water. These particular chemicals are traceable to the production of a chemical warfare agent, and insecticides, respectively. It was concluded, since the bog was known to respond to changes in groundwater levels, that these contaminants had reached the north boundary via a groundwater route.

In response to the discovery of groundwater contamination at Rocky Mountain Arsenal's north boundary, the Arsenal, in concert with the U. S. Army Toxic and Hazardous Materials Agency (USATHAMA), developed and implemented programs to define the problem and to develop corrective measures. In 1978, Black & Veatch was engaged by the Omaha District of the U.S. Army Corps of Engineers to provide engineering services for the design of remedial measures at three locations on the Arsenal.

This paper discusses Black & Veatch's design for an expanded containment barrier, additional dewatering and recharge wells, and a treatment plant for removing fluoride from intercepted contaminated groundwater migrating across the north boundary of the Arsenal.

DESIGN DESCRIPTION

For the concept design, five alternative control methods were investigated. These consisted of four hydraulic systems involving the extension of a previously installed 1,500 foot pilot groundwater barrier system by a hydraulic barrier comprised of dewatering and recharge wells, and one system comprised of an impermeable barrier with dewatering and recharge wells (Figure 3). Although hydraulic systems were determined to be functional, it was decided to use a bentonite-soil barrier because it would offer a more positive cutoff in the unlikely event of power failure; and more importantly, the bentonite-soil barrier would essentially eliminate repumping of already treated groundwater.

Barrier Design:

Preliminary to design, Black & Veatch and ESA conducted a groundwater hydraulic analysis, utilizing a finite difference model developed by ESA. Flow estimates made by ESA were compared to estimates made by various other investigators and found to be in general agreement. The areal distribution of the contaminated groundwater flow migrating off the Arsenal's north boundary was determined by the model and further assessed by mass flux analysis of available water quality data. Through these analyses, the lateral extent and general alinement of the barrier were determined. An extensive geotechnical program was also conducted during this project to obtain information for designing the barrier depth.

This program was developed to comply with engineering instructions provided by the Corps of Engineers. The implemented program produced a complete geophysical analysis of 30 boreholes along the centerline of the proposed groundwater barrier, and included two electric logs: spontaneous potential and resistivity, and three radiation logs: natural gamma, neutron and gamma-gamma, and a caliper log. Continuous core samples were recovered and preserved for use by the successful bidder; standard penetration tests and material gradation analysis were also performed. Shear strengths were obtained from selective unconfined compressive strength tests. Boring logs and groundwater level observations collected at other locations near the proposed system were also obtained and used during the design of the containment barrier system.

The geohydraulic and geotechnical analyses indicate that a 30-inch barrier width of select, low permeability (10^{-7} cm/sec or less) backfill is adequate to impede groundwater flow under the anticipated gradients imposed by the operation of dewatering and recharge wells.

The lateral limits of the containment barrier were defined from data obtained from both field and modeling studies. The depth of the barrier was ascertained from geotechnical data and pump test results. For the most part, the barrier extends through the alluvial aquifer and identified segments of the weathered claystone bedrock units, keying into competent claystones. The barrier was deepened in some areas to intercept deeper bedrock sand units, Denver Sands, when they were determined to be in contact with the alluvium aquifer. Isolated sand units identified as being contaminated are to be intercepted by deep wells.

Pumpage rates have been increased to handle pumpage from storage in addition to the eventual pumpage of bypassed flows.

(3) Decreased water levels on the upgradient side of the barrier is desirable, so in the event of failure of the well system, a zone exists as a storage buffer. To achieve this buffer, pumpage must exceed the natural flow rate.

(4) As a precaution against increased groundwater levels resulting from surface flooding, and to account for localized effects, a 50 percent safety margin was included in the design pumping rates.

Based on these analyses, 35 wells are required. Projected pumping rates range from 1.0 to 26.2 gpm with drawdowns of 1.4 to 4.8 feet under steady state conditions. The wells will be constructed using steel casings and 316L stainless steel screens with a 0.060 inch slot size; the 316L screen material was selected because of the corrosive nature of the groundwater. The wells will be installed in a 16-inch minimum bore hole, thus providing a minimum 4-1/2 inch gravel pack around the 6-inch diameter well. Screen lengths and well depths were designed from conditions observed during the geotechnical field work; however, screen placement and well depths for all wells will be based on conditions observed at each well site during actual construction.

Wells designed for the deeper sand units were located based on geotechnical and water quality considerations. A total of 19 wells were designed to pump a total of 31 gpm; which is approximately 10 times the estimated natural flow through these routes. The design was based on two pump tests and on drawdown calculations. The relatively large

number of wells used to pump the spill volume of water is necessary in order to develop a deep sink for intercepting contaminants during short pumping periods. Because of severe boundaries, interference and drawdown calculations are approximate, and as such, allowances were made for estimating errors.

Since these wells were designed to dewater at low pumping rates, slotted 4-inch diameter PVC casings were selected. Milled slots of 0.064-inch were designed for the screened portion of the well. The wells will be installed in 9-inch boreholes providing a 2.25-inch annular space for gravel packing. A 10-inch PVC conductor casing placed in a 16-inch well bore, and grouted in place with cement, will be used to seal the well from the overlying alluvial aquifer.

The sands dewatering system is designed to operate intermittently on an as-needed basis and to allow monitoring of contaminant levels.

Thirty-eight recharge wells are required to assure adequate recharge capacity without causing significant alterations in the natural groundwater patterns. Using the computer model analysis, flows at the treatment plant were apportioned among these wells with the objective of restoring groundwater to a natural condition without causing surface flooding. Recharge rates range from 0.4 to 57.0 gpm with an increase in head from 0.5 to 2.3 feet.

All recharge wells will be constructed in the alluvial aquifer and consist of 12-inch steel casing and 304 stainless steel screens with

0.060-inch slots. Wells will be placed in 24-inch bore holes, thus producing a large effective radius.

Manifold System:

Water quality flux analyses have indicated rather definitive plumes of contaminants in the vicinity of the barrier. Under the instructions of the user agency, and with approval of the Corps of Engineers, Black & Veatch designed a three manifold collection system. The physical extent of each collection line, i.e. manifold, is determined by a series of eighteen valves positioned along the main collection line. These valves are used to either increase or decrease the length of any particular manifold, thus effectively providing the user with the flexibility to intercept and treat groundwater of similar quality. Denver Sand wells are connected to a single collection pipe and are fed into one manifold. Each manifold is connected to a specific influent wetwell, which in turn is connected to a specific treatment process stream (Figure 5).

Groundwater Treatment:

Groundwater treatment at the north boundary is presently being accomplished by an activated carbon system leased from Calgon, Inc. Hydrocarbons found in the groundwater include DIMP (diisopropyl-methylphosphonate) and DCPD (dicyclopentadiene). Since the inception of the ongoing abatement programs at RMA, other contaminants have been detected in the groundwater in vicinity of the north boundary. These organic contaminants are effectively being removed from the groundwater by the activated carbon pilot plant system.

Because the State of Colorado requires that reinjected water be subject to drinking water standards, including a fluoride criteria of 2.4 mg/l, fluoride became a design requirement for the north boundary project. The following discusses the recently designed fluoride removal system.

Several alternatives were evaluated for fluoride removal, including ion exchange, lime softening, bone char adsorption, and activated alumina adsorption. While ion exchange of fluoride is possible, fluoride is last on the exchange selectivity series for monovalent ions. Thus the removal of fluoride with ion exchange is not feasible because of low media selectivity for fluoride. Excess lime softening coprecipitates calcium fluoride with magnesium hydroxide. However, the combination of process equipment requirements, space requirements, chemical use, and waste sludge handling problems eliminated softening as a practical solution for fluoride removal. Bone char will adsorb fluoride, but repeated regeneration will cause the bone char to permanently lose its fluoride adsorption capacity. Therefore bone char was also eliminated from consideration. Activated alumina adsorbs fluoride and retains its adsorption capacity through repeated regeneration. On the basis of fluoride removal efficiency, and process reliability, the activated alumina adsorption process was selected.

The following criteria were used in the design of the activated alumina columns:

Hydraulic loading	
Normal	5 gpm/ft^2
Maximum	7 gpm/ft^2
Superficial velocity	
Normal	0.67 ft/min
Maximum	0.95 ft/min
Minimum empty bed contact time	5.3 min
Adsorption capacity	104 gm F/cu ft media

The fluoride level in the manifolded stream to be treated is 3.7 mg/l. The one manifold stream which will be treated to remove fluoride is expected to average about 110 gpm; however, the flow rate of this stream could go as high as 150 gpm. To provide adequate treatment facilities in case of high fluoride water in more than one manifold stream, provisions were included in the treatment plant to treat a maximum of 450 gpm. As will be discussed later, these provisions included both physical facilities and changes in operating procedures.

The regeneration waste treatment system recirculates several effluent streams to the activated alumina column system. These waste streams increase the influent fluoride level to 4.8 mg/l when the waste regenerant is being processed. These return streams total 10 gpm. Both the increased fluoride level and the flow were taken into account in the process design.

Based on the column design criteria, the adsorption capacity of the activated alumina, the fluoride levels, and flow, the columns were designed as follows:

Number of columns	3
Diameter	6.5 ft
Bed depth	5 ft
Sidewall depth	10 ft

The sidewall depth is provided to allow expansion of the bed during backwashing. The tanks are constructed of steel to meet the ASME design code for 125 psig. (Normal operating pressure is 25 to 30 psig.) The tanks are rubber lined. All internal piping is PVC, including the influent distributor and effluent collection piping.

Flow through the fluoride removal facility is relatively simple. Effluent from the granular activated carbon (GAC) plant flows to an influent sump in the fluoride treatment building and, depending on the flow rate, is pumped to one or more of the activated alumina columns. Prior to reaching the columns the flow is automatically adjusted to an optimum adsorption capacity pH level of 5.5 with sulfuric acid. After passing downflow through the alumina, the water flows to an effluent sump at the GAC building to be recombined with other treated manifolded streams prior to reinjection. Provisions have been made to adjust the pH of the combined recharge stream upward using sodium hydroxide if it becomes necessary.

The fluoride treatment system utilizes two parallel columns, operating in a "staggered-exhaustion" mode, to treat the entire flow up to a maximum of 160 gpm (150 gpm influent plus 10 gpm recycle). A portion of the GAC effluent is slipstreamed and mixed with the effluent of two columns operating in parallel when the flow is between 160 and 460 gpm.

The third column is required so that it can be placed in service while one of the previously used columns is being regenerated. The treated effluent fluoride level varies from 0 to 1.6 mg/l when 150 gpm or less is being treated; for flows above 150 gpm the effluent fluoride level will be fixed at 2.2 mg/l using the variable slipstream to maintain a constant effluent fluoride concentration. The value of 2.2 mg/l was selected to provide a cushion below the limit of 2.4 mg/l.

Column regeneration is an eight-step process. The first cycle is backwashing the bed: the accumulated suspended solids are removed from the columns and the media is expanded, rearranging the orientation of the alumina particles to minimize channeling. The remaining seven cycles involve removing the fluoride from the bed and preparing the bed for further service.

Regeneration is accomplished in Cycle 2, by treating in an upflow direction the exhausted bed with a 1 percent solution of sodium hydroxide. The bed is then rinsed with water to flush out the fluoride in Cycle 3. It should be noted that all water used at high pH, either for diluting sodium hydroxide or rinsing it from the bed, is softened water. This is done to prevent fouling the media through precipitation of calcium and magnesium. Cycle 4 consists of simply draining the column to reduce the dilution of the next sodium hydroxide treatment and Cycles 5, 6, and 7 are identical to Cycles 2, 3, and 4, respectively, except the flow is down rather than up. Cycle 8 is used to adjust the pH of the bed prior to returning it to service. During the rinse process, the

pH of the rinse water is adjusted to 2.5 with sulfuric acid and maintained at this level until the column effluent pH has been reduced to 6.5. The rinse water is then adjusted to a pH of 5.5 for the remainder of the cycle.

