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Woodward-Clyde Consultants

83 C 2236-7
March 14, 1984

E.I. duPont de Nemours & Co., Inc.
Niagara Plant
P.O. Box 787
Niagara Falls, NY 14302

Attention: Mr. Timothy D. Van Domelen

**SUPPLEMENTAL INVESTIGATIONS
AND REMEDIAL PROGRAM
NIAGARA PLANT
NIAGARA FALLS, NY**

Gentlemen:

We are pleased to present, herein, an outline of our plan for supplemental investigations for the Niagara Plant Site, Niagara Falls, NY. These investigations are planned to: 1) further define the site geohydraulic regime and 2) provide detailed information for the design and implementation of a remediation program.

INVESTIGATION STRATEGY

In order to effectively plan and implement supplemental investigations for the Niagara Plant, it is first necessary to define the overall approach and strategy for these studies. The investigatory work plan is divided into the two areas of geohydrologic investigations and remediation investigations. The project strategy is to actively to pursue remediation of the "source" while concurrently conducting supplemental geohydrologic investigations. The remediation investigations are therefore presently focused on cleaning up the source (or sources) located within the overburden. While this work is on-going studies of groundwater flow in the bedrock will be conducted. Hence, at such time as remediation of the sources in the overburden is on-going or complete, data required to assess need for additional remediation of the groundwater in the rock will be available. The following report details our plan for supplemental geohydrologic and remediation investigations.

SUPPLEMENTAL GEOHYDROLOGIC INVESTIGATIONS

As part of the Site Assessment studies conducted during 1983, 52 monitoring wells were installed in the plant site area. The aerial distribution of the monitoring wells was sufficient to characterize the site geohydrology on a plant-wide scale as described in our Report dated December 23, 1983. The following is a synopsis of additional field studies that are required to better define the geohydrologic properties of the overburden and bedrock water bearing zones.

OLIN PRODUCTION WELL

The response of the DuPont monitoring wells to Olin production well pumpage was observed primarily in the C, D, E and F water bearing zones. In the area of monitoring wells 19 A & B and 20A, no discernable pumping effects were observed. To further define the effects of the Olin production well in this area, it is recommended that a B zone monitoring well be installed at Location 20. Further, C-CD, D and Fwater bearing zone monitoring wells should be installed at location 19. The location of monitoring well cluster 20 may impose physical constraints on the placement of additional wells. It is recommended that a monitoring well at location 20 be installed in the B-zone and a full complement of wells be installed (A, B, C-CD, D and F zones) north of well cluster 20, north of Buffalo Avenue, as shown on Plate 1. These wells will provide water level information useful in determining groundwater flow directions and permit sampling to define the quality of the groundwater in this area.

BUFFALO AVENUE

Groundwater flow direction in the bedrock is principally in a northerly direction. Limited information is available as to the groundwater hydraulic head in the areas of the plant site along Buffalo Avenue and the effects of the Buffalo Ave. sewer on the groundwater regime. As discussed in the previous section, the placement of B, C, D and F zone monitoring wells at location 20/24 would aid in obtaining additional information in this area. In addition, it is recommended that A, B, C and D zone monitoring wells be installed at location 22 to the southeast of monitoring well cluster 17, in the far northeast corner of DuPont property (Plate 2). The difference in groundwater levels between monitoring wells U-7 and 17A would be checked by using hollow stem auger drilling techniques in the regolith to determine when the water table is encountered. It the water table is encountered at a depth similar to that of monitoring well U-7 then it is recommended that monitoring wells be installed in the upper section of the water table at the two aforementioned locations. The groundwater elevation data collected would be used to define the groundwater flow regime of the regolith in this area.

GILL CREEK

Groundwater elevation data collected for the A zone during the plant site assessment indicated that Gill Creek is potentially both a groundwater discharge and recharge point. Sufficient data is available for the west plant area to define the direction of groundwater flow to Gill Creek. In the east plant area Gill Creek appears to be a recharge point. It is recommended that an A zone monitoring well be installed near Gill Creek, south of monitoring well 12 (Plate 1) at location 23. The groundwater table elevation data collected for this well will aid in determining if Gill Creek is recharging the groundwater regime in the east plant area.

