CONTAMINATION REPORT
SEPTEMBER 17, 1982

GEOTECHNICAL REPORT
SEPTEMBER 17, 1982

CONTAMINATION REPORT
JUNE 15, 1982

Report DRXTH-AS-CR-82137

CONTAMINATION SURVEY

IOWA ARMY AMMUNITION PLANT

J. Clear
P. Collins

Environmental Research Group, Inc.
117 North First Street
Ann Arbor, Michigan 48104

17 September 1982

Final Report for Period 1 February 1981 - 31 October 1981

Prepared for:

Mason & Hanger - Silas Mason Company, Inc.
Iowa Army Ammunition Plant
Middletown, Iowa 52638

U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland 21010

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CONTAMINATION REPORT

IOWA ARMY AMMUNITION PLANT

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31 October 1981

Revised
15 June 1982

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September 17, 1982

Mason & Hanger, Silas Mason Company
Iowa Army Ammunition Plant
Middletown, Iowa 52638

re: Contract DAAA09-78-C-3008; Report DRXTH-AS-CR-82137

Gentlemen:

Pursuant to a request made by the Chief, Assessments Division, USATHAMA (see correspondence A.W. Anderson to Commander, USAAMRC, 25 August 1982), we are submitting recommendations for actions relative to the findings in the Brush Creek and Pink Water Lagoon sections of the IAAP. For details on these sections, please see 4.7 and 4.8 of the Final Report.

Accordingly, it is recommended that:

1) further testing be conducted in the Brush Creek section to determine the probable effectiveness of erosion control measures in reducing the future contamination of groundwater in that area; and

2) the Pink Water Lagoon be registered according to RCRA protocol and additional testing of monitoring wells and sediments be conducted in order to prepare closure plans for the area.

In both cases, the contaminant of concern is RDX; we see no obvious need to investigate other chemicals during the future studies.

Respectfully submitted,

James J. Bolger
Vice President
Professional Services Division

JJB/cj

Enclosure

cc: J. Clear
P. Collins

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Discussion of the contamination as related to its potential to migrate from the IAAP facility. Incorporates all data gathered to investigate groundwater and surface water flows. Points out suspected source areas.

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Contamination Summary
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EXECUTIVE SUMMARY

An environmental contamination survey of the Iowa Army Ammunition Plant was performed to determine the extent of contamination and its potential to migrate beyond installation boundaries. Groundwater, surface water, sediment, and soil samples were collected and analyzed for explosives, cyclotrimethylene trinitramine (RDX), anions, metals, priority pollutant organic chemicals, pesticides, and PCB's.

The investigation of the Iowa Army Ammunition Plant by Environmental Research Group, Inc. indicated that contamination migration is occurring at Brush and Spring Creeks. The principal contaminant is the explosive material, RDX. The concentrations of RDX determined in this one set of samples indicates that RDX levels in waters leaving the facility are below the criteria for aquatic life developed by U.S. Army Medical Bioengineering Research and Development Laboratory.

Also, groundwater in the Pink Water Lagoon/Line 800 area is contaminated with RDX and other explosive contaminants. It could not be determined from the available data and information if this contamination is contributing to the concentrations detected in runoff from Brush Creek. The data on groundwater flow rates, however, suggest that the plume of contamination around the Pink Water Lagoon is localized.

ACKNOWLEDGEMENTS

Environmental Research Group, Inc. (ERG) wishes to acknowledge the following persons for their participation and effort toward successfully completing this contamination survey at the Iowa Army Ammunition Plant.

Doug Reed, Floyd Laue, and other staff members of Mason & Hanger - Silas Mason Company, Inc. set schedules, prepared contract documents, and contributed information and assistance to ERG. United States Army Toxic and Hazardous Materials Agency (USATHAMA) representatives LTC Walter Youngblade, Paul Lancer, Don Pugh, CPT Brian Boevers, Marty Stutz, and CPT Rey Jimenez provided technical direction on all aspects of the contamination survey. Subcontractor Soil Testing Services staff members Dave Jedlicka, Ron Hutchens, and Jim Overtoom conducted the geotechnical studies reported in this document.

ERG's project team consisted of staff from both Ann Arbor and Minnesota. The following persons were major contributors to this project:

From the Minnesota office, overall project coordination was supplied by Dr. Roger Blomquist. Field operations were completed by Duane Dittberner and Michael Martin.

Ann Arbor personnel performed the analytical tasks and other project management responsibilities. Overall laboratory coordination was supplied by Dr. Frank Hammer. Those directly involved with the analysis of organic and inorganic samples included: Jim Endres, Bob Foster, Mike Jaeger, Skip McKee, Arthur Mitchell, Kurt Picel, and Terri Sarris.

Members of ERG's administrative group were instrumental in assuring log-in and chain-of-custody; they were: Pamm Baxter, Maureen Lindsay, and Jim Grysban.

Quality Control information processing was accomplished by Linda Dunlap and computer processing by Betsy Whitely.

The Final Report was prepared and submitted by Jack Clear and Peter Collins.

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1.0 INTRODUCTION

1.1 Objective

The objective of the study by Environmental Research Group, Inc. (ERG) was to determine if explosives, heavy metals, or other toxic/hazardous wastes existed at the Iowa Army Ammunition Plant (IAAP) and if so, whether they were migrating or have the potential to migrate beyond the boundaries of the facility. To achieve this objective, ERG sampled ground and surface waters, sediments, and soils in areas within the plant property. These areas were suspected as potential contributors of hazardous and toxic wastes. Also, all major pathways of potential migration of contaminants from the facility were monitored by the collection and analysis of samples in order to determine if any contamination of areas outside the facility was occurring.

Sampling sites were determined by the United States Army Toxic and Hazardous Materials Agency (USATHAMA). The choice of sites by USATHAMA was based on knowledge of previous and ongoing operations at the facility and information developed through previous government studies conducted at IAAP (1, 2, 3, 4)*.

1.2. Project Authorization

This contamination survey of the IAAP was authorized by the Department of the Army under USATHAMA direction. The contracting authority

*For referenced citings, please see Section 6.0, p. 60.

for this project was the Mason & Hanger - Silas Mason Company, Inc. which is the operating agency for the IAAP. The contract to conduct this survey was awarded to Environmental Research Group, Inc. in December 1980. ERG employed a subcontractor, Soil Testing Services (STS) of Peoria, Illinois to accomplish the well drilling and geotechnical analyses.

1.3 Background

The Iowa Army Ammunition Plant (IAAP), located at Middletown, Iowa, is a U.S. Government-owned facility operated by Mason and Hanger-Silas Mason Company, Inc. to load, assemble, and pack various types of ammunition. This facility has been in operation, with varying degrees of activity, since 1941.