The fluoride removal process waste comes from two sources: regeneration of the alumina columns and regeneration of the water softener. Wastes from the alumina columns include sodium hydroxide and sulfuric acid used in the regeneration of the alumina media. These wastes have a high fluoride content (100 to 125 mg/l). The softener regeneration waste contains high levels of sodium and calcium chloride.

Several alternatives were considered for disposal of wastes from the fluoride removal process. Water losses generally associated with waste disposal practices were unacceptable because the using agency is required to return essentially all of the water removed from the aquifer. Thus, the alternative selected includes chemical precipitation of the fluoride, using a mechanical sludge dewatering system. This system and its operation are described below and are shown on Figure 6.

A lined concrete precipitation basin is utilized for batch coagulation and precipitation of the regeneration waste. The basin has treatment capacity for two complete regeneration waste volumes. A 30-foot diameter basin, with 14.5-foot sidewater depth and a 2-foot freeboard allowance provides the necessary volume. The basin is lined with fiberglass reinforced epoxy and is baffled to facilitate complete mixing and to prevent vortexing. Basin equipment includes an influent distribution

weir, two 75 horsepower bridge-mounted rapid mixers, and a rotating sludge collection system for removal of the precipitated solids. A decant mechanism consisting of a flotation supported flexible hose is included to provide an adjustable drawoff point for recycling reactor supernatant. Chemical addition points are located above each rapid mixer to facilitate complete dispersion of sulfuric acid and calcium chloride throughout the basin. Sludge formed during the precipitation reaction is collected by the rotating sludge collection system and directed to a central sludge pit for pumping to the gravity dewatering filter bed.

The selected chemical treatment system utilizes calcium chloride addition and pH adjustment to reduce fluoride levels in the regeneration waste. The calcium fluoride precipitate formed during the reaction of calcium chloride with fluoride is a very stable, insoluble compound. Once formed, calcium fluoride does not ionize in water, and therefore can be easily and safely disposed. To facilitate maximum fluoride removal, the regeneration waste is adjusted with sulfuric acid to a pH of approximately 6.5 immediately following calcium chloride addition. This step permits additional fluoride removal through aluminum hydroxide precipitation/adsorption.

The waste from the final neutralization of the alumina beds is held in a lined concrete basin prior to recycle to the plant influent wetwell. The basin is unequipped except for the recycle pump suction.

Two 5-foot diameter pressure filters are provided to remove suspended solids from (1) alumina bed backwash, (2) dewatered sludge filtrate,

and (3) precipitation basin decant flows prior to recycle. One filter is used to filter the recycle flows, while the second filter functions as a standby. The filters are sized for a maximum solids loading of 1 pound suspended solids per square foot of media area. Mixed media (coal/sand/ garnet) is specified because of its high surface area per unit volume, resistance to breakthrough, and high solids storage capability. Total media depth is 36 inches, and a surface wash system is utilized to obtain maximum solids removal during backwash.

To permit solids removal from the system, a 70-foot diameter evaporation basin is provided outside the treatment building. Filter backwash could be discharged to the basin once per month. The basin is sized for a net annual evaporation rate of 26 inches and has storage capability for five consecutive years of low net evaporation. Provisions for discharge of filter backwash to the sludge sump at the head of the GAC plant or to the filter backwash evaporation basin are included for operational flexibility.

Gravity sludge dewatering is utilized to reduce the sludge volume prior to disposal. Two 8-foot by 25-foot wedgewire filter beds are employed. Sludge formed during chemical treatment of two complete regeneration waste volumes is applied to one of the filter beds; the second bed serves as a standby. A conditioning tank is included for mixing polymer with the sludge pumped from the precipitation basin. The conditioned sludge then flows by gravity to the filter bed. The polymer system is designed to use either liquid or dry polymer. Provisions are made for discharging filtrate to the pressure filter influent, the

sludge sump at the head of the GAC plant, the precipitation basin, the filter backwash evaporation basin, or directly to the fluoride removal system influent wetwell.

When the sludge has reached a consistency that permits it to be handled easily (typically 1 to 2 days), removal of the cake is initiated. Cake removal consists of hand-cleaning and placing into containers. The filled containers are sent to the disposal site, and the screen is hosed down to remove any accumulated solids.

Total fluoride removal system water losses (i.e., losses attributable to sludge removal and filter backwash evaporation) represent approximately 0.1 percent of total system related water production (at 150 gpm plant flow).

PROJECT STATUS

The north boundary expansion project, although contracted as a single engineering design, has been submitted to the Corps of Engineers in two packages. The first submittal consisted of bid documents covering the dewatering, containment, and recharge facilities including appurtenant structures such as roads, wetwells, retrofitting of existing wells, and expansion of the GAC building to house additional piping.

The fluoride treatment portion of the project has been designed and submitted to the Corps of Engineers. The State of Colorado, recognizing that fluoride removal may not be necessary once the total barrier system becomes operable, has allowed for a delay in construction of this facility. The State has stipulated that once the barrier system becomes

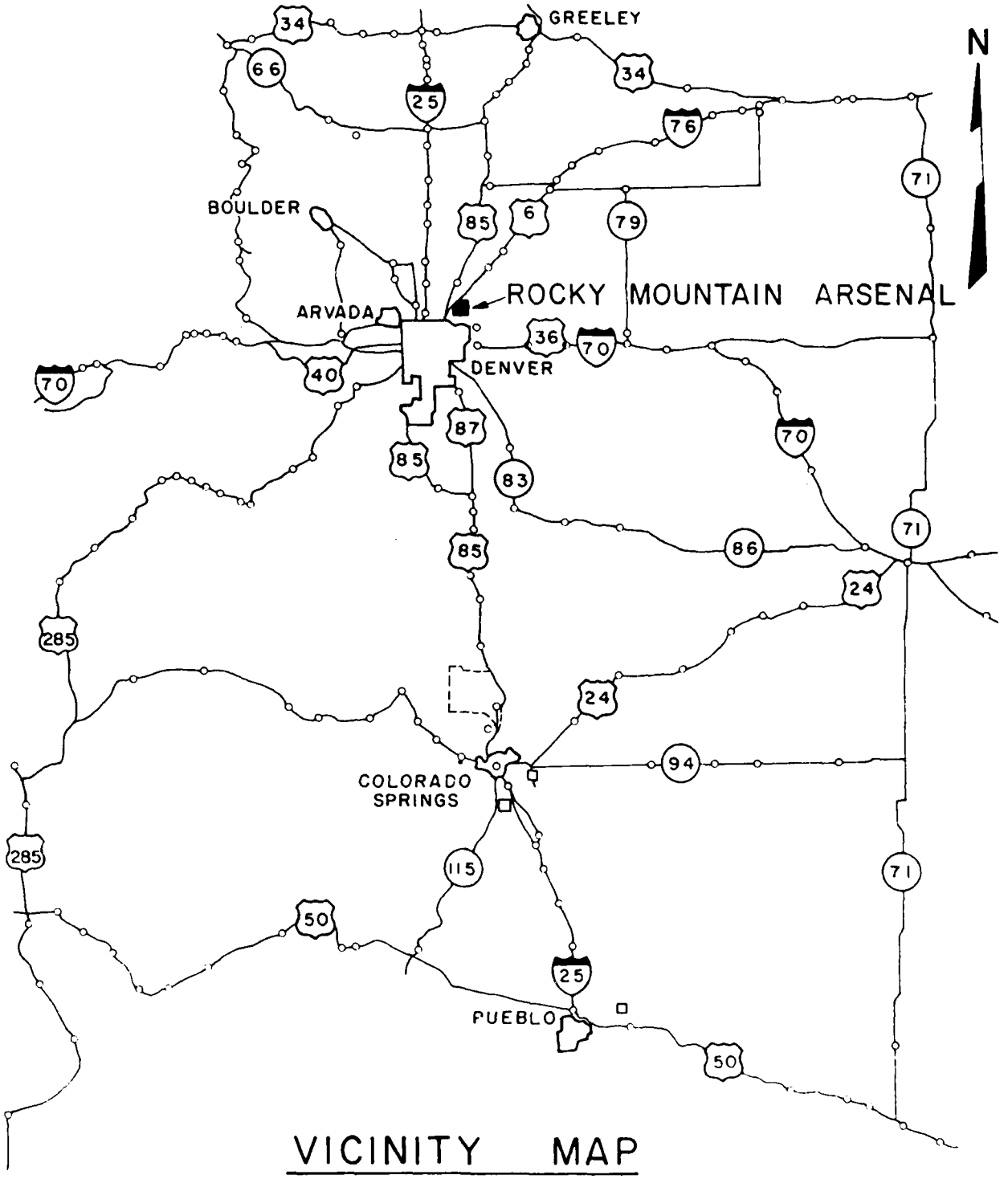
operable, close monitoring for fluoride will be performed for a period of about 90 days. In the event fluoride levels are found to be near the drinking water standards of 2.4 mg/l, the decision may be made not to require fluoride removal. In the event removal will be required, one could reasonably expect construction to begin in early 1982.

FUTURE WORK

This project represents a segment of Phase III of a four phase program to abate subsurface and aboveground contamination at Rocky Mountain Arsenal. This phase also includes containment of a 93-acre liquid waste holding lagoon and groundwater treatment downgradient of the lagoon. Also included in this phase is a dewatering, treatment, and recharge system downgradient of an abandoned liquid waste lagoon and solid waste disposal area.