FRACTURE ZONE HYDRAULIC COMMUNICATION

The principal vertical groundwater flow path in the bedrock of the plant site area is through near vertical and vertical fractures. Estimation of the magnitude of vertical communication between horizontal fracture zones at well clusters can be determined by pumping. The results of low volume pumping tests at selected well clusters can be used to estimate the vertical leakage from non-pumping fractures to the pumping fracture. It is recommended that monitoring well clusters containing both an A and B or an A and C zone monitoring well be pumped at low volumes to determine the vertical communication between fracture zones. The test procedures, in general, would include the pumping of the B-zone (C-zone if B-zone is not present) monitoring well at a rate of from between 1 and 20 gallons per minute (depending on well yield) for a time period of about 1 to 2 hours (depending upon the response). No test is expected to last more than three hours. The water level changes in each well will be monitored using pressure transducers coupled to strip charts. The B wells will be used to determine the communication between A and C zones. This procedure will be repeated until all of the wells are tested. At the present time it does not seem necessary to pump the A and/or deeper monitoring wells at a cluster. The response of these wells will be measured while testing the B-zone. If the water bearing zones at depth are effected during the B-zone test, it is recommended that these deeper zones also be tested. This expanded scope of work is not expected to significantly add to the cost of the test.

VERTICAL FRACTURE FREQUENCY

If the results of the fracture zone hydraulic communication pump test are inconclusive it may be necessary to further investigate vertical fractures. If such further investigation is required, it is recommended that contingency low angle core holes be considered in the vicinity of the well clusters tested. The information from the core holes would be correlated to the pump test results, refining the conceptual hydraulic model of the plant site and, if possible, used in refining the estimates of groundwater flux rates between the A and B zones.

GROUNDWATER ELEVATIONS

As a prerequisite to the development of a viable plant site data base, it is recommended that a schedule of monthly water level readings be initiated. The monthly water level readings can be performed by WCC, on-site personnel, or a local contractor. The monthly readings should be continued for a minimum of one year to develop an understanding as to the effects of seasonal changes on the groundwater regime. Thereafter, or until the wells are sealed, water levels should be taken on a quarterly basis. This information should be used to maintain up to date well hydrographs.

REGIONAL GROUNDWATER FLOW

The direction of groundwater flow in the bedrock at the plant site is in the direction of (1) the northwest toward the Olin production well and (2) to the northeast in the direction of an unknown groundwater sink. The groundwater sink to the northeast may be related to the Power Authorities water intake conduits. It is recommended that additional information be collected with respect to the design of the conduit. In addition, the town of Niagara Falls has information available with respect to other subsurface structures in the plant site area. The location elevation and design of these structures may help define their impact on bedrock groundwater flow. WCC would prepare and submit a list of information to be requested of the authorities by DuPont.

MANMADE PASSAGEWAYS

The evaluation of the contaminant loading in the Adams Avenue sewer passageway needs to be evaluated by an additional test pit/utility well west of utility well 1. The sampling of the Adams Avenue sewer west of the pump station would also add to the data available in regards to contaminant leaving the site.

The evaluation of the contaminant migration in the vicinity of utility well 10 and 11 can be addressed by means of additional monitoring wells. It is recommended that two additional utility wells be installed adjacent to each of the manmade passages affected. This will allow for the evaluation of flow and the contaminant transport along the passageways.

SUMMARY AND SCHEDULE

Presented on Plate 1 are the locations and fracture zones recommended for the installation of monitoring wells. A schedule of activities is provided on Plate 2.

REMEDIATION INVESTIGATIONS

The investigations described herein are planned consistent with the phased approach to the project which first necessitates remediation of the source. Remediation of the bedrock will not be considered at this time although the impact of proposed source remediation upon the bedrock must be evaluated.

SUBSURFACE CONDITIONS

Impact of practical concern to the remediation program is the general site stratigraphy and geohydrologic conditions. These have been described in detail in our

December 23, 1983 report. The impact of subsurface conditions upon remediation is discussed herein. The overburden material consists of miscellaneous fill overlying alluvial, lacustrine, and till deposits of variable thickness. Consistant with the variability of the overburden materials (type, density, thickness and extent) a wide range in the hydraulic conductivity (permeability) is expected. In general the silt-clay (fine grained) soils tend to restrict fluid movement, while the granular (coarse grained) soils tend to more readily transmit fluids.

The groundwater in the area of the DuPont Plant Site is encountered in both the overburden and underlying bedrock. Of primary interest to the plant site remediation program is the groundwater regime in the overburden material. From data collected during previous investigations, it was found that groundwater at the site in the overburden material was encountered at relatively shallow depths. Noting that the primary mechanism for recharge in the overburden infiltration of precipitation, it is expected that the groundwater elevations will flucuate over several feet during the course of a year. The apparent boundary that devides the east and west plant flow regimes is Gill Creek. Remediation alternatives must also consider fluid flow from the overburden to the bedrock. In general the hydraulic potential (head) in the rock is less than that in the overburden material, which results in a general downward flow potential from the overburden to the bedrock.