The production operations have resulted in discharges of explosives and their by-products to the land and water at the complex. These discharges, as wastewaters, entered various holding ponds, lagoons or watercourses. Other types of discharges or emissions arose from areas at the facility used to burn explosives, conduct detonation tests, and dispose of miscellaneous solids. Because of these operations and past government studies at the facility, it is known that contaminated areas do exist within the facility (4).

It is also known that contamination of areas outside the facility has occurred previously. This contamination was due to discharges of wash waters containing explosives into an impoundment constructed in 1948 within the confines of Brush Creek. Waters, which left this impoundment, were suspected of contaminating a few shallow wells located close to Brush Creek outside the IAAP property in the early 1950's. This problem

was reportedly (IAAP records) alleviated by making changes in methods of disposal, including treatment and filtration of process waters prior to discharge.

This contamination survey was designed on the basis of results from several previous studies that investigated selected areas within the facility's property for contamination. A list of the publications summarizing these projects is located in Section 6.0, Literature Cited, of this report. Some of the information obtained in those previous studies is utilized in this report in order to fully discuss aspects of environmental contamination.

The contamination survey began in February 1981, with the drilling of 31 groundwater observation wells by STS. Sampling of these wells began in June 1981. At the same time, soil, water and sediment samples were collected from the designated sampling sites; these collections were completed in early July 1981. Analysis of the groundwater, surface water, soils and sediments was begun in July and completed in October 1981.

In the course of this project, three reports were prepared by ERG; the first two were interim reports. The first interim report was the Geotechnical Report. This report contained all the geological and hydrological data used in determining the overall hydrogeology of this site.

A separate Contamination Report comprised the second interim report. This report included all the data generated through the analysis of surface water, groundwater, soils, and sediments. Included in that

report were discussions concerning laboratory techniques and protocols used in the analytical program, and information on the operation of the quality control program.

The third report in the series is this Final Report, which incorporates and synthesizes the results of the geotechnical investigation, analysis of environmental samples and previous research regarding the contamination on-site. For the sake of clarity and conciseness, only those data are contained herein which are significant in assessing the risk for potential contaminant migration off-site and the risk affecting the surrounding environment. The complete data can be reviewed in the aforementioned interim reports.

In addition to the three major reports described above, there also exist two smaller reports, Safety Plan and Quality Assurance Plan. These were used as protocols for tasks selected for the investigation. The first report specified the safety procedures used during the conduct of field and laboratory studies; the second contained the quality assurance/quality control protocols used in the laboratory.

2.0 HYDROLOGY OF THE PROJECT AREA

2.1 Regional Setting and Geology

2.1.1 General

This section is a summation of the geotechnical findings developed from data obtained in this study. An interim Geotechnical Report which contains details of the full geotechnical investigation, including well logs, data on soil properties, cross-sectional maps, and a groundwater contour map, is available. In addition, the interim report contains a brief discussion of the area's climate, supported by local meteorological data. Summary of well data is located in Appendix A.

2.1.2 Climate

The climate in the IAAP area is temperate, with maximum temperature ranges of 44° C (111° F) to -33° C (-27° F). The mean annual temperature is 11° C (52° F).

Mean annual precipitation is reported as 103 cm (40 inches) and is well distributed throughout the year. About 1/4 to 1/3 of that precipitation occurs as snow. This type of climate and precipitation pattern creates higher creek and river discharges in spring due to snowmelt. High discharges can cause the spreading of contamination because spring runoffs tend to be erosional and therefore carry large amounts of suspended sediments. Erosion occurs readily due to the presence of frozen or saturated soils having very low infiltration rates (5). The sediment loading in spring runoff can contain contaminants transported either as

suspended solids, dissolved species, or materials adsorbed on sediment particles.

Weather conditions during the field activities were typical; no unusual conditions were experienced which may have impacted the progress or quality of the work.

2.1.3 Geology and Topography

The IAAP facility is located near Middletown, Iowa, in the southeast portion of the State of Iowa (see Figure 2-1). The geological setting for this area is a limestone bedrock overlain by glacial deposits and windblown sands and silts (6). The glacial deposits, and in some areas, the bedrock material, are dissected by erosional cuts created by drainage streams developed in Pleistocene and Recent geologic stages (7). The IAAP facility, which consists of 20,000 acres, is situated on these glacial deposits in a rolling topography and is dissected by three major drainage streams. Long Creek, Brush Creek, and Spring Creek traverse the IAAP property in a northwest-southeast direction; Long and Brush Creeks drain into the Skunk River which is approximately one mile south of the facility. These waters, in turn, enter the Mississippi River system; the confluence of the Skunk and Mississippi Rivers is about six miles from the southeast corner of the IAAP property. Spring Creek enters directly into the Mississippi River, less than a mile above the confluence.

The areas not encompassed by manufacturing facilities are either vegetated with native trees and herbaceous cover or used for cultivation of cash crops, mainly corn and wheat.