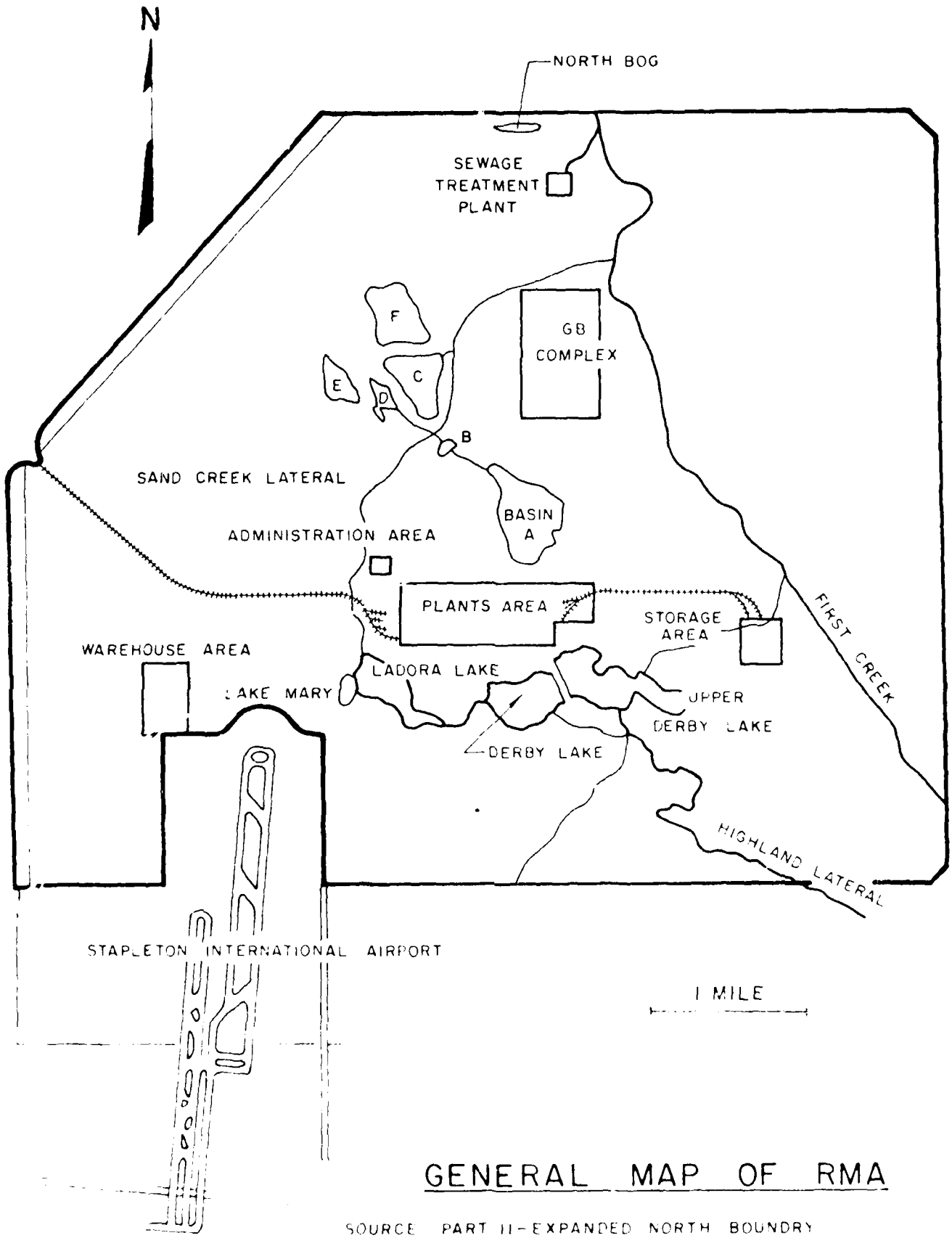
Phase IV of the proposed abatement program is directed toward providing surface runoff and wind erosion controls at contaminated surface sites.

The installation restoration programs at Rocky Mountain Arsenal will continue to require major efforts by the various concerned agencies/commands. The cleanup of contamination at Rocky Mountain Arsenal may take many years to accomplish. However, the right course is being taken by the government in rectifying a problem generated in the past.



VICINITY MAP

FIGURE NO. 1



GENERAL MAP OF RMA

SOURCE PART II-EXPANDED NORTH BOUNDRY CONTAINMENT OPERATIONS DRAFT ENVIRONMENTAL IMPACT STATEMENT, APRIL 1979

FIGURE NO. 2

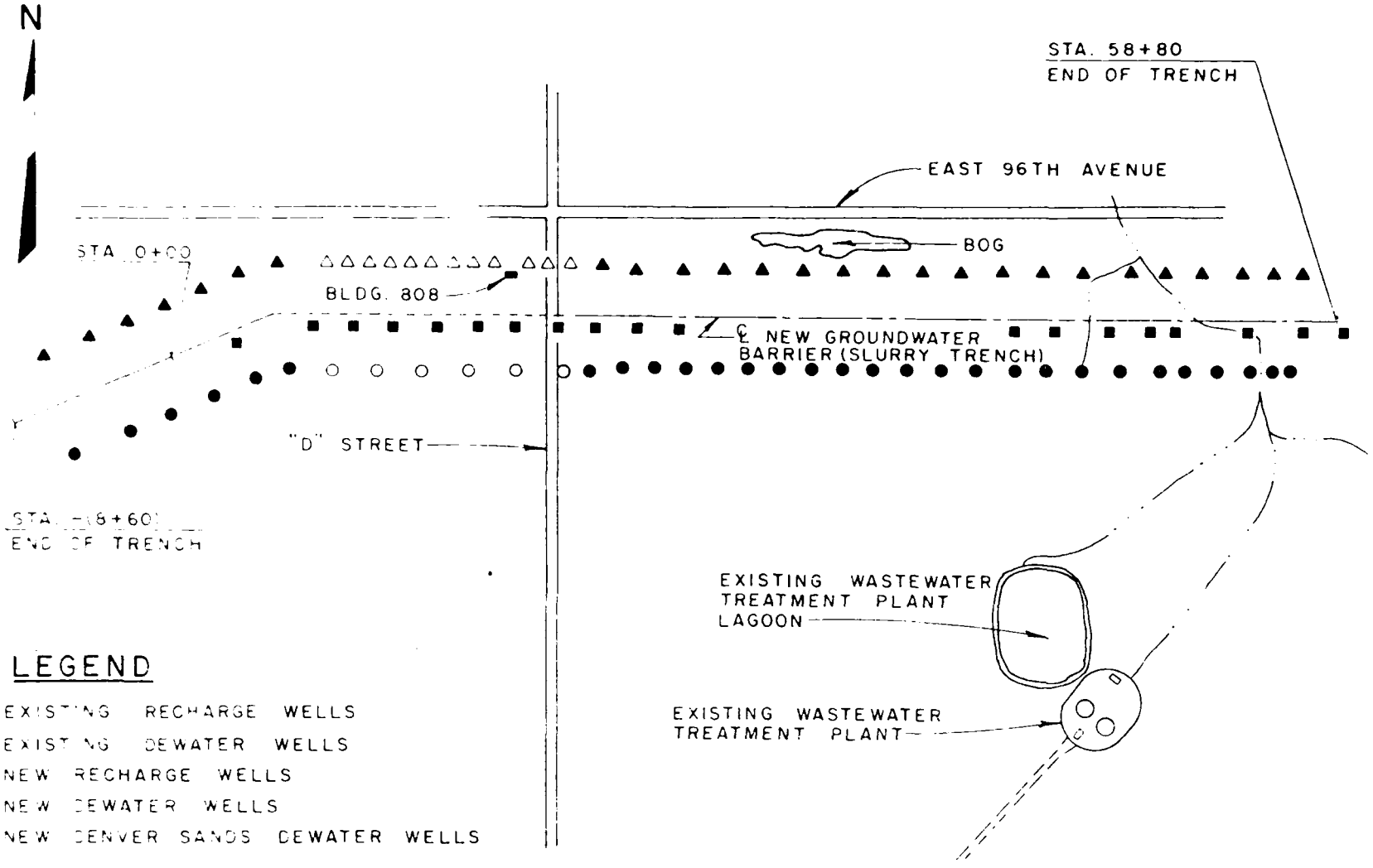
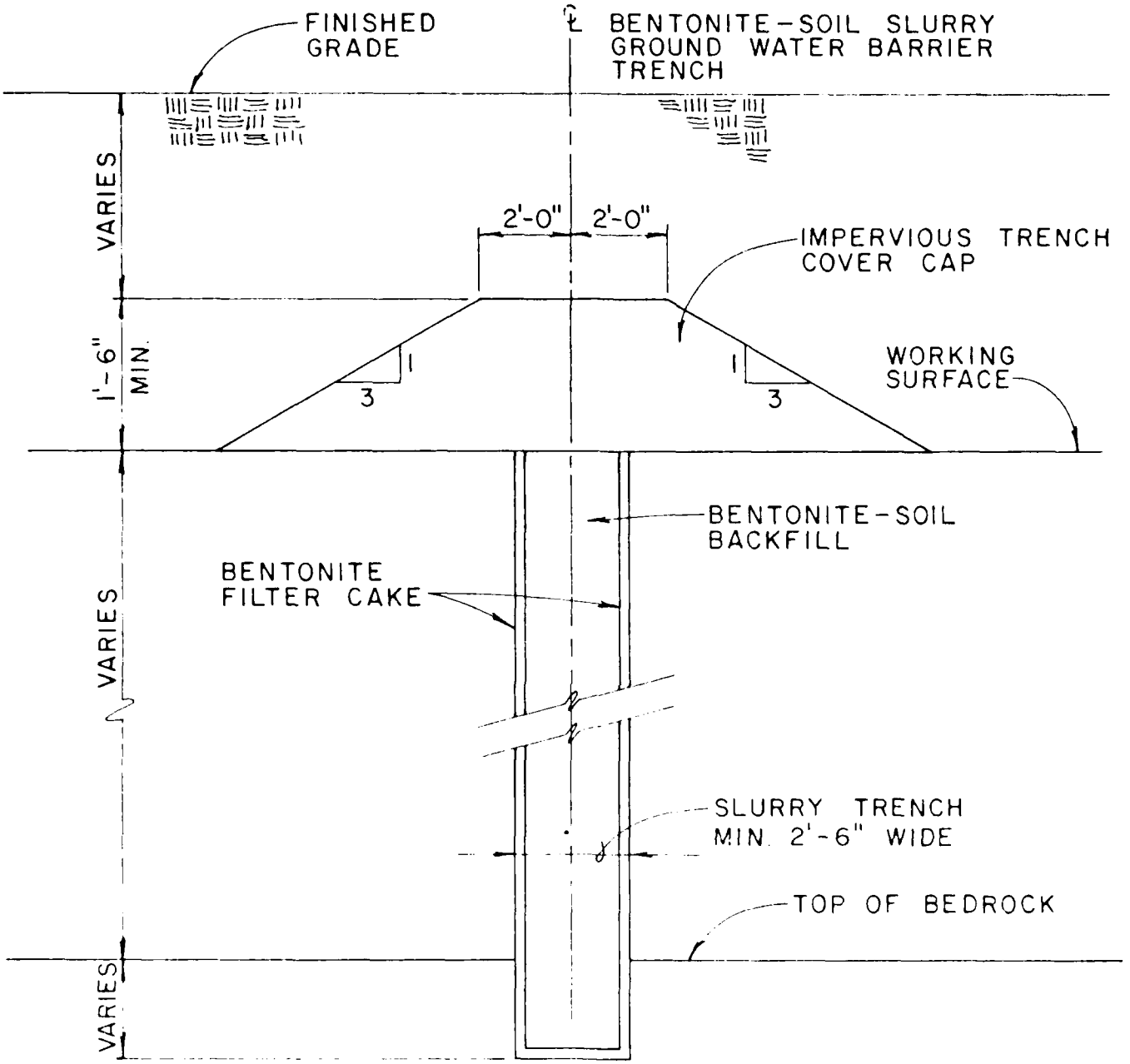