REMEDIATION APPROACH

Remediation of the Plant Site is presently focused upon controlling the pollutant source. The purpose of the remediation program is to remove, contain and/or neutralize the contaminant sources. Pollutants at the site are present as both soluble and non-aqueous liquids.

REMEDIATION TECHNIQUES AVAILABLE

There are two categories of remediation techniques: 1) passive systems, such as creating a physical barrier, to contain the contaminants and 2) active systems, such as altering groundwater flow with purge wells to prevent contaminant migration.

PASSIVE SYSTEMS: Horizontal and vertical grout curtains, slurry walls, sheet piling along with surface sealing, and grading and revegetation, constitute the passive systems typically utilized at contaminated sites of this type. The purpose of impermeable barriers is to limit the off-site migration of the contaminants and provide a convenient collection zone. For example, consistant with the general groundwater flow regime, and noting the location of known utility lines, a vertical barrier to horizontal flow may be achieved, if necessary, by constructing a slurry wall within the southwest and the northeast Plant Site limits. Excavation in the northeast and southwest corners would be expected to average approximately 23 feet and 13 feet respectively. Passive system such as this could be augmented by the use of active systems described below.

ACTIVE SYSTEMS: A likely approach to the utilization of active systems would be to collect the contaminants near located sources of surface or near surface non-aqueous liquids. Active systems consisting of groundwater pumping, solution mining techniques, in-situ detoxification/neutralization, bioreclamation and leachate control techniques would also be considered.

Groundwater pumping would lower the groundwater levels in the near vicinity of the pumping wells causing an increase in gradient toward the pump intake. In addition, due to the lower hydraulic potential in the overburden materials near the pump location, an upward gradient can be induced causing upward flow from the bedrock. As a consequence of this pumping a superimposed directional force vector is induced. In addition to acting on the local groundwater regime, this induced directional force vector also exerts a driving force on the non-aqueous phase liquid toward the pumping source.

The solution mining technique mobilizes contaminants by flushing them through the groundwater for collection. This technique is well suited for flushing heavy metals and organics. It is, however, difficult to determine the extent to which the solvent (water) makes contact with the contaminants. This sytem is generally used in conjunction with groundwater pumping and/or leachate collection. To affect different compounds, the nature of the solvent can be altered by changing pH, temperature, or by introducing complexing and chelating agents. In addition, surfactants may be added for the purpose of improving the recoverability oils and greases.

Neutralization/detoxification is an in-situ technique whereby a substance is applied to or injected into a specific contaminant species to immobilize or destroy the contaminant. In general, this method of treatment is limited to contaminants that have nontoxic breakdown products and/or result in an insoluble precipatate upon treatment. This method is further limited in use to cases where the contaminant is well defined, specific and segregated from other contaminants.

Bioreclamation or the bacterial degradation of petrochemical and other organic compounds can be an anaerobic or an aerobic process. If it is an aerobic process, aeration most likely would be required. This method is not particularly effective for groundwater contaminated with heavy metals, certain chloronated organics and other nonbiodegradable compounds. Moreover the use of bacteria as the degradation agent requires strict system control. That is to say, each bacterium has a specific environment in which it can exist. If this environment is altered, the destruction of the bacteria may result. Since different contaminants migrate across the site, maintaining a specific environment will be extremely difficult. For this reason, and others mentioned previously, in-situ biodegradation appears to have a limited application on this project. Biological treatment of pumped water does offer a greater potential however.

Leachate control is a system whereby the subsurface leachate/elutriate is intercepted or otherwise collected before it migrates off-site. A variation of this method, namely the use of sediment traps/basins or trenches may be effective in collecting sediment-laden runoff. A form of leachate collection is currently under consideration utilizing the test pit recovery wells.

REMEDIATION INVESTIGATION PLAN

The remediation investigation plan has been developed and will consist of two phases. The first phase will include a review and ranking of all of the available remediation methods. Information regarding their applicability, limitations, advantages, disadvantages, and their environmental effectiveness will be developed and evaluated. This initial assessment will be conducted in order to develop a "short list" of remediation techniques which would be further evaluated in the second phase. Phase II remediation studies would be conducted to determine design criteria, develop cost information, and select the final remediation program. Hence, at the completion of Phase II studies, a conceptual remedial action program with preliminary design criteria will be developed. This can be submitted to the appropriate regulatory agencies for their review. The following subsections describe in further detail these studies.