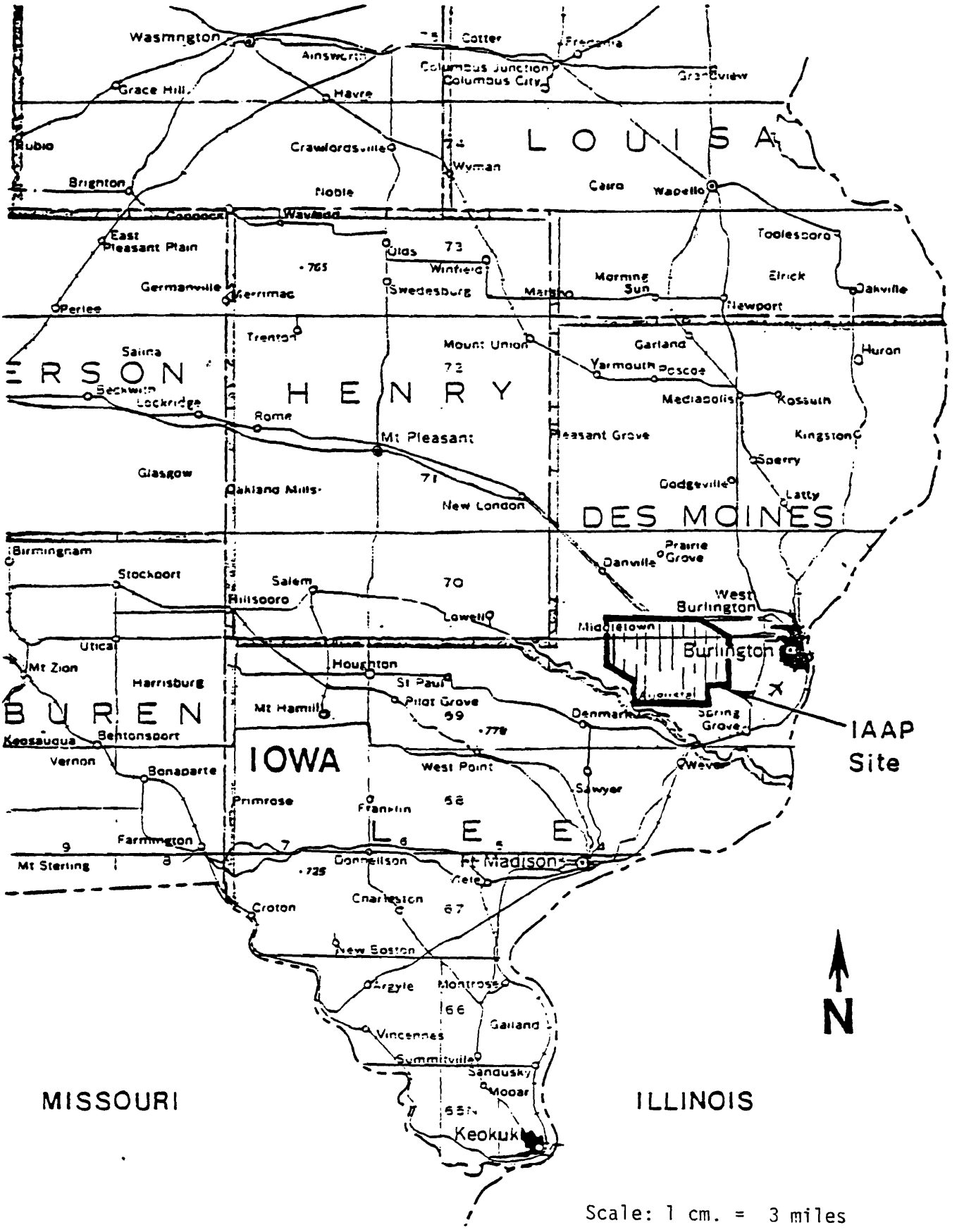

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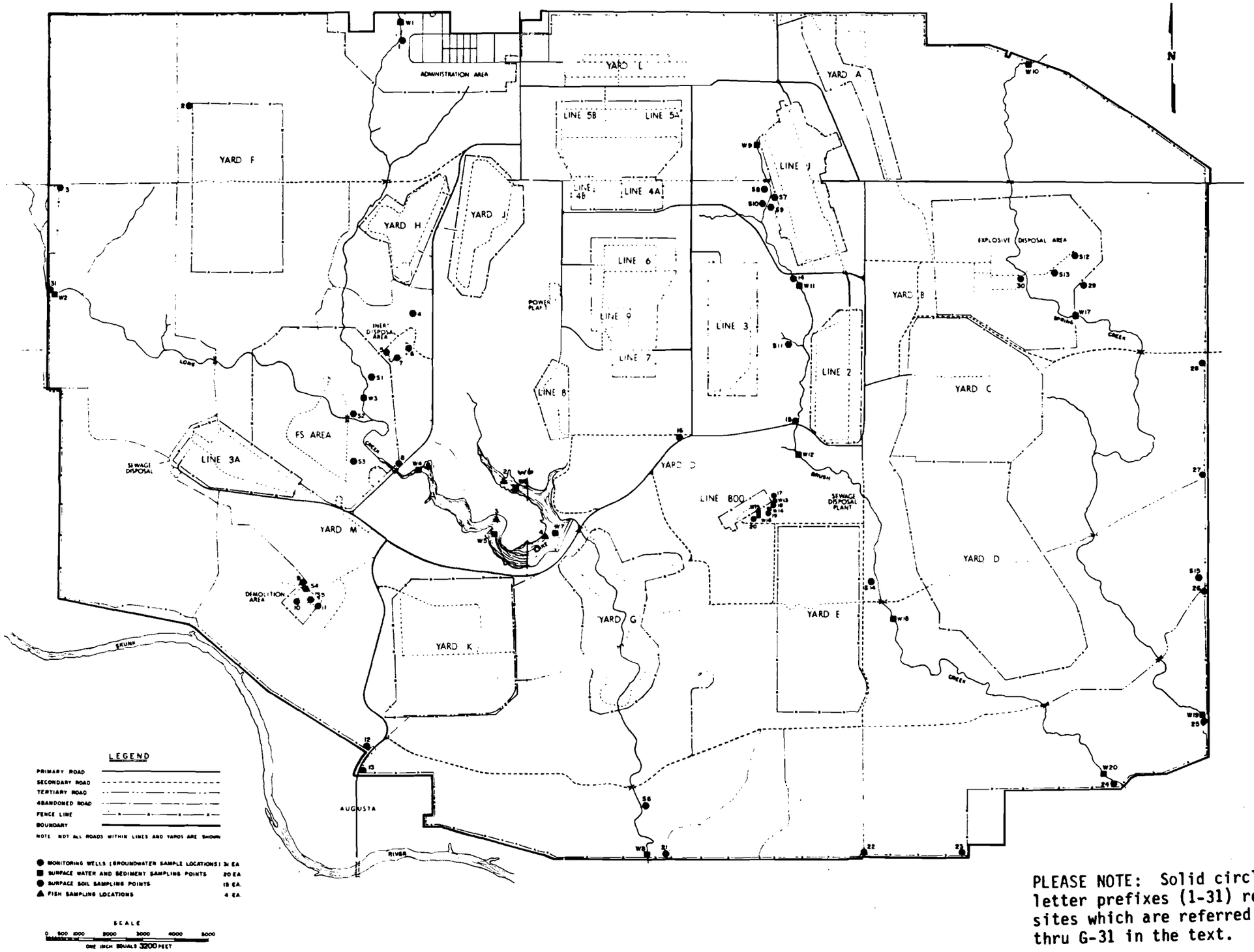
Figure 2-1

Location of the Iowa Army Ammunition Plant Site, Middletown, Des Moines County, Iowa.

2.1.4 Sample Site Locations

The areas chosen for contamination testing were chosen by USATHAMA and were based on information and data derived from previous investigations (4) and records of operations. Within these areas, specific sampling sites were chosen to determine the extent of known or potential contamination sources and to determine if these sources have caused or have the potential to cause any contamination to migrate from the IAAP facility. Sampling sites were placed to test areas where flows entered and exited the facility. This provided background and migration data respective to contamination present on the installation. Testing included surface flows and anticipated subsurface flows. In addition, some groundwater wells were grouped into small networks around suspected contamination areas, including sites used previously for demolition activities, materials storage, and other processes (Figure 2-2).