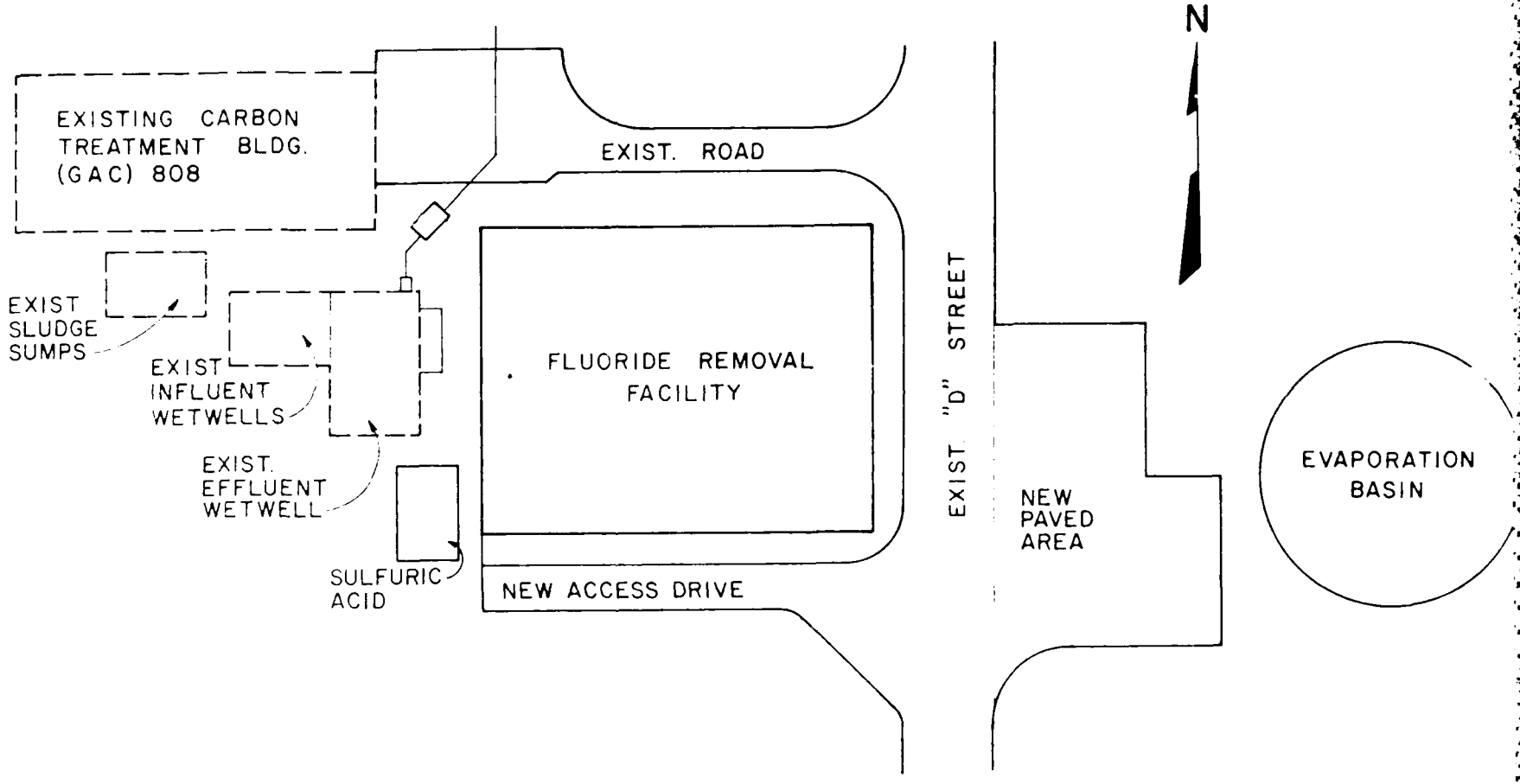
FIGURE NO. 3

NORTH BOUNDARY EXPANSION LAYOUT



TYPICAL BENTONITE-SOIL SLURRY GROUND WATER BARRIER TRENCH SECTION

FIGURE NO. 4



SITE PLAN

FIGURE NO. 5

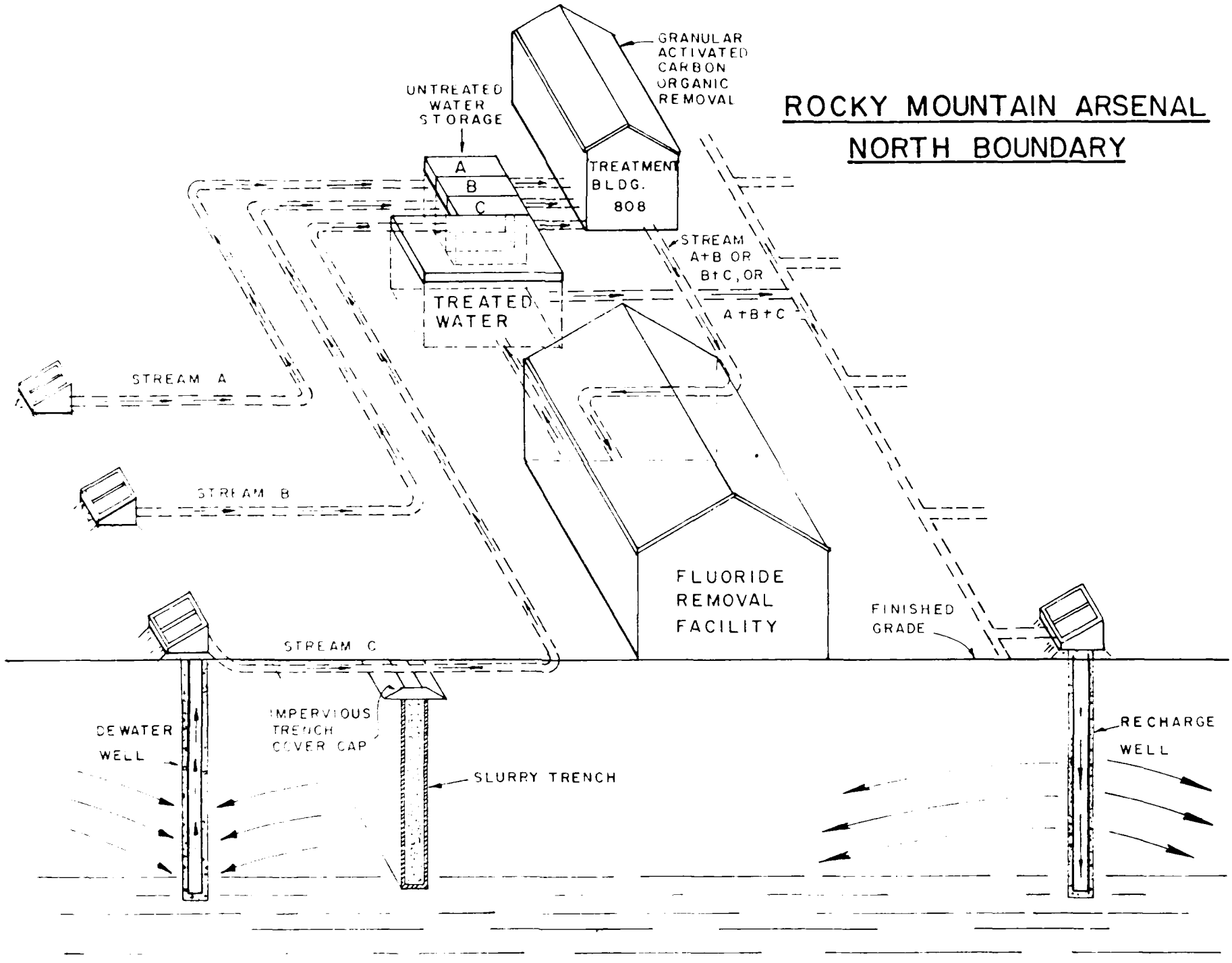
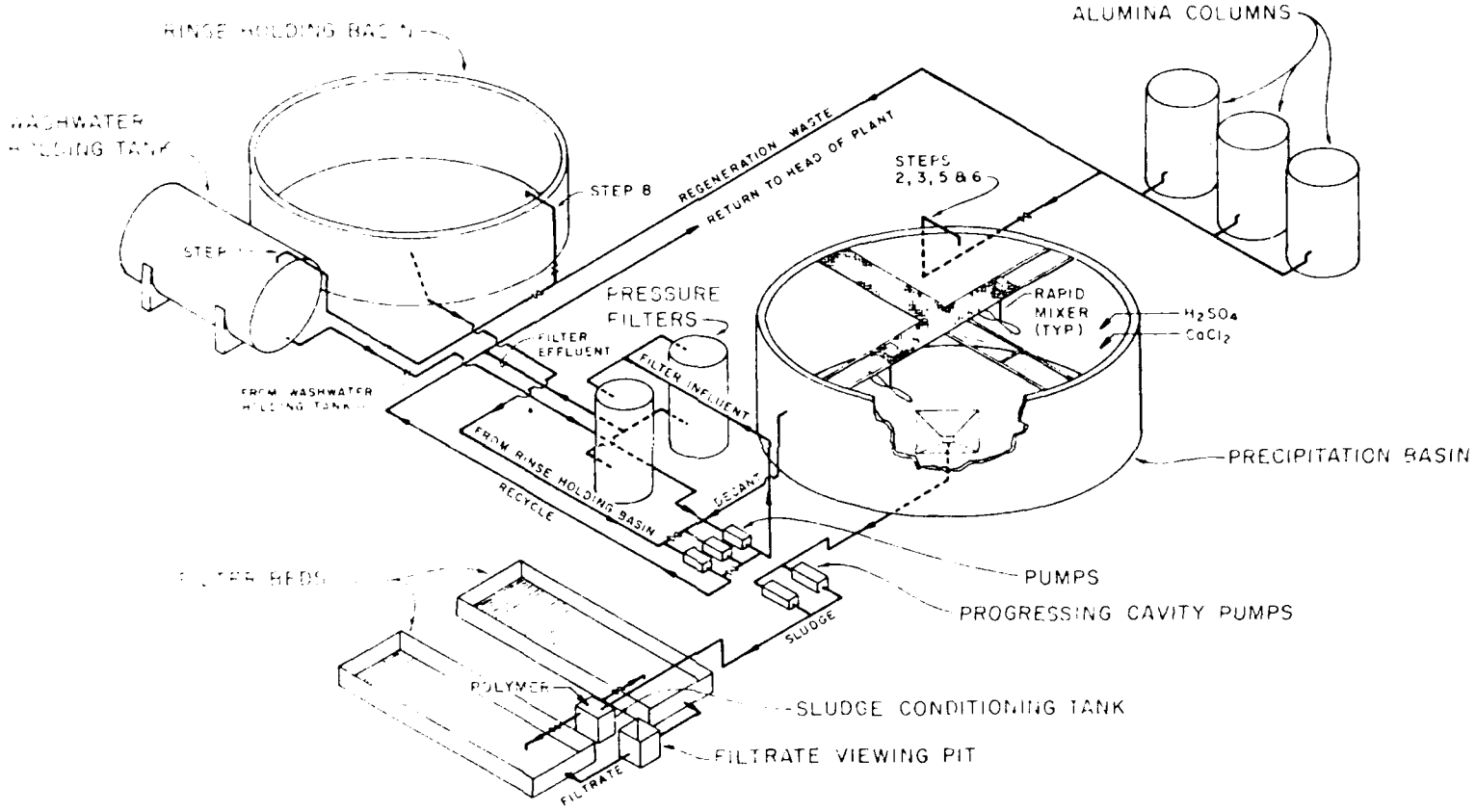

ROCKY MOUNTAIN ARSENAL
NORTH BOUNDARY
GRANULAR ACTIVATED CARBON ORGANIC REMOVAL
UNTREATED WATER STORAGE
A
B
C
TREATMENT BLDG. 808
STREAM A+B OR B+C, OR A+B+C
TREATED WATER
STREAM A
STREAM B
STREAM C
FLUORIDE REMOVAL FACILITY
FINISHED GRADE
DEWATER WELL
IMPERVIOUS TRENCH COVER CAP
SLURRY TRENCH
RECHARGE WELL

FIGURE NO. 5A



NOTE: STEPS 4 & 7 DRAIN COLUMNS TO CHEMICAL SUMP

FIGURE NO. 6

FLUORIDE WASTE TREATMENT SYSTEM

REMOVAL OF HEAVY METALS FROM WASTEWATER & ETCHING SOLUTIONS

John E. Nohren, President & Dr. Karl Moeglich, Vice-President
Chief Scientist, Innova,Inc., 5170 - 126th Ave. No. Clearwater, Florida, 33520

It is with pleasure that we present our paper today relative to a new and different technology permitting the removal, separation, and high concentration of both anions and cations from solutions. Our advancement to the state-of-the-art is the development of an ion permeable hudraulic barrier known as the Innova Ion Transfer Membrane to differentiate it from the thin film ion implanted ion exchange membranes with which you are no doubt familiar.