PHASE I REMEDIATION STUDIES: Phase I remediation studies would be conducted to assess all the available remediation techniques and to develop a ranking for these techniques. Ranking would be based upon an evaluation of (1) technical feasibility, (2) environmental effectiveness, (3) impact on site operations, and (4) costs. The alternatives discussed earlier, as well as all other available remediation techniques, would be evaluated during these studies. Hence, the list under consideration would be exhaustive. At the completion of this evaluation a short list of viable remediation techniques would be prepared and further investigated in the Phase II studies.

As part of the Phase I studies, a detailed work plan would be provided describing the tasks as associated with developing the preliminary design of each short listed alternative to be considered in Phase II. This detailed work plan would permit concurrent development of preliminary designs for each of the attractive alternatives so as to permit an expedient evaluation of the most suitable remediation technique for the Niagara Plant site. It is likely that the components within the remediation alternatives would also be compared. For example, if groundwater treatment is required as a component within a remediation alternative, methods of groundwater treatment would be evaluated and ranked.

At the end of the Phase I studies, a report would be prepared describing in detail the engineering evaluations, the ranking of the alternatives, and the development of the short list for further investigation in Phase II studies. Further the detailed work plan for Phase II studies will be submitted at this time.

PHASE II REMEDIATION STUDIES: The most attractive remediation alternatives would be further evaluated during Phase II studies. Preliminary design of each of these alternatives would be developed in order to permit cost comparisons. In addition, detailed work plans for any additional work that might be required prior to final design and construction of the selected alternative will be prepared at this time.At the completion of Phase II studies, a report would be prepared describing Phase II investigations and presenting our recommendations regarding the remediation program for the Niagara Plant site. It is anticipated that at the end of Phase II studies, the remediation program would be narrowed down to no more than three options and preferably only one.

REMEDIATION INVESTIGATION SCHEDULE

Presented on Plate 2 is our schedule for the performance of our Phase I and Phase II remediation studies. As shown on the schedule, Phase I remediation studies will be completed and the report prepared by March 30, 1984. Phase II studies, the development of the conceptual remediation program, is scheduled to be completed by May 30, 1984.

It is noted, at this time, that the appropriate resources from within Woodward-Clyde Consultants would be utilized for the evaluation of remediation alternatives and the determination of the appropriate remedial action program. It is expected that expertise would be drawn from other offices, as required. For example, it is likely that Bruce Page, from our Walnut Creek office would be involved in the evaluation of treatment technologies. Overview and peer review of the remediation program would be the responsibility of Mr. Joseph R. Kolmer. The other project staff assigned to the Niagara Plant project remains unchanged. Resumes of Mr. Kolmer and Mr. Page are attached herewith.

As noted, this draft supplemental investigation plan is submitted for our discussion and as a basis for our discussion in the meeting scheduled for Thursday March 1, 1983. Based upon the work scope described herein and the results of our March 1 meeting, the supplemental investigations plan will be finalized and work initiated. We sincerely appreciate the opportunity of providing these services to you on this project. If you have any questions please contact us.