The sampling sites consisted of 31 groundwater wells, 15 sites for collection of soil samples, and 20 sites for collection of both surface water and sediment samples. Groundwater wells in general were tapped into the first water-bearing zone. In the cases of five wells (G-10, 11, 13, 24, and 30),the first water-bearing zone was the limestone bedrock; the remaining 26 wells were situated in either glacial materials or fluvial deposits. Soil samples were grab samples of near surface (less than six inches deep) materials. Sediment and surface water samples were collected at the same sampling site. Detailed discussion of sampling sites and procedures are found in Section 3.0 and Appendix B of this report.



PLEASE NOTE: Solid circles without letter prefixes (1-31) represent well sites which are referred to as G-1 thru G-31 in the text.

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FIGURE 2-2

Locations of Surface Water, Groundwater, Soil, and Sediment Sampling Sites Used in the 1981 Contamination Survey conducted at Iowa Army Ammunition Plant, Middletown, Iowa, 1981. Locations per Legend.

2.1.5 Monitor Well Installation

Groundwater observation wells were installed at 31 locations throughout the IAAP facility. The wells were drilled in a manner which limited contamination potential during drilling and were constructed in such a manner as to monitor discrete water-bearing zones.

The wells were bored with 3-1/4 inch hollow-stem auger equipment. Drilling was ended when a hole was dug into a water-bearing zone at a depth sufficient to set a well screen. Once the well screens and associated casing were implanted in the bore hole, the well screen was gravel packed and the annulus area was sealed from overlying zones by grouting with bentonite cement. This seal, or grouting, was continuous from the top of the water-bearing zone to the surface.

The well casing, where it extended above the ground surface, was protected from damage and water inflow by a large diameter casing which was driven over the well head. This protective casing extended two feet into the grouting and was of sufficient height to surround the well head. A typical well installation into bedrock is shown in Figure 2-3. Wells set into a glacial aquifer were of similar construction.

2.1.6 Subsurface Geology

Information obtained from existing records (6) and the data from the well logs generated during this investigation indicate that the IAAP site consisted of a complex glacial strata overlying limestone bedrock. The glacial material ranged from 0 to 50 feet in thickness.

These glacial deposits are considered to represent the activities of four glacial advances and retreats, which account for the wide variation

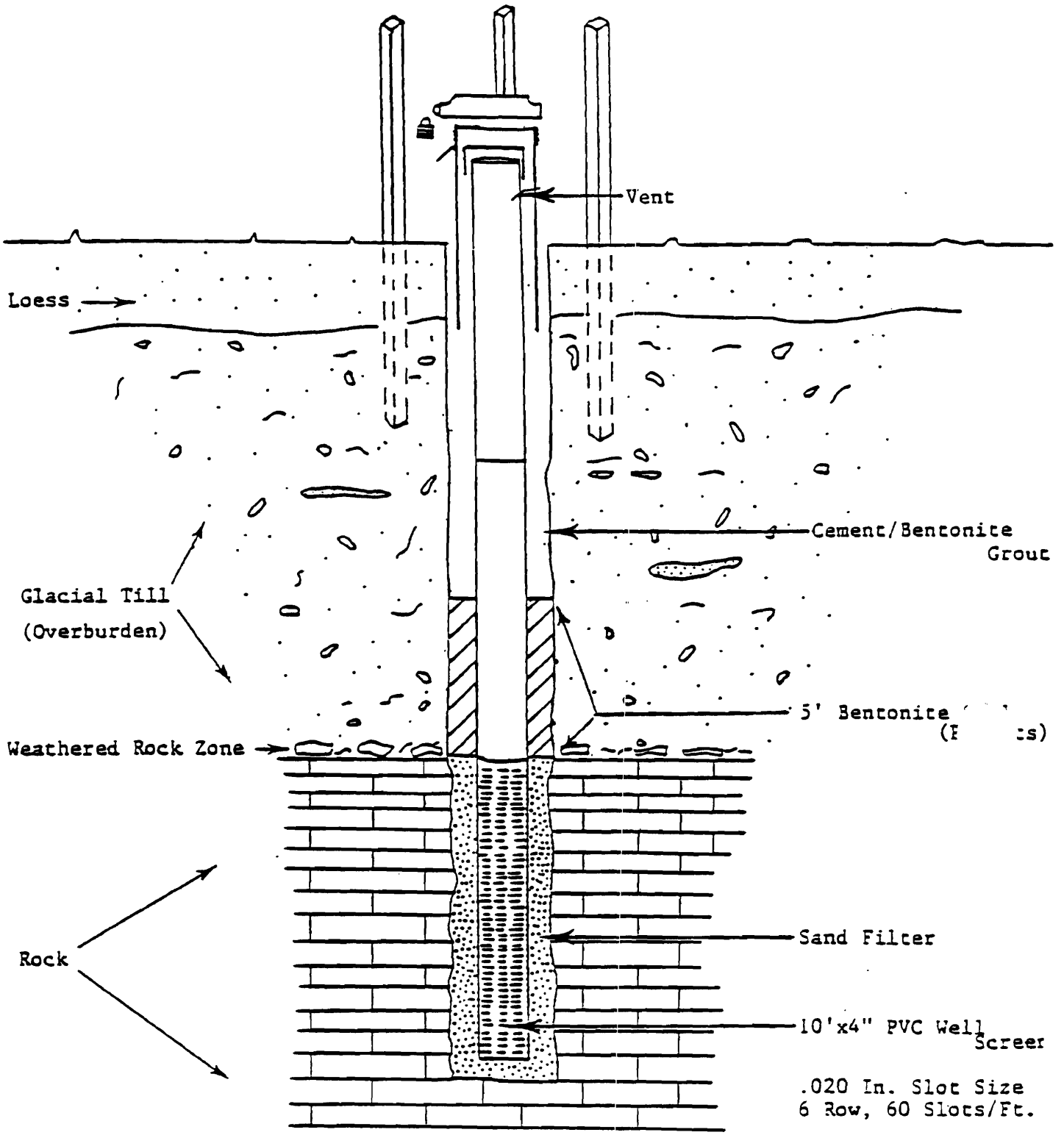

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Figure 2-3
Typical Construction of a Groundwater Monitoring Well, Showi
Completion in Bedrock, at the Iowa Army Ammunition Plant Sit
1981.

of materials and stratification found at the different groundwater sampling stations (8). Extremely local interbedded clays, sands and gravels create small aquifers, some of which are perched. Also, many discontinuous layers, consisting of clays or impermeable tills, are found to further complicate the glacial hydrology.

Below the glacial deposits are relatively flat-lying bedrock units. The uppermost unit is a Mississippian limestone. The contamination survey was limited to testing of this upper bedrock unit. Other literature (9) indicates that several usable aquifers lie beneath this unit. One such unit is a principal aquifer of potable water, the Jordan Sandstone. However, several shale units exist between the upper bedrock units and the major potable water unit (9). These shales may effectively reduce the migration of any near-surface water into that unit. On the other hand, according to the IAAP, upper rock units have also been used for water supply, while very few wells use the limited aquifers of the glacial units.