In contrast to the ion exchange membranes, the Innova Ion Transfer Membrane does not have, nor require, ion implantation. In contrast to reverse osmosis, membrane pressure is not applied. The Innova Ion Transfer Membrane is thick, approximately 9mm or 3/8 inch in thickness, is rugged, and is not subject to plugging or fouling. The Innova Ion Transfer Membrane is free of the typical membrane potential providing the coulumbic charge which attracts organic matter leading to the blinding of conventional membranes. Further, as the Innova Ion Transfer Membrane is essentially hydraulically inert, contaminants are not carried into the membrane and without the presence of water for hydration, reactions do not occur within the membrane.

The basis for the development of the Innova Ion Transfer Membrane was the result of research in boundary layer phenomena and surface free energy. As a component of this research we established a capillary pressure constant which showed approximately 1400 kilograms of force to be available in a capillary of 4 angstrom diameter. The Innova Ion Transfer Memgrane is of a capillary nature and utilizes such natural phenomena. It is also constructed of relatively inert materials which have a high resistance to corrosion in both weak and strong acids, bases, and radioactive compositions. We guarantee the acceptable functional life at 2 years in 15% chromic acid.

The membrane is applied in electrodialysis or unialysis. In the dialysis configuration three chambers are used, the anolyte and catholyte chambers being two outer sides of the center dialysate chamber. Generally speaking, two electrodes are used, the anode in the anolyte chamber and the cathode in the catholyte. The effluent to be separated is introduced into the center dialysate compartment with the transfer of the negatively charged ions through the membrane into the anolyte chamber and; similarly, the positively charged ions through the opposite membrane into the catholyte chamber.

Frequently it is necessary or desirable to remove or separate either the anions or cations. For such case a simple two compartment unialysis cell is used with anolyte and catholyte chambers.

In a typical commercial application for cleansing plating rinse waters, modules are arrayed parallel, eight to a tank, which is approximately 4' x 2' x 2'; each membrane module is approximately $0.25m^2$. When applied to a chrome rinse each module will remove 55-166g CrO_3 per day and is capable of lowering the chromium content in the rinse to below .01 ppm, although on closed-loop systems such dramatic pull down is not required. The chromium is concentrated in the anolyte compartment of the cell to approximately 15% before being syphoned off and returned to the plater's bath, the catholyte being the plater's rinse bath. Significantly, the energy cost is less than half the value of the chrome recovered.

For the chrome plater, the Innova membrane system, we call the ChromeNapper^{TM}, has provided a simple effective means to recover his valuable plating compounds lost through drag-out while reducing his water and sewerage bill by providing a completely closed-loop re-cycle system. Importantly, the Innova system operates automatically and does not require operator attention or servicing except for the few minutes required to periodically remove the concentrated chromic acid in the anolyte.

Systems of this nature are currently being installed at plating plants around the country, the first of which was installed in January, 1980, after more than one year of laboratory and in-house testing. The installed systems for the treatment of chromium waste are functioning in all cases equal to or exceeding expectations for efficiency and freedom from maintenance requirements.

The Innova Ion Transfer Membrane systems are also being applied for the treatment of various forms of nuclear waste. At the Department of Energy plutonium facility in Richland, Washington, the operating contractor, UNC Nuclear Industries, has installed an Innova pilot system from which very dramatic results are currently being obtained. As an example, the system has demonstrated the capability of removing and concentrating radioactive iron to the point below which discharge of the effluent would be permitted.

The same pilot system has also demonstrated the feasibility of treating etching solutions, that is cleaning solutions, similar to a 2% phosphoric acid solution which is utilized to clean the first loop of the nuclear reactor. Currently, the etching solution is made up of food grade phosphoric acid which is diluted with deionized water to make up a 500,000 gallon 2% acid

solution. After contamination of the solution by its use as a reactor cleansing compound, it is subsequently evaporated with the residuals mixed with Portland cement for burial. The basic cost involved each year is $100,000 for the original food grade phosphoric acid plus approximately $.90 per gallon for evaporation and eventual burial of the residual solids. This leads to an expense of approximately $550,000 per year for the annual cleaning of the reactor's first loop.

In the future, two storage tanks will be utilized; one for the contaminated solution and the second for the treated or cleansed solution with the Innova membrane system positioned between the two storage tanks. Thus, a relatively small Innova system will be used to remove the radioactive contaminants picked up during the cleaning operation permitting the storage and re-use of the cleansed solution, thus reducing treatment costs by some 90% or one-half million dollars per year for this application alone.

Other nuclear waste treatment applications currently under test is the removal of the radioactive ions from fuel storage basin ponds and secondly, the treatment and recovery of the sulfuric acid used to regenerate the ion exchange resins which have become contaminated and saturated with radioactive ions. As an example, the 105 cubic foot ion exchange resin tower currently requires 10,000 gallons of 4% sulfuric acid for regeneration with an additional 7,500 gallons of rinse water, all of which is combined within a single waste tank. Currently at the reactor in question, 770,000 gallons of such waste are generated annually and are being stored or processed at a cost of $.90 per gallon. In the future this storage cost will be eliminated and the value of the recovered acid will more than offset the energy and capital costs of the treatment and recovery system.

We have also been successful with the application of the Innova Ion Transfer Membrane for the separation and recovery of U_{238} in one instance and U_{235} in a separate application. An Innova dialysis system has been employed to treat holding pond water containing U_{235}. We successfully isolated the U235 and precipitated this material in pure hydroxide form separating it from other metals and contaminants which were also present. In our opinion this process offers unique opportunities not only to eliminate the environmental hazard but to recover this very valuable resource.

Innova has been successful at separating U_{238} from solution mining leachants and Florida phosphoric acid. While it is too early to tell the economic viability versus conventional solvent extraction, it does demonstrate the versatility and flexibility of this process for widely diverse applications dealing with contaminated liquors which themselves represent an environment in which no similar process could be satisfactorily employed.

Relative to military applications of the Innova Ion Transfer Membrane, we have used an Innova Ion Transfer Membrane cell to treat and destroy lead azide. The cell was of the dialysis configuration as it was our desire to recover the acid for recycling while transferring and precipitating the lead in the catholyte compartment.

We have also treated the famous Rocky Mountain Arsenal Basin F effluent initially removing the metal ions as the first stage of treatment. The second treatment would then be the oxidation of the organics. Thus, the Innova Ion Transfer Membrane cell may also be used to treat military wastes containing mineral or metal ions as are found in the various herbicides and agents such as Agent Orange which have received a degree of notoriety over the past few years.

The Innova process using the ion transfer membrane may be employed for the treatment of brackish water and the replacement of the reverse osmosis systems which are prone to clogging and bacterial growth. As the Innova system does not require other than an electrical supply, it may well be ideally suited for field use in areas such as the Persian Gulf. Systems can be developed and sized suitable for the individual soldier as well as for the platoon or company.

We trust our brief presentation has provided some insight into the flexibility and versatility of this new process which in many ways is limited only by the user's imagination. We appreciate your attention and interest, and look forward to future discussions of our process and how it may solve environmental, purification, or recovery problems that we as a nation face today.

A STANDARD DESIGN CONTAMINATED WASTE PROCESSOR

by

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Project Manager	Senior Vice President/	Project Engineer
U. S. Army -	Military Projects	Ammunition Equipment Office
Corps of Engineers	Booker Associates, Inc.	Tooele Army Depot

INTRODUCTION

The Army has explosive (ordinance) maintenance and manufacturing facilities which generate combustible and noncombustible waste material contaminated or potentially contaminated with explosives or propellents. Safety regulations control and restrict the disposition of the "contaminated waste." Contaminated wastes have been disposed of by opening burning. As a result of the Clean Air Act and various State Implementation Plans, some states where ordinance facilities are located do not permit open burning. Previously the Army's program for eliminating open burning included construction of Air Curtain Destructors (ACD). Some states regarded the air curtain destructor as an extension of open burning and not Best Available Control Technology (BACT). In an effort to produce a viable alternative to open burning and the ACD, the Army has developed the Contaminated Waste Processor (CWP).

GENERAL

In order to field the CWP by timeframes required by various regulations, it appeared advantageous to develop a standard design which could be readily site adapted to any installation.

It was recognized that a standard design for a total CWP facility would consist of two distinct pieces.

1. "Brick and Mortar"

2. "Process Equipment"

Generation of a timely standard design required both the "Brick and Mortar" and "Process Equipment" design to be developed simultaneously. The simultaneous coordination of these efforts was an extremely difficult task. In addition, the criteria for the "Brick and Mortar" and "Process Equipment" were developed while the design progressed.

The design for the CWP has been completed and the projects are scheduled for bid openings in December. The estimated construction cost for these facilities are approximately two million dollars each.

BRICK & MORTAR

Design of the "Brick and Mortar" for the project was undertaken by Booker Associates, Inc. under contract with the U. S. Army Corps of Engineers. The scope of work included the design and preparation of plans and specifications for the building to house the process along with site and utility development. This part of the presentation will cover design considerations and solutions for equipment requirements, user requirements and safety requirements.

EQUIPMENT REQUIREMENTS

Equipment to be enclosed and sited included the furnace, feed systems, and air pollution control systems. Of particular importance was the development of the interface between the contractor-furnished facility and the government-furnished equipment. Other considerations included access to the Air Pollution Control Systems for maintenance, installation and operation of the material handling equipment, and remote installation of the operator's control panel.

USER REQUIREMENTS

The user requirements included providing facilities based on the desired worker occupancy, vehicle access to the site, control of fugitive emission, year-round operation, and operator's protection from the weather.

SAFETY REQUIREMENTS

The safety considerations included wash down water collection, smooth interior surfaces, elimination of dust-collecting ledges, fire protection sprinklers, and suppression of missiles in the event of accidental detonation. Also considered were OSHA and DARCOM safety manual requirements.

SUMMARY

As a result of the foregoing considerations, the "Brick and Mortar" part of the design has been completed utilizing the following worst-case design criteria:

1) Seismic zone #3 2) 40 PSF snow loading 3) 125 mph wind gusts
4) Minus 7F to plus 98F design temperatures 5) Operator protection for a one pound TNT detonation.

Key features of the facility, in particular relating to the accidental detonation of one pound of TNT, included the following elements shown in the view graph floor plan:

1) Concrete missile shields at furnace and shredder 2) Steel shield wall between furnance area and operator area 1/8" thick 3) Polycarbonate viewing window 3/8" thick 4) Wash down water troughs and sump 5) Dust ignition-proof electrical system 6) Deluge sprinkler system at conveyor wall pentration

Other features of the design included an enclosed material sorting area, overhead trolley system for material handling and a furnace heat reclaiming system to provide building comfort heating. Building design was based on utilizing a standard pre-engineering metal building adapted to these specific criteria.

PROCESS EQUIPMENT

The purpose of this part of the paper is to describe the basic characteristics of the Contaminated Waste Processor (CWP) that has recently been designed by the Army and will be installed at a number of facilities throughout the United States in the next two or three years.

During normal operations at Army ammunition plants and Army depots, large quantities of waste and metals are generated that is known or suspected to be contaminated with explosives or propellents. Because of the hazardous nature of these explosive contaminated wastes and metals, the contaminated waste must be incinerated by the Army and the explosive contaminate in the metal be flashed away before the metal can be sold for recycling.