Very truly yours,

WOODWARD-CLYDE CONSULTANTS

for Craig R. Calabria

Mark N. Gallagher
Assistant Project Engineer

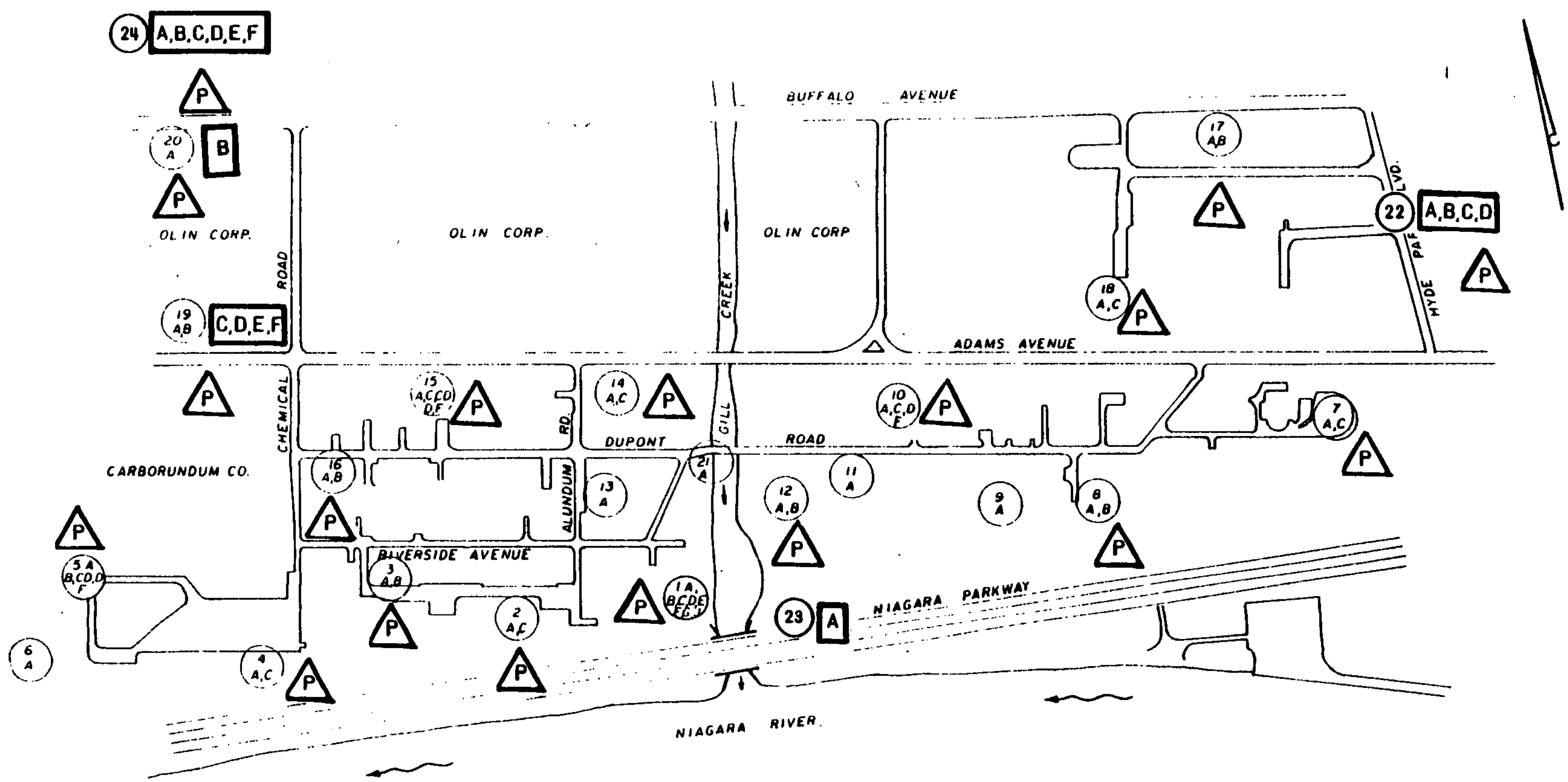
Jeffrey C. Evans/gmb

Jeffrey C. Evans, P.E.
Project Manager

MNG/mm

cc: Mr. Frank S. Waller, Woodward-Clyde Consultants
Mr. Joseph R. Kolmer, Woodward-Clyde Consultants
Mr. Craig R. Calabria, Woodward-Clyde Consultants
Mr. R. J. Gentilucci

Plates



1984 GEOHYDROLOGICAL STUDIES

LEGEND:

(17 A,B) — WELL CLUSTER NUMBER (NO.) / WELL TYPE (LETTER)

(P) PROPOSED LOCATION OF B-ZONE PUMP TEST

[B,C,D] PROPOSED MONITORING WELLS

PROPOSED MONITORING WELL LOCATIONS
NIAGARA PLANT
E.I.DUPONT DE NEMOURS & CO.