2.1.7 Groundwater Levels

Multiple measurements of groundwater elevations were made at all observation wells during various phases of the field studies during this survey. These data are found in Appendix A and in the interim Geotechnical Report. Observations of well levels used for the development of the groundwater contour map were made within a two-week period in March 1981. Groundwater levels in wells on the site varied considerably during this investigation, mainly due to the extremely low recharge rates. This fact, together with data previously noted in Section 2.1.6,

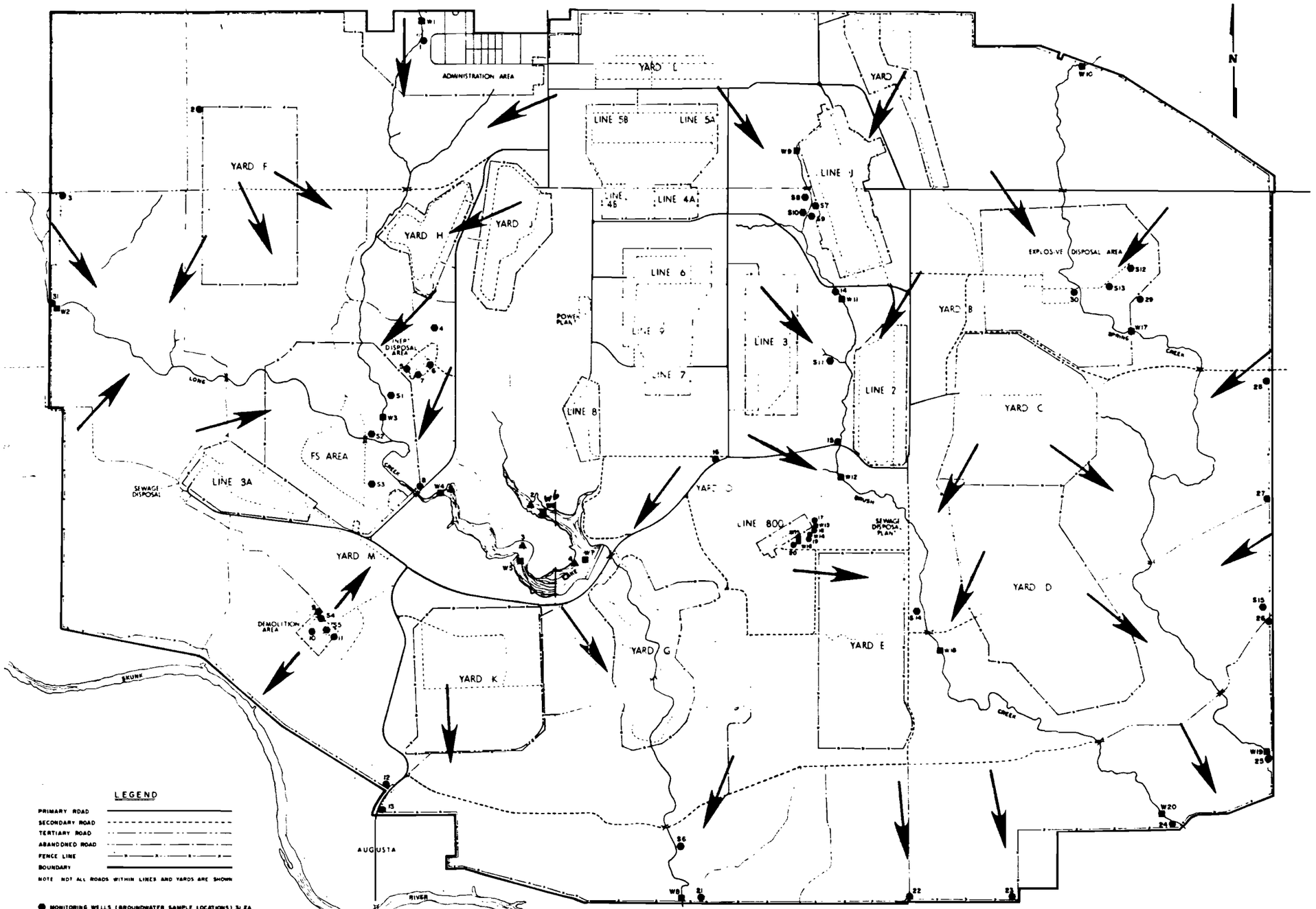
reinforces the highly complex nature of the glacial materials found at the IAAP facility. The groundwater contours mapped as a result of this investigation must be viewed as only approximate, since: 1) only 31 sampling locations were used to define the groundwater surface for an area of almost 20,000 acres; and 2) very few of the wells monitored the same aquifers and so, strictly speaking, are unsuitable for estimating groundwater contours. As stated in Section 2.1.6, many aquifers are believed to be extremely small; some units appear to cover only a few hundred square feet. Finally, in some cases, the zone of saturation appears to be less than one foot thick, as observed during the well-drilling operation.

All wells on the northwest and east perimeters indicate groundwater flows into the facility. Southern perimeter wells indicate that groundwater flows out of the facility toward the Skunk River. The direction and rate of groundwater movement in the upper glacial aquifers appears to be strongly influenced by the topography of the IAAP facility as well as by the composition of the glacial materials. A summary of the direction of groundwater movement in the glacial materials is shown in Figure 2-4.

2.1.8 Groundwater Movement

The rate of groundwater movement at the IAAP site was investigated by means of slug tests, recharge rates, and information obtained during well development. The results of these tests are reported in the interim Geotechnical Report. "Flow rates"* of water through the various aquifers

*Because of the relatively small number of wells that have been slug tested, the relatively small number of total observation wells on the site, and the discontinuous nature of the aquifers present on-site, flow rates reported herein represent the measured hydraulic conductivity of groundwater under a unit gradient.



PLEASE NOTE: Solid circles without letter prefixes (1-31) represent well sites which are referred to as G-1 thru G-31 in the text.

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FIGURE 2-4

Summary of Groundwater Flow Directions on the Iowa Army Ammunition Plant Site, 1981.

were also found to vary by a factor of 100. The highest flow rates were found in wells which tap sand lenses or bedrock units. Examples of such are wells G-21, G-20, and G-14, which had flow rates of 1.2 meters/day, 1.3 meters/day, and 7.4×10^{-1} meters/day, respectively. The lowest flow rates were found in wells G-10, G-29, and G-3, all of which tap clay-bearing zones. The flow rates for these wells were 2.4×10^{-2} meters/day, 5.7×10^{-2} meters/day, and 5.8×10^{-2} meters/day respectively.