FURNACE TESTS

Furnace tests have been completed on a Modified APR 2048 Flashing Furnace located at Tooele Army Depot, Tooele, Utah. During the demonstration/development tests on the prototype furnace, essentially no visible smoke was present. The measured particulate levels nearly met the incineration standards of many states without either an afterburner or an air pollution control system. The stack sampling data indicated an average particulate grain loading of 0.03 gr/SCF and essentially no NO_x (less than 30 ppm) was present. CO was below detectable levels.

The tests have shown that the furnace exhibits excellent temperature control characteristics providing assurance of destroying hazardous or toxic materials that may be present in the contaminated waste.

FURNACE DESIGN

The CWP is designed around a carbottom furnace to provide the capability for both incinerating waste and flashing metal. The furnace is a refractory lined, oil fired, batch type process furnace 22' long x 8.5' wide x 6.5' high. The furnace chamber is lined with a lightweight ceramic fiber backed with mineral wool block. The furnace car bottom has a top surface of abrasion resistant castable refractory. The doors, which are closed during normal furnace operation, are lined with a ceramic fiber blanket. Two burners are located at the front of the furnace chamber on each side and above the exhaust duct. When used specifically as a flashing furnace, all the air is brought into the system through the burners. For waste incineration, automatically controlled air injection ports and burners are implemented to maintain proper furnace draft, control exhaust temperature, and optimize waste combustion.

The CWP has been designed to incinerate 600 lb/hr of combustible waste and to flash 10,000 lb/hr or contaminated metal. The furnace carbottom and burners have been sized accordingly, although it is expected that the metals will generally be flashed when incinerating mixed waste metal loads for minimum fuel usage.

FEED SYSTEMS

Two types of feed systems are provided for the CWP: 1) A batch loading system; and 2) a continuous furnace top dump conveyor system with front end preparation. The overhead trolley batch loading system uses baskets as a means of collecting and holding the waste as it is destroyed in the furnace. The baskets are 6' wide x 12' long x 2' high and are fabricated of steel with wire braided sides and bottom tray to catch the ash and residue. The baskets are loaded in the loading area and are picked up and transferred to the furnace by the overhead trolley. Quick release hooks remotely controlled, load and unload the baskets to insure the safety of an operator. The system is controlled automatically by a microprocessor control system.

The top dump continuous conveyor feed system will increase the processing capacity of the furnace as well as its flexibility. The waste will be loaded onto a continuous feed conveyor and carried to the shredder. The industrial waste shredder is driven by a hydraulic motor with automatic hydraulic anti-jamming reversing capabilities. The shredded waste will be carried from the shredder via a cleated conveyor and dumped into the furnace through a double sliding valve/air lock system.

AIR POLLUTION CONTROL SYSTEM

Although the furnace will be designed with a capacity and control system that will minimize load monitoring, the possibility of improper loading causing smoke release would always exist. Also, it is recognized that the continuous feed system may stir up a certain amount of ash when in use. An air pollution control system (APCS) will thus be used to assure compliance with emission standards under all operating conditions.

The APCS consists of a gas cooler, cyclone, baghouse, exhaust fan, and exhaust stack. The furnace exhuast gases (1600-1800°F) will be cooled to 900°F with dilution air. The gas cooler will cool the exhaust gases to provide a gas temperature of 250°F which is within the operating limits of the baghouse. The gas cooler is used to minimize the exhaust fan power requirements as well as exhaust gas processing requirements. The exhaust gas will then pass through the cyclone to remove particulate down to approximately 30 micron size followed by the baghouse for removal of particulate to 0.5 micron. It is expected that better than 99% of the emitted particulate will be removed by the cyclone/baghouse combination.

SUMMARY

It is expected that furnace will effectively incinerate and flash the explosive contaminated wastes and metals generated at Army Depots and AAPs while meeting all current and future emission standards of State and Federal EPAs.

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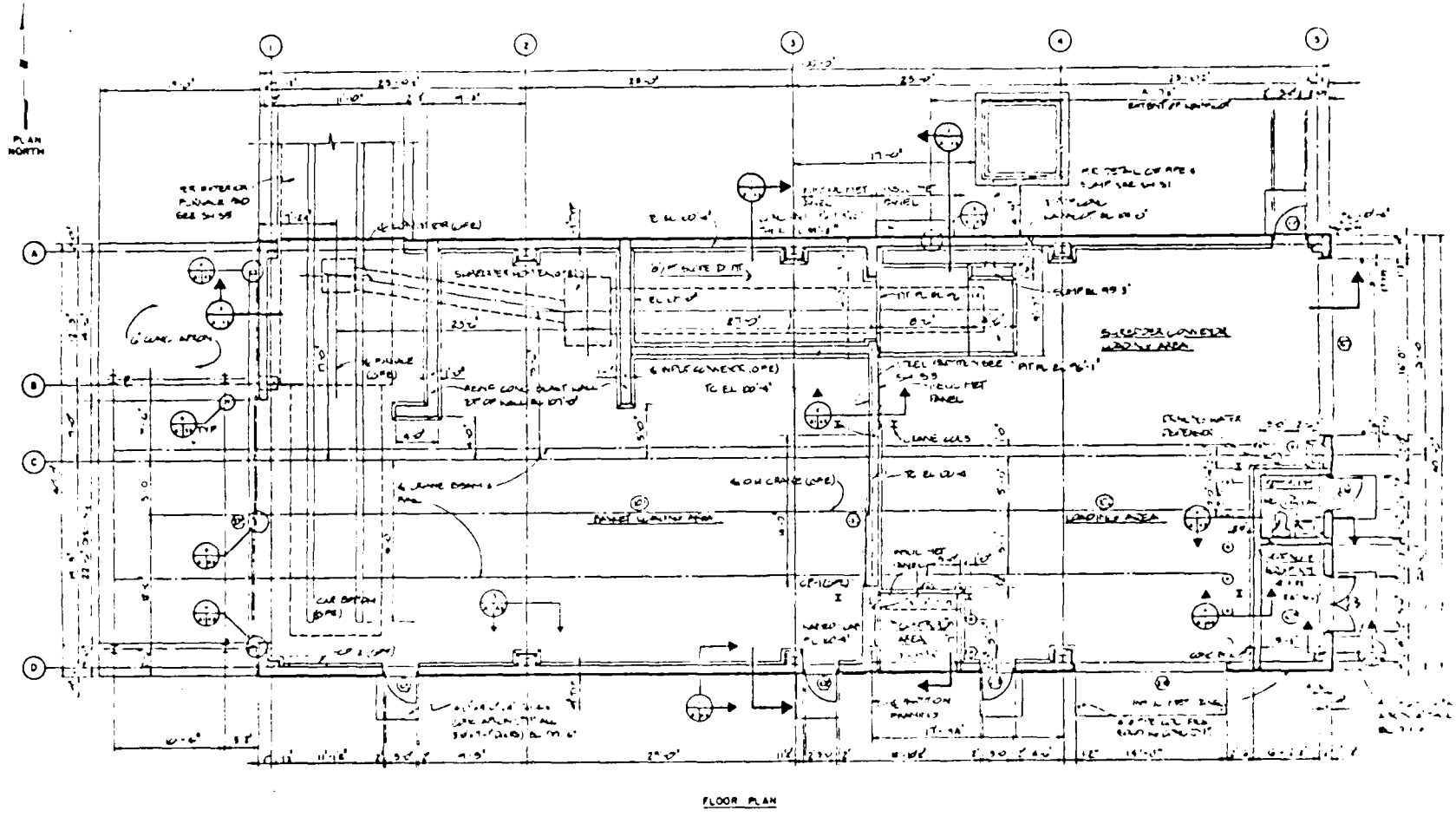
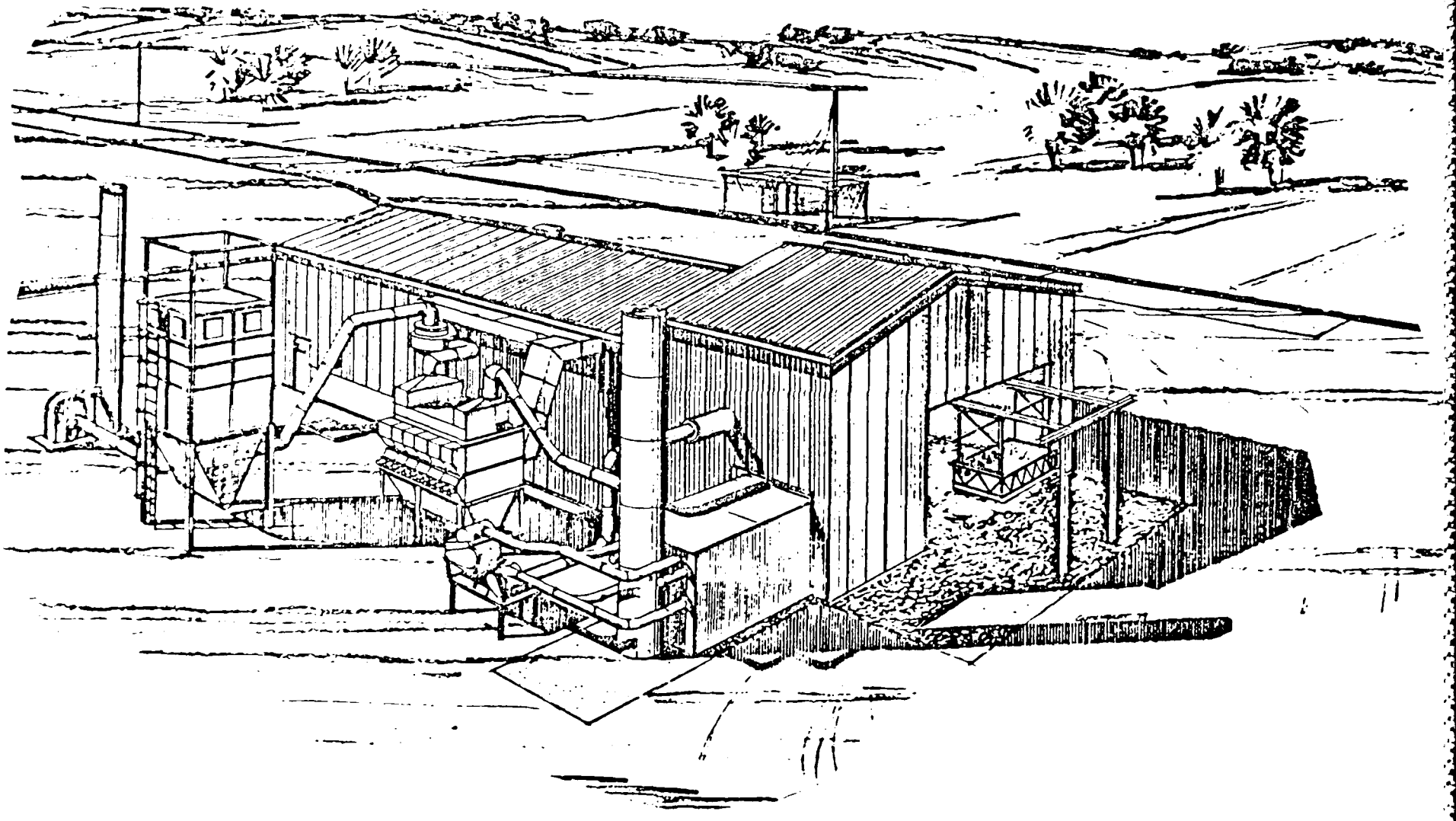