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

DRAWN BY: T.P.	SCALE in FEET 0 — 300	DATE: 3/14/84
CHECKED: J.C.E.		JOB: 83C2236-5

PLATE 1

ESTIMATED INVESTIGATION SCHEDULE
DUPONT NIAGARA PLANT
MARCH 1, 1984

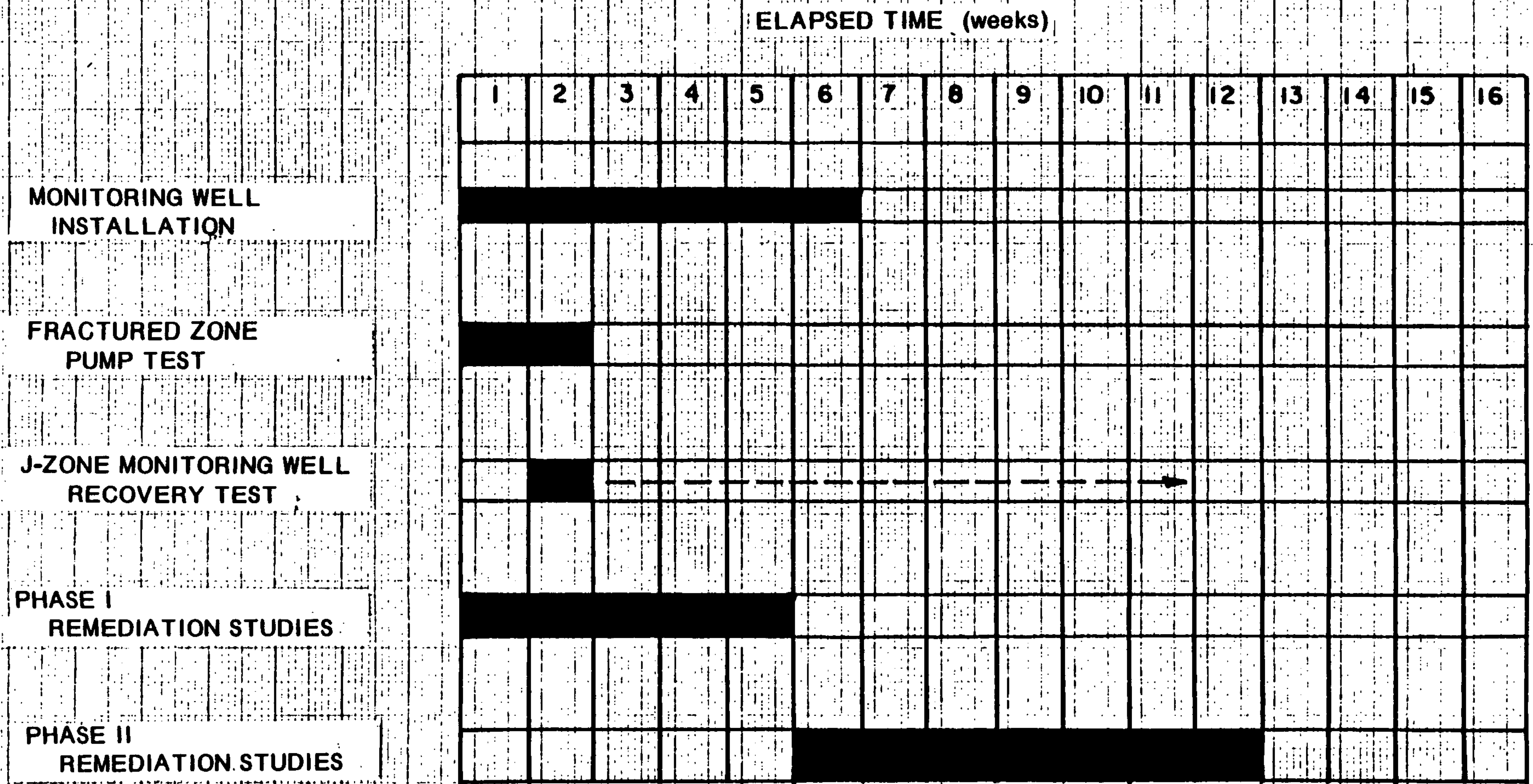


PLATE 2

Attachments

JOSEPH R. KOLMER

groundwater engineering
solid/hazardous waste management
environmental earth sciences
geological engineering

EDUCATION

University of Tulsa: M.S., Environmental Earth Sciences
St. Louis University: B.S., Geological Engineering

REGISTRATION

Professional Engineer: Mississippi

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Director of Waste Management, 1979-date
U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, Developmental Sanitary Engineer, 1978-1979
U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Grounds, Maryland, 1975-1978
U.S. Army Environmental Hygiene Agency, Directorate of Environmental Quality, Solid Waste Management Division, Aberdeen Proving Grounds, Maryland, 1972-1975
Hudgins, Thompson, Ball and Associates, Tulsa, Oklahoma, 1972
University of Tulsa, Tulsa, Oklahoma, Graduate Student, 1971-1972
U.S. Army, Artillery, Army Officer, 1968-1971
Woodward-Clyde and Associates, St. Louis, Missouri, Field Engineer, 1967-1968

REPRESENTATIVE EXPERIENCE

Mr. Kolmer has more than ten years experience in solid and hazardous waste management. He has worked for several agencies of the U.S. Army and has assessed military waste disposal sites and practices throughout the United States and in the Far East. He is experienced in the geological, geohydrological, and chemical aspects of assessing existing site conditions and in the enviornmental and geotechnical engineering aspects of remedial program development and design. Since his employment with Woodward-Clyde Consultants, he has become involved in the supervision of large scale waste management consulting projects, research and development of remedial action techniques for hazardous waste disposal sites, and the negotiation of contaminated site problems and remedial programs with State and Federal regulatory agencies.

While with the U.S. Army Environmental Hygiene Agency, Mr. Kolmer assessed waste disposal sites on numerous military facilities. These assessments included evaluation of existing landfill conditions, wastes being disposed at the facility and treatment processes. He also assessed the environmental impacts associated with storage of retrograde cargo from Vietnam, both on the Island of Okinawa and at Sierra Army Depot in California. A disposal site selection study was conducted on Okinawa and a disposal area was identified and preliminary operations plans prepared. The work at Sierra Army Depot involved remedial action at a disposal area to prevent contamination of the drinking water supply for the military facility and the adjacent community.