The data developed through these tests, in conjunction with other site-specific geologic data (i.e., soil borings), indicate that little can be deduced about the rate of movement of water on a larger scale in the upper aquifers of the site. Flow rates vary considerably, even for two wells in the same aquifer (i.e., G-18, 9.3×10^{-2} m/day; G-20, 1.3 m/day). This variation means that estimates of movement of groundwater over even moderate distances (e.g., 440 yards) are quite unreliable. Any inferences regarding rates of movement of groundwater must be made with extreme caution and limited to very local distances.

2.1.9 Summary of Groundwater Conditions

The groundwater regimes found at the IAAP facility consist of three general units:

1) Jordan unit;
2) Mississippian Limestone; and
3) Glacial and Fluvial materials.

The first unit, the Jordan, is a deep unit having an ample supply of potable water. It does not appear to be affected by any upper groundwaters because of the presence of aquitards between it and upper groundwater.

The second unit is the limestone underlying the glacial material. It can be used as a source of groundwater supply. It can also be affected by contamination at the IAAP. Contamination can enter the limestone by water infiltrating through the glacial material; however, this infiltration appears limited due mainly to the low permeability of the overburden. A potentially more significant source of recharge of this limestone can be by direct infiltration from surface streams which dissect the limestone, thereby allowing direct contact of surface water to the bedrock. Consequently, contaminated surface water has a greater impact on the quality of the limestone aquifer than contaminated glacial groundwater.

The third groundwater regime is the glacial and fluvial materials. The glacial materials are multi-layered and not used as primary water sources. Horizontal migration of water in these units appears to be greater than vertical migration because of the existence of horizontal aquitards. This, in turn, means that a contaminated zone in the glacial material is generally more likely to pollute surface streams than the lower aquifer, as evidenced in the Pink Water Lagoon. However, since the streams appear to recharge the limestone aquifer, the contamination in the glacial material's groundwater, which then seeps into the streams, can still be an important factor in the migration of contamination.

The fluvial materials are not used generally as a water source but are quickly affected by contamination and can act as a saturated zone holding and slowly releasing contaminated waters to surface streams and, in some areas, directly to the limestone aquifer, as evidenced in Brush Creek.

2.2 Surface Water

2.2.1 General and Historical Information

Surface waters on the site are controlled by three main streams which flow through the IAAP facility. Brush, Spring, and Long Creeks flow in a southerly direction to the Skunk River; they vary considerably in their discharge volumes, which are principally a function of the annual snowmelt-precipitation cycle. Runoff in spring (April-June) is high, and summer low flows, interspersed by runoff from precipitation, occur in August, September, and October.

Spring and Long Creeks originate or have major contributing tributaries that originate off the facility and drain predominantly agricultural lands. Both of these creeks are also subject to discharges from wastewater treatment plants located upstream from the IAAP property. While Brush Creek formally originates on the IAAP facility, its watershed extends north of the facility.

Although the main contribution to these streams is direct surface runoff, it appears that there are also localized areas of seepage from the glacial aquifers. It also appears that the creeks may contribute water to the limestone bedrock, as evidenced by previous contamination of wells in the lower reaches of Brush Creek (4).

A portion of Long Creek was impounded to provide a source of water for the IAAP facility. Removal of water at this location for ammunition plant use ceased in 1977. Subsequently, all water for production or drinking purposes has been obtained from the City of Burlington (raw water source is the Mississippi River). Discharge of treated wastewater into Long Creek has been substantially reduced, according to information obtained from IAAP.

Brush Creek was also altered by a dam (1948-1957). It has been and continues to be subject to discharges of explosive-contaminanted waste from munition production lines. Siltation occurred in the impoundment. As a result of the installation of improved wastewater treatment facilities, the dam was eventually removed, thus allowing Brush Creek to return to its normal gradient. It was during this return to its natural channel slope that some contamination may have occurred downstream due to the resuspension of contaminated silts from the impoundment area. The resuspension of silts was caused mainly by the erosional cut of Brush Creek's discharge after the impoundment was removed.

Spring Creek has no impoundments.

2.2.2 Existing Conditions

Currently, there exists a discharge of treated wastewater into Brush Creek. The discharge is permitted under U.S. EPA's NPDES program; limits are set for the explosives, TNT and RDX. The current limits of discharge are 1 ug/L and 25 ug/L, respectively.

Spring Creek has tributaries that originate off the IAAP property. Although most of the water flow in Spring Creek is surface runoff, one of its tributaries receives a discharge from a wastewater treatment plant situated upstream from the IAAP property. This wastewater discharge passes to the main channel of Spring Creek which then flows through the southeastern portion of the IAAP facility.

Long Creek is presently impounded, but is no longer a reservoir for water use by IAAP. An off-site tributary upstream from the IAAP property receives a discharge from a wastewater treatment plant.

2.2.3 Sampling Conditions

Sampling of surface waters and sediments from these creeks was done during a low flow condition in June and July 1981, which must be carefully considered when evaluating the analytical results of samples collected from the creeks. The water quality of a stream at any point in time can be extremely variable, depending upon many factors (e.g., rainfall, thaw duration, seasons) (10). In the case of these streams, the major controlling factor is runoff. Furthermore, in the case of the streams flowing through the IAAP facility, a major concern is whether contaminants on land areas are being washed into the stream. If no major surface runoff has occurred prior to sampling of the water, and the parameters being monitored are highly soluble, then it is very possible that sampling under low flows with dry conditions will not indicate any movement of contamination from some areas which, at times, act as sources of it.

This is due to the flushing action of the streams. Highly soluble contaminants which are in solution will migrate off the IAAP site within hours. Soluble contaminants adsorbed to sediments which are carried into the stream by runoff, will also flush from the stream, but at a slower rate, possibly measured in days to months.

On the other hand, sediments in the streams can give indications of adsorbed contamination because they consist in part of trapped silts which may have contamination adhering to them. However, in rapidly flowing streams such as those on the IAAP facility, sediments may not accumulate. Suspended sediments in runoff, which may have contaminated material attached to them, can enter the creeks during runoff events;

however, because volumes and velocities of flows normally increase during these events, much of the contaminated material may move through the system and be deposited much further downstream in a depositional zone outside the IAAP facility. In the hydrologic system surrounding the IAAP facility, the Skunk and Mississippi Rivers are the apparent depositional zones containing major accumulations of silts.

The foregoing demonstrates some of the limitations of this type of survey which must be borne in mind when developing a sound understanding of the analytical data showing the presence of contamination.