ARCHITECTURAL FLOOR PLAN

CONTAMINATED WASTE PROCESSOR



STANDARD DESIGN

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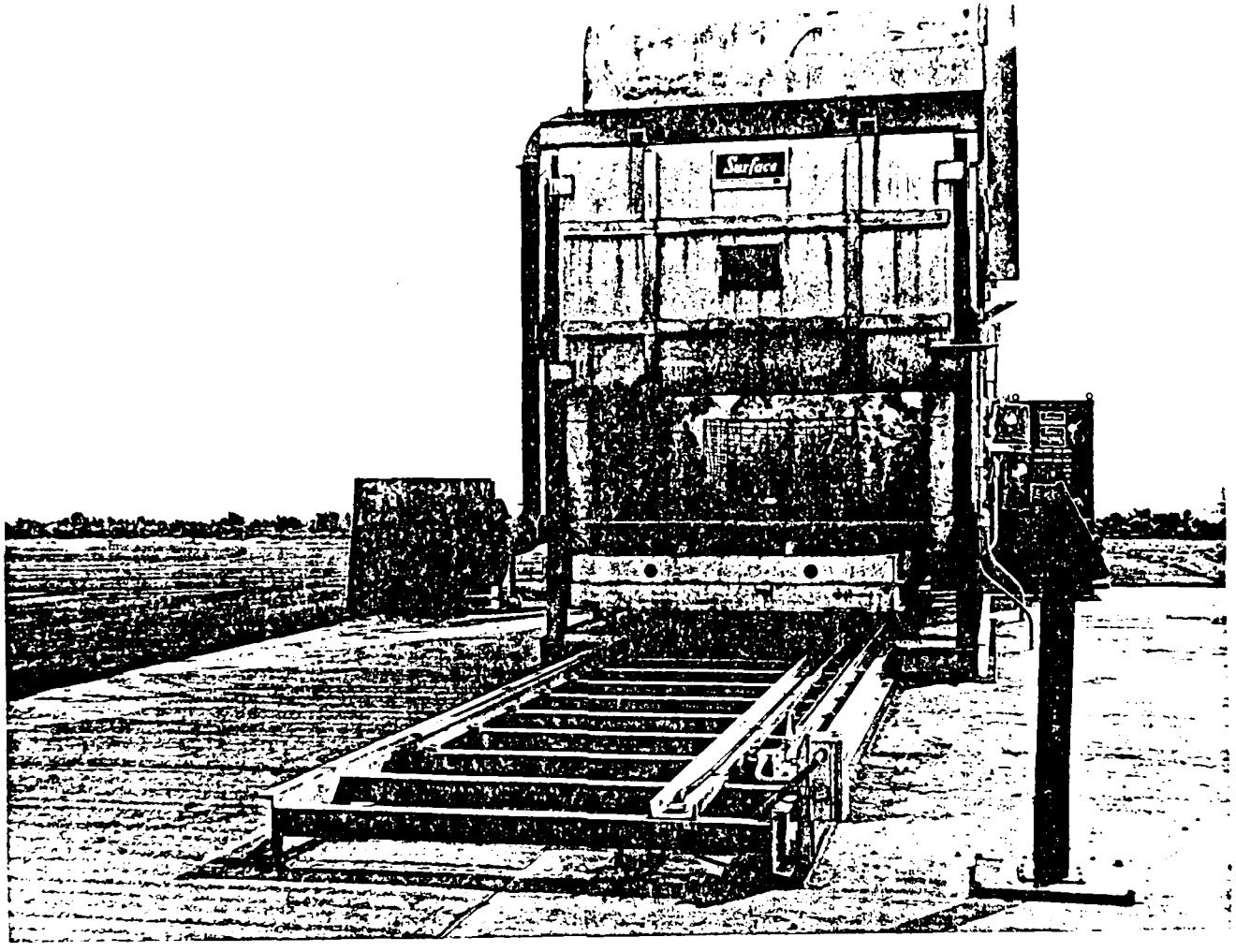
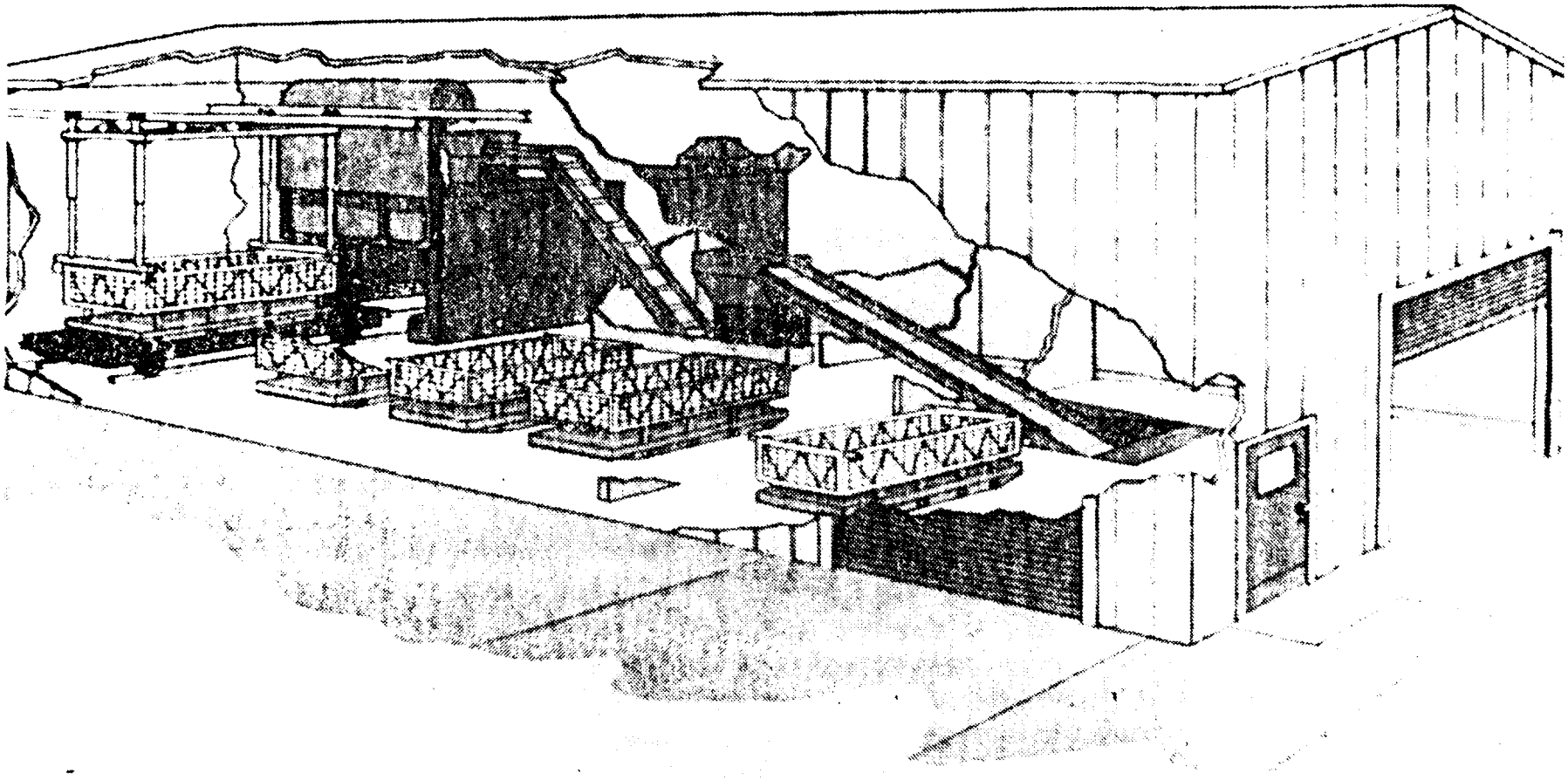


MODIFY APR 2048 FLASHING FURNACE

CONTAMINATED WASTE PROCESSOR



MATERIAL HANDLING FEATURES
CONTAMINATED WASTE PROCESSOR

SIMULATION AND COST BENEFIT/ANALYSIS OF REMEDIAL ACTIONS AT INACTIVE DISPOSAL SITES

by

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Every region of the U. S. is faced with a present potential for environmental damage due to the inadequacy of state-of-the-art waste disposal practices of the past. Most of the reported incidents have involved migration of chemically contaminated leachate from land disposal areas to ground water or surface water. Resources for implementing remedial actions are limited, and the technical effectiveness of remedial action alternatives is largely untested. Even if Superfund legislation is enacted by the Congress, complete clean-up of all existing disposal sites with the potential for adverse environmental impact may be neither technically nor economically feasible. In order to allocate resources effectively, there is therefore a strong need for:

(1) defining the present and probable future nature, extent and risk of contamination from identified disposal sites; and

(2) evaluating the probable effectiveness and costs of clean up, containment, and/or treatment alternatives for reducing the estimated risks.

Arthur D. Little, Inc., in cooperation with the U. S. Army Toxic and Hazardous Materials Agency, has developed a modularized computer simulation of the transport of contaminants from land disposal areas through the hydrological and ecological regime, under base line conditions and after implementation of containment and/or decontamination measures. The modules developed are shown schematically in Figure 1, and include:

Water Transport. This module simulates transport of contaminants from terrestrial sources to water table aquifers and surface water bodies. Input data include containment concentration measurements, hydrogeologic parameters, and land use characteristics. Outputs include levels of concentration and patterns of migration.

Ecology. This module simulates changes in productivity at different trophic levels resulting from changes in concentration of contaminants by geographic area and over time. Input data include sources and levels of contamination, biological species, density of species populations by geographic area, consumption patterns of installation organisms, and rates of reproduction, growth and mortality of species or selected groups of species in "contaminated" and