Mr. Kolmer was the engineering team leader for the evaluation and design of remedial programs for hazardous waste facilities while with the U.S. Army Toxic and Hazardous Materials Agency (formerly the Office of The Project Manager for Chemical Demilitarization and Installation Restoration). This engineering team was responsible for development of remedial techniques at all military installations involved in the Installation Restoration Program. While holding this position, Mr. Kolmer assessed and quantified the groundwater conditions at Rocky Mountain Arsenal, Denver, Colorado, and developed a pump well, treatment and recharge system for removal of groundwater contamination. After installation of the system, the operational monitoring showed that the system was functioning as designed. This system was one of the first in the country that balanced groundwater withdrawal, treatment and recharge to natural groundwater flows across a finite line distance.

Mr. Kolmer was employed as a Developmental Engineer with the U.S. Army Engineer Waterways Experiment Station at Vicksburg, Mississippi. He was responsible for numerous groundwater assessments, one of which included a large area assessment of groundwater flow conditions as well as associated water quality conditions. This particular project required that a multilevel aquifer system be assessed and quantified. Full scale field pumping tests were conducted as well as abbreviated aquifer tests (slug tests). Long-term monitoring was conducted for hydraulic conditions as well as water quality conditions. The final report for this project detailed the direction of groundwater flow, the quantity of flow, the seepage velocity, the lateral and vertical distribution of contaminants in the groundwater system and the mass movement of contaminants with time in the groundwater flow. This field work formed the basis from which a remedial action program could be developed and designed.

During Mr. Kolmer's employment with Woodward-Clyde, he has held the position as Director of Waste Management for the Eastern Region. He has been Program Manager for several groundwater assessments, primarily those associated with hazardous waste disposal operations. He is presently the Project Manager for the consulting work that WCC is doing for Hooker Chemical Company. During the course of this work as well as several other projects, Mr. Kolmer has gained experience in the negotiation of contamination problems with State and Federal regulatory agencies. He is also the Program Manager for the remedial action research and development work for hazardous waste disposal facilities. He has studied the movement of organic liquid wastes in groundwater systems and has applied the principles of two phase fluid flow to assess and mitigate this type of contaminant movement. He is also teaching groundwater hydrology in the Graduate School at Villanova University, Villanova, Pennsylvania.

PUBLICATIONS

Kolmer, J.R., and Lambert, R.S., March 1981, "Investigation of the LiPari Landfill Using Geophysical Techniques", USEPA Remedial Action Research Program, Municipal Environmental Research Laboratory, Cincinnati, Ohio

Hasson, S.W. and Kolmer, J.R., August, 1978, "Operation of the Drill and Transfer System at Dugway Proving Ground, Utah, Final Environmental Impact Statement", Department of the Army, Officer of the Project Manager for Chemical Demilitarization and Installation Restoration.

Kolmer, J.R., et al, February 1978, "Seismic Risk for Rush Valley, Utah, and an Earthquake Design Analysis of Ammunition Storage Facilities for the South Area of Toole Army Depot", Office of the Project Manager for Chemical Demilitarization and Installation Restoration, NTIS No. AD-A0672 405.

Kolmer, J.R. and Anderson, G.A., July, 1977, "Pilot Containment Operations, Final Environmental Impact Statement, Installation Restoration of Rocky Mountain Arsenal, Colorado", Department of the Army, Office of the Project Manager for Chemical Demilitarization and Installation Restoration.

Kolmer, J.R., August, 1975, "Handling and Storage of Retrograde Cargo, Sierra Army Depot, Herlong, CA.", U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Study No. 26-008-73/76.

Kolmer, J.R. and Coonley, L.W., July, 1975, "Disposal of Waste Water from Entomology Operations, Ft. Lee, VA", U.S. Army Environmental Hygiene Agency, Solid Waste Management Special Study No. 99-016-75.

Kolmer, J.R., June, 1975, "Soil Permeability Characteristics, Okinawa", U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Special Study No. 26-004-74/75.

Schaub, S.A., Meiser, E.P., Kolmer, J.R., Sorber, C.A., May, 1975, "Land Application of Waste Water: The Fate of Viruses, Bacteria and Heavy Metals at a Rapid Infiltration Site", U.S. Army Medical Bioengineering Research and Development Laboratory, Ft. Detrick, MD.