3.0 ANALYTICAL METHODS

3.1 General

The analytical portion of this project involved an extensive certification program to meet USATHAMA standards and a rigid quality control protocol. The program involved analysis of environmental samples consisting of water, sediments, and soils. The certification process culminated in a separate report entitled Quality Assurance Manual. Certification approval of analytical procedures was received from USATHAMA prior to the actual analysis of field samples.

A second report containing the analytical results for the analysis of field samples was produced. That report entitled Contamination Survey contained the quality control data produced during the analyses of samples. A summary of the analytical methodologies is contained in Appendix C of this report.

Additional data, obtained through analyses performed as part of an internal checking procedure by EPA after review of the original data set (contained in the Contamination Report), are in Appendix D. These data include a full GC/MS scan of groundwater from wells G-18, G-19, and G-20 using, in part, model compound search procedures.

3.2 Summary of Quality Control

All methods for explosives, nutrients, and metals were certified prior to the start of the analytical program. Standard water and standard soil samples were spiked in duplicate with each analyte at representative

levels for four separate days. Spiking levels of 0.5 DL, DL, 2 DL, 5 DL, and 10 DL were utilized, where DL = desired detection limit. The resultant data were subjected to linear regression analysis according to the program based upon Hubaux and Vos to develop the sample-specific detection limits, precision, and accuracy.

The GC/MS and HPLC screening methods were qualified using the specified surrogate compounds spiked into the standard matrices, resulting in one day's worth of duplicate spike data. These data were subject to linear regression analyses to develop detection limits for the surrogates which were spiked into all samples, plus the quality control samples. The pesticide and PCB methods were qualified by multi-level spikes during the course of the analyses of the environmental samples.

In the laboratory, environmental samples were handled in batches, the sizes of which were dependent upon the analysis rate of the analytical method. A majority of the groups ranged from 8 to 10 samples per batch.

Each batch of samples for each analyte included a blank, a duplicate, plus a matrix and/or method spike. The same procedures were used on batches to be subjected to screening by means of GC/MS. All method and matrix spikes were required to fall within three standard deviations about the mean of the recovery value. In the case of method spikes, the mean was developed from the standard matrix spike conducted as part of the USATHAMA certification procedures. The mean for matrix spikes was developed from the recovery in each matrix for each analyte in order to reflect the different matrices involved.

Further discussion of the quality control procedures used in this contamination survey is found in two Interim Reports submitted during this investigation. These are: Quality Assurance Plan and Contamination Report.

3.3 Detection Limits, Precision and Accuracy Data

Tables 3-1 and 3-2 present all the detection limits plus precision and accuracy data for each analyte in both water and soil/sediment matrices. The data were developed using the certified methods for this project on natural water and soil collected from the IAAP facility. The detection limits met the contract criteria.

The sulfate data are missing from the soil/sediment table due to the lack of recovery found at spiking levels under 150 mg/Kg. This problem is fully discussed in the Contamination Report.

3.4 Sampling Summary

The sampling procedures followed for the IAAP investigation were completed in a manner which attempted to absolutely minimize cross-contamination and obtain a sample which represented actual conditions. The following is a short summary of the sampling portion of the project. A full report is included in Appendix B.

Sample container preparation was completed in the ERG laboratories under controlled conditions. Bottles and caps were new, and prepared according to USATHAMA requirements (Appendix B). The bottles were sealed and only opened prior to adding the sample material. When the sample was water, the sample container was rinsed with the sample water, drained and filled with fresh sample.

TABLE 3-1

Detection Limits, Precision and
Accuracy Achieved
for
Water

IAAP CONTAMINATION SURVEY - 1981

Analyte	Detection Limit (ug/L)	Accuracy	Precision
Ba	41	1.098	10.54
Cd	1.8	0.808	0.344
Cu	4.1	1.119	1.133
Cr	4.9	0.527	0.642
Pb	6.9	0.949	1.505
Zn	47	0.912	11.20
Nitrate	44	0.967	11.56
Nitrite	17	1.009	4.647
Total Phosphate	77	1.083	22.88
Sulfate	4.8	1.127	1.444
2,4,6-TNT	3.6	0.851	0.758
2,4-DNT	1.6	0.839	0.341
2,6-DNT	5.7	0.938	1.295
1,3,5-TNB	2.1	1.269	0.656
1,3-DNB	3.3	0.866	0.706
Tetryl	2.9	1.220	0.906
RDX	6.5	0.711	1.141
Lindane	0.78	1.018	0.146
aldrin	0.75	0.813	0.113
p'p'-DDD	2.83	0.897	0.473
p'p'-DDE	1.97	0.972	0.356
p'p'-DDT	8.18	1.206	1.843
dieldrin	1.03	1.082	0.203
endrin	1.61	0.982	0.293
alpha endosulfan	0.27	1.054	0.051
beta endosulfan	1.38	0.910	0.230
heptachlor epoxide	1.58	0.747	0.219
endosulfan sulfate	3.85	1.141	0.791
heptachlor	0.60	0.835	0.092
arochlor 1254	0.06	0.903	0.010
toxaphene	12.19	0.653	1.454
chlordane	0.23	1.084	0.016

TABLE 3-2

Detection Limits, Precision and
Accuracy Achieved
for
Sediment and Soil

IAAP CONTAMINATION SURVEY - 1981

Analyte	Detection Limit (ug/L)	Accuracy	Precision
Ba	6.0	1.067	3.561
Cd	0.49	0.866	0.247
Cu	0.66	1.262	0.458
Cr	1.4	0.508	0.382
Pb	0.68	1.095	0.408
Zn	2.1	0.798	0.985
Nitrate	9.6	1.006	5.604
Nitrite	8	0.916	4.233
Total Phosphate	30	0.576	10.12
Sulfate			
2,4,6-TNT	0.6	0.784	0.289
2,4-DNT	0.3	1.154	0.213
2,6-DNT	0.8	1.144	0.543
1,3,5-TNB	1.7	0.895	0.902
1,3-DNB	0.7	0.972	0.402
Tetryl	2.3	1.024	1.378
RDX	15	0.514	4.648
Lindane	0.01	1.015	0.002
aldrin	0.03	1.072	0.006
p'p'-DDD	0.05	0.909	0.008
p'p'-DDE	0.02	1.142	0.004
p'p'-DDT	0.14	1.198	0.030
dieldrin	0.09	1.019	0.017
endrin	0.37	0.824	0.057
alpha endosulfan	0.14	0.811	0.021
beta endosulfan	0.07	1.008	0.012
heptachlor epoxide	0.02	0.964	0.004
endosulfan sulfate	0.04	1.005	0.006
heptachlor	0.02	0.841	0.002
arochlor 1254	0.03	1.049	0.005

Sample equipment was washed after each collection station or individual sample collection. Care was taken to minimize exposure of equipment to atmospheric dry fall or blowing dust which may have contained pollutants.