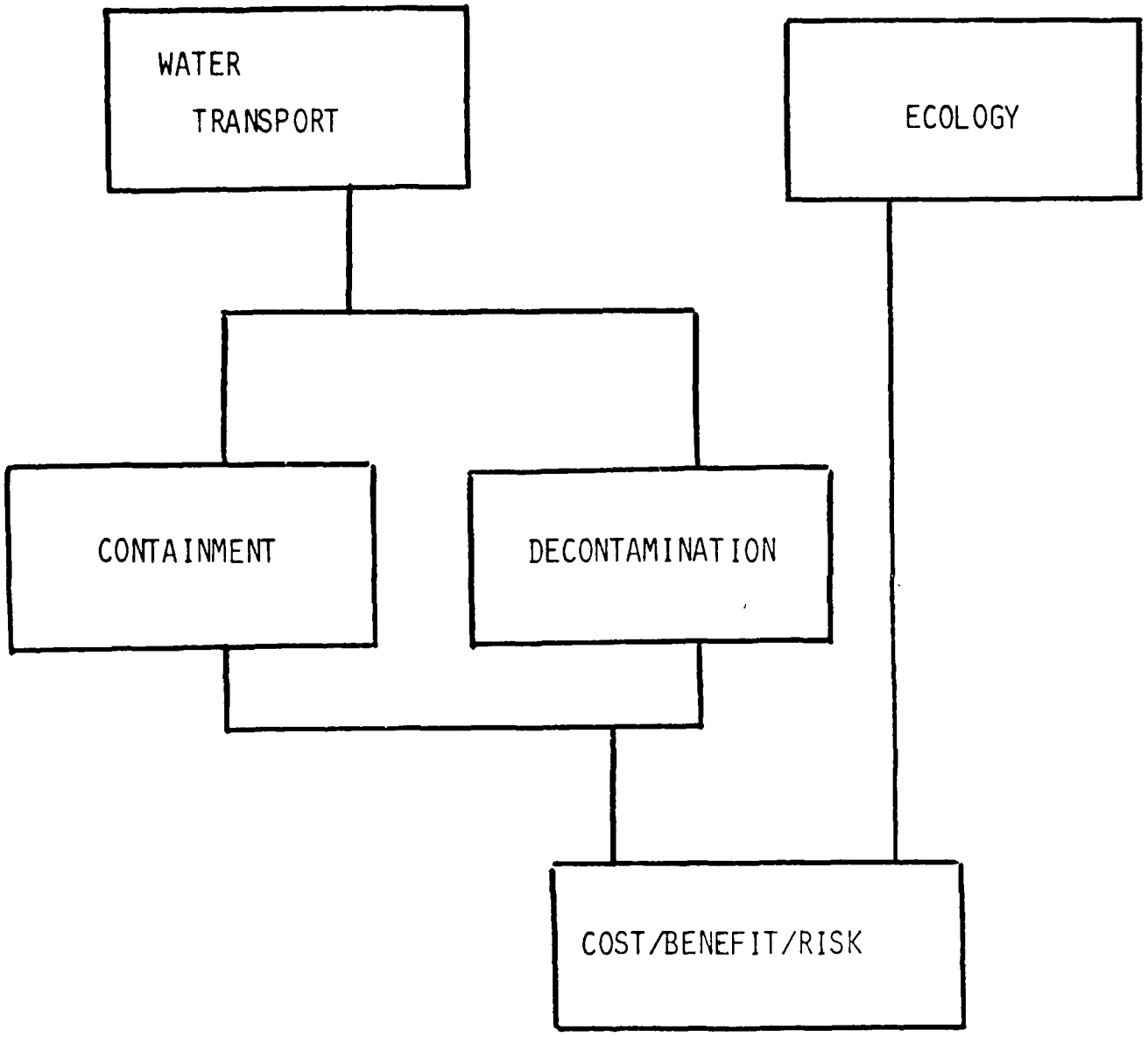

FIGURE 1. INSTALLATION RESTORATION SIMULATION MODULES

"uncontaminated" areas. Outputs include changes in species or function group productivity by geographic area and over time, and how a species or group may accumulate, modify or transmit contaminants.

Containment--This module is very closely coupled to the water transport module. The containment module specifies changes in input parameters to the water transport module due to emplacement of various types of containment barriers, including capping, lining, surface drainage, stream isolation, stream diversion, dams, cutoff walls, wells, dewatering pumps, recharging pumps and combinations. The effects of containment measures on contaminant migration are simulated by the water transport module. Capital and operating costs of containment are calculated within the containment module.

Decontamination This module simulates a number of decontamination processes including diltration, activated carbon, lime precipitation and activated alumina. The module is constructed so that unit processes and operations can be added, by assembling data on treatability of different types of contaminants at different levels of concentration, and poisoning of the process/operation by contaminants of interest. Given flow and concentration data for an input stream, the module automatically selects and stages sets of unit processes/operations that will reduce contaminant concentrations in the final effluent stream to acceptable levels. The module then calculates capital and operating costs for treatment trains judged technically feasible.

Cost/Benefit/Risk Analysis This module integrates reports from each of the above modules to produce a cost/benefit/risk summary report.

Application of the simulation to a site that had been used for disposal of chemical wastes from 1942 to 1955 showed:

1. that capping of the contaminated land area to reduce precipitation infiltration could result in increased chemical concentrations in the underlying aquifer if the soil, due to past flushing action, is relatively less contaminated than the ground water,

2. that interception of ground water flow at the site boundaries, through the use of slurry walls, upgradient extraction wells and a water treatment system, and downgradient recharge wells, should be effective in maintaining water quality at or below existing standards, and water flow at present levels, beyond the site boundaries,

3. that chemical migration of chemicals that bioconcentrate may be detected sooner by biological monitoring than by water quality monitoring;

4. that simulation can be a useful aid to selection of indicator species for determination of ecological effects, and

5. that the use of two carbon adsorption treatment units in series can be more cost effective than the use of a single unit of equal capacity.

In general, simulation is neither a substitute for field measurements, nor an end use for field measurements. Simulation does provide logical algorithms for examining the implications of field data, and particularly for predicting future states from present conditions. As such, simulation can be used effectively in planning field efforts; in assessing whether additional data are needed and if so what kind to improve the quality of decisions with respect to required remedial action; and in testing the cost, benefit and risk implications of a wide range of alternative remedial actions.

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RECONDITIONING PROCESSES FOR DRUMS CONTAINING HAZARDOUS MATERIALS

by

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INTRODUCTION

Burying of steel drums that presently or formerly contained hazardous materials often represents a wasted resource. Such drums can be reconditioned using burning or washing processes to remove and accumulate hazardous material residues so that the steel drum can be returned safely to useful service. Moreover, when a drum's useful life is spent, drum cleaning permits safe ultimate disposal. Reconditioning processes either destroy the hazardous residues or concentrate them in a form more amenable to further treatment.

Benefits of reconditioning steel drums could be considerable. New drums cost nearly $20, and reconditioned ones are about $12. Thus, at sites where there are thousands of drums, potential reclamation value could be significant assuming that drums are in good condition. Moreover, reclamation would help to alleviate a nationwide shortage of reconditionable 18-gage drums.

An 18-gage drum weighs about 50 pounds and occupies a space of more than 9 cubic feet. If drum contents can be treated and disposed separately, then hazardous waste transportation costs could be reduced simply because of lower weight. Furthermore, if emptied drums could be processed and cleaned so they would not have to be disposed in secured landfills or if they could be reused or sold for scrap, life of secured landfills could be extended.

Therefore, reconditioning of drums that presently and formerly contained hazardous materials could have considerable economic and environmental benefits.

RECONDITIONING PROCESSES

There is a well-established steel drum reconditioning industry in the U.S. During 1979, about 250 reconditioners processed

more than 41 million steel drums. More than 95% were 55-gallon drums; most of the rest were 30-gallons. About two-thirds of the drums are reconditioned at washing plants which process tight head drums; the remainder, mostly open head drums, are burned in drum reclamation furnaces.

For new drums, largest numbers are produced for the chemical (40.2%) and petroleum (15.2%) industries. Other end uses include paint and printing ink, janitorial supplies, food, and unspecified categories. A high percentage of oil and petroleum drums are re-used and recycled. On the other hand, a low percentage of chemical drums are reused. Hence, it is not surprising that drums containing spent industrial chemicals or chemical residuals comprise a significant number of drums found at abandoned hazardous waste disposal sites, because such drums exit the user system quicker.

In a washing plant, primarily used for tight head drums, the following operations generally are employed, although there is considerable variation between plants. Drums are preflushed using a strong hot caustic solution. Subsequently, they proceed to a submerged caustic washing tank where the caustic strength is from 10 to 15% and the solution is heated to between 180°F and 200°F. When drum contents are difficult to remove using caustic alone, chains are inserted into the drum along with caustic and the drum is tumbled to dislodge adhering materials. If drum contents cannot be removed by chaining or are cleaned only with great difficulty, the drum heads are removed, thus converting them to open heads, and they are sent to a burning plant. About one-third of washing plants remove rust using hydrochloric acid washes. Tight head drums then are rinsed, dedented, shot blasted, leak tested, and painted.

The process during washing whereby many toxic and hazardous materials, such as pesticides, are detoxified is alkaline hydrolysis. Phosphorus and nitrogen-containing pesticides are particularly susceptible to this treatment.

Except for a few small batch incinerators, most open head drums are burned in tunnel-type continuous furnaces. Conveyor belts move drums through the furnace at an average rate of from 6 to 8 drums per minute. During the 4 minute residence time, drum residual contents, linings, and outside paint are burned at an average furnace temperature of 1250°F. The drum temperature reaches at least 900°F. Drum temperatures higher than 1000°F could cause warping, scaling, and structural damage. After cooling, open head drums are shot blasted, dedented, leak tested, lined, and painted.

Furnace off-gases pass through an afterburner to control air emissions. During normal operation, afterburner average temperature is 1490°F, with an average residence time of 0.5 second. Air emissions also can be controlled by varying conveyor speed, spacing drums farther apart, and mixing "hot" drums with normal types. The State of California requires reconditioners who burn pesticide drums to operate afterburners at 1650°F using a 0.5 second residence time. Most toxic and hazardous materials are detoxified effectively at the 1650°F temperature; however, 2000°F is recommended for chlorinated

hydrocarbons and to provide maximum assurance for complete combustion of noxious compounds.

Plants that process pesticide or other hazardous material drums on a regular basis use special handling and operational and processing procedures.

POLLUTION CONTROL PRACTICES

For routine burning of steel drums, afterburners adequately control air emissions. If a high percentage of potentially hazardous drums are burned on a campaign basis, higher afterburner temperatures (i.e. 1650^{0}F) with a residence time of 0.5 second are acceptable. The afterburner then is followed by a scrubber system for maximum emission reduction. For certain persistent compounds, even higher afterburner temperatures may be required.

There is some evidence that time/temperature tradeoffs are possible in meeting environmental quality standards at burning facilities. For example, it has been proposed that if drum residence time is extended in the reclamation furnace, lower temperatures may be possible. Additional research is necessary based upon the particular materials of interest.

For air pollution control, presently all conventional burning plants use afterburners. In addition, 37% use other equipment as well, including scrubbers, packed towers, baghouses, and dust collectors. (Dust collectors also are used for shot blasters at washing plants).

Most routine washing facilities either recycle and reuse caustic and rinse waters or discharge effluents into public sewerage systems. In fact, about half of all plants (including those that burn), discharge some water into public sewers. Nearly 20% of washing plants claim to have completely closed cycle systems. Only 10% are direct dischargers after treatment. Mean flow for a typical facility is 15,000 gallons per day.

Clearly, recycle systems for caustic solutions and rinse water will be required for facilities specializing in washing of hazardous material drums. In this way, hazardous constituents will be concentrated in sludge and other solid residues. These residuals must be disposed in a safe, economical, and environmentally acceptable manner. Because of the very high organic component in caustic sludges (nearly 60%), high temperature incineration is the preferred choice for residue disposal. On the average, an "empty" drum received by reconditioners contains 0.65 gallons or 5.4 pounds of residues.

Most commonly used water pollution control equipment at routine washing plants includes: screens, oil/water separators, flocculation and sedimentation tanks, filters, and dissolved air flotation units. Those plants specializing in hazardous material drums might be expected to use activated carbon, membrane processes, and oxidation methods such as ozonation for further treatment.

Operating procedures such as preflushing, stream segregation, and cascading water use are important adjuncts to pollution control equipment.

COSTS

Current costs for new tight head drums of most gages are about $18. New open head drums cost around $17 for 19, 20, and 20/18 gage, whereas 18 gage and heavier cost between $22 and $23. Reconditioned drums, both tight and open head, average slightly less than $12. The reconditioning laundry/service fee is nearly $6.

A typical reconditioner pays about $400 per month in sewer surcharges. Flow surcharges average $0.449/1000 gallons, and BOD and total suspended solids cost $0.51/pound of material for concentrations greater than about 200 mg/l.

Almost 90% of water used by reconditioners is purchased from local public or private water distribution systems at an average cost of $0.86/1000 gallons. Other utility costs, principally gas and electricity, average approximately $66,000 per year for a typical plant. Plants burning hazardous materials routinely would be expected to have much higher fuel bills.

Presently, average residue disposal costs are $0.15 to $0.17 per reconditioned drum. Evolving RCRA requirements will cause substantial increases, particularly for plants specializing in hazardous residues.

Recently, reconditioners have spent 20 to 50% of their capital budgets for pollution control. Presently, the industry has $12.7 million in installed pollution control equipment, $9.1 million of which is undepreciated (assuming 10-year life and straight line depreciation). Annual operations and maintenance costs for pollution control equipment are $5.5 million or around $45,000 for a typical plant.

Current pollution control costs per reconditioned drum are in the $0.35 to $0.38 range.

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