Kolmer, J.R., April, 1975, "Soil Permeability Characteristics, Mainland, Japan", U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Special Study No. 29-012-74/75.

Stachiw, K., Kolmer, J.R. and Newell, E., February, 1975, "Solid Waste Management, Ft. Detrick, Frederick, MD", U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Special Study No. 26-013-74/75.

Kolmer, J.R., May, 1974, "Evaluation of Disposal Methods and Soils Characteristics, Schofield Barracks, Hawaii," U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Special Study No. 26-013-74/75.

Kolmer, J.R., Young, J.L. and Kestner, R., May, 1974, "Solid Waste Management Survey, New Cumberland Army Depot, New Cumberland, Pennsylvania", U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Study No. 26-008-74.

Kolmer, J.R., December, 1973, "Solid Waste Management Survey, Newport Army Ammunition Plant, Newport, Indiana", U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Study No. 26-001-74.

Kolmer, J.R. and Young, J.L., October 1973, "Solid Waste Management Survey, Pine Bluff Arsenal, Pine Bluff, Arkansas", U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Study No. 26-011-73/74.

Kolmer, J.R. and Stachiw, K.L., August, 1973, "Solid Waste Management Survey", Ft. Dix, New Jersey, U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Study No. 26-010-73/74.

Stachiw, K.L. and Kolmer, J.R., June, 1973, "Solid Waste Management Survey, Anniston Army Depot, Anniston, Alabama", U.S. Army Environmental Hygiene Agency, Solid Waste Management Division Study No. 26-009-73.

Kolmer, J. R., March, 1973, "A Wave Tank Analysis of the Beach Foreshore Grain Size Distribution", Journal of Sedimentary Petrology, Volume 43, No. 1, pp. 200-2-4.

JRK 1/84

BRUCE W. PAGE

hazardous waste treatment
adsorption and ion exchange
chemical engineering

EDUCATION

University of California, Berkeley: Ph.D., Chemical Engineering, 1971
University of California, Berkeley: M.S., Chemical Engineering, 1968
Northwestern University: B.S., Chemical Engineering, 1965

PROFESSIONAL HISTORY

Woodward-Clyde Consultants, Senior Project Engineer, 1982-date
Engineering-Science, Senior Engineer, 1982
E.I. duPont de Nemours, Inc., Senior Engineer, 1972-1981
Bay Area Air Pollution Control District, Air Pollution Engineer, 1972
Aqua-Ion Corporation, Chemical Corporation, Research Engineer, 1965-1966
Co-op Student, 1962-1965

REPRESENTATIVE EXPERIENCE

Since joining Woodward-Clyde Consultants Dr. Page has been project manager or task leader on several remedial action programs including two ground-water problems with heavy metals and one lagoon containing plating wastes. Treatability studies leading to treatment plant designs were done under his direction. Ion exchange, carbon adsorption and metals precipitation were used where appropriate. Dr. Page was also task leader on a government-sponsored report on national ground-water contamination and its measurement. Site assessments, remedial alternative analyses, and chemical property characterizations for an abandoned acidic pickle liquor lagoon, a large chemical spill, organic solvents leaked or spilled into ground water, a hazardous waste landfill, and a risk assessment for shipboard incineration of hazardous chemicals have also been part of Dr. Page's experience at Woodward-Clyde.

At Engineering-Science, Dr. Page was a consultant on hazardous and industrial waste problems. He was the project manager for the design of a treatment plant to remove both volatile and nonvolatile solvents from the ground water at an electronics firm. He was also the project manager on the site assessment work at an abandoned scrapyard contaminated with heavy metals.

At duPont, Dr. Page was the corporate consultant on process ion exchange, desiccant drying, and liquid-phase adsorption. Working in the Engineering Services Division of the Engineering Department, he assisted on all phases of projects from research through development and design to trouble-shooting existing facilities. Both waste treatment and process applications were treated on a very wide range of activities from old-line industrial chemicals to bio-chemicals, organic chemicals, and Department of Energy sites (SRP and SRL).

AFFILIATIONS

Editorial Advisory Board, Industrial Water Engineering

PUBLICATIONS

Mixed-bed ion exchange desalting by the calcium hydroxide process (with G. Klein, F.M. Golden, and T. Vermeulen). AICRE Symposium Series 152 (71), 121, 1975.

Conversion of mine drainage to potable water by sulfate cycle ion exchange. Draft Final Report for Hittman Associates, Columbia, Maryland, 1972.

A new filtration device for concentrating neutralized AMD sludges (with M.J. Copley and J.M. Shackelford). 4th Symposium on Coal Mine Drainage Res., Pittsburgh, Pennsylvania, April 1972.

BWP 11-83/14

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