Most groundwater wells were purged of five times their standing water volumes prior to obtaining a sample for analysis. In some cases, well recharge rates were extremely slow and, due to time constraints, would not allow the normal five-volume purge. These wells were reviewed on an individual basis, and field decisions were made by USATHAMA representatives on the amount of purge volume needed. (A list of those wells and the amount of water purged is found in Appendix B.)

Fish samples were obtained from Long Lake and preserved by refrigeration at the IAAP facility. The fish analysis was postponed until final results of water studies were completed and would have been done only if the results of water tests were considered by USATHAMA to indicate a problem to aquatic life. The final decision was not to analyze the fish.

Sample containers were labeled immediately prior to or after sample material was placed into the vessels. The samples were placed in ice-chilled coolers until they could be placed in a secure refrigerator. Shipment of samples took place within three days of collection, and samples were shipped in ice via commercial carrier, ensuring less-than-24-hour delivery.

All sampling information was recorded on USATHAMA-approved sample sheets. The data were later entered onto the computer program designed for this project.

3.5 Barium Anomaly

During ERG's analysis of water obtained from the IAAP facility, it was noted that barium values were exceptionally high. This phenomenon was found for both surface water and groundwater samples.

Barium is found in almost all natural waters. Its sources are generally barium salts which were formed by precipitation during formation of sedimentary rock and are released to the water by chemical erosion. Natural concentrations range from 5-200 ug/L; except for some localized occurrences near naturally occurring mineral barite deposits, the highest concentrations of barium in natural waters are approximately 350 ug/L (11). However, all analyses of water samples from the IAAP facility indicate concentrations of barium in the 1,000 to 4,000 ug/L range, with one analysis at 13,000 ug/L. A review of the literature shows that there are no known barite deposits in the region (11).

These facts suggested that the barium data be further evaluated, even though the results, quality control data, and detection limits met the contractual requirements of the contamination survey. Re-checks of analytical procedures, data charts, and sampling methods did not show any cause for the elevated barium concentrations. ERG, accordingly, conducted two analyses of water samples by Neutron Activation Analysis, in order to determine if some form of interference associated with the specified atomic absorption spectrophotometry methodology caused this anomaly. The results of the Neutron Activation Analysis were inconclusive: one pair of results was in approximate agreement, another pair was not, as shown below:

	BARIUM	
Sampling Station	Atomic Absorption	Neutron Activation
W-1	2.1 mg/L	1.0 mg/L (65% recovery)
G-3	3.5 mg/L	<0.4 mg/L

One hypothesis for the high values obtained is that the presence of calcium, or other elements in the sample, interfered with analysis for barium. The additional Neutron Activation Analysis studies could not explain or confirm the hypothesis. Any additional effort using Neutron Activation Analysis was considered beyond the resources allotted to this contamination survey.

It is known that barium nitrate was used at the facility; however, it is difficult, if not impossible, to understand how that source could affect virtually all water samples, including groundwater samples from upgradient areas. These areas have no pathway from probable sources and, therefore, represent data on background levels of barium. Thus, the barium levels measured are apparently endemic to this region.

3.6 Data Management

All data generated by this project were entered onto the USATHAMA Univac 1100/60 system. This included geotechnical data, sampling data, and analytical results.

The computer system software was to be used to produce maps and plots in interpreting the results. However, because of the size of the facility, the limited number of sample points and the overall complexity of the hydrology, the computer software was unable to generate usable map products.

4.0 CONTAMINATION EVALUATION

4.1 Overview of Methodology

The IAAP facility is very large (approximately 20,000 acres) and is divided into three main surface drainage areas and several smaller units which are parts of other, off-site, watersheds. The subsurface flows are equally complex, as discussed in Sections 2.1 and 2.2. Because of this complexity of systems, it is impossible to discuss potential or real contamination problems for the entire facility as a single unit. Therefore, for the purposes of evaluating the extent of contamination migration or potential to migrate beyond the installation boundaries, the IAAP facility was divided into seven groups or study areas. These groups were basically chosen on the basis of their drainage; however, one area, the Pink Water Lagoon (Line 800), was treated separately because of its location and analytical results.

The following subsections of this chapter will discuss each area studied. Included in the discussions are details of existing contamination and potential or actual migration of contamination.

The analytical data included in these sections reflect only a small portion of the set of analytical data developed on the environmental samples collected from the IAAP. The only data presented in this report are detectable levels of explosives and the presence of other analytes which exceed water quality standards. (A summary of the methodologies used to measure each analyte is found in Appendix C.) "No contamination" is defined in this report as the absence of contaminants above the

appropriate Standards Criteria. A list of Standards Criteria for Human Health and Aquatic Life is given in Table 4-1. A full list of analytical results is found in the Contamination Report.

The criteria used to determine if a contamination problem existed at any tested areas were U.S. EPA water quality data as set fortn in 40 CFR, Part 265, or Water Quality Criteria Documents, 45FR79318, 28 November 1980 (12). Also used as a source of applicable water quality standards was that of the State of Iowa, (13).

In the case of explosives, neither U.S. EPA nor the State of Iowa has established criteria or standards. The United States Army conducted tests based on U.S. EPA methodologies (FR, 43, 21506-21518; FR, 44, 15926-15981, 1979), and has developed human health and aquatic life criteria (14). These data were used in assessing the results for explosives.

4.2 Group One - Long Creek

The largest drainage area in the IAAP facility is the Long Creek Watershed (Figure 4-1). This watershed drains areas both inside and outside the IAAP boundary. It consists of two feeder creeks which originate north and west of the property. These creeks unite to form the main portion of Long Creek. The creek has been impounded to form a lake which previously had been utilized as a reservoir for most of the IAAP water needs. It has been reported that when water was used from the Long Creek impoundment for the facility, no flow from the creek dam into the lower reaches occurred during the low water periods (4). During those periods, all Long Creek water, plus some reserve from the lake, was used for manufacturing processes and human consumption. The

TABLE 4-1
Water Quality Criteria* and Standards[1,2]
for Contaminants Studies at the Iowa Army Ammunition Plant

Compound/Element	Aquatic Life Criteria (Freshwater)	Human Health Criteria*	Other
RDX	300**	33.68**	--
2,4,6-TNT	60[t],**	44.24**	--
2,4-DNT	62**	740 mg/L @ 10^{-5}**	--
Nitrate	--	--	10 mg/L[1]
Cadmium	1.5 max*	10	0.010 mg/L[1]
Barium	--	--	1 mg/L[1]
Zinc	180*	5000*	5000[2]
Chromium	2200*	170000*	--
Copper	12 max*	200*	0.05 mg/L[1]
Lead	74 max*	50*	0.05 mg/L[1]

All units ug/L unless otherwise indicated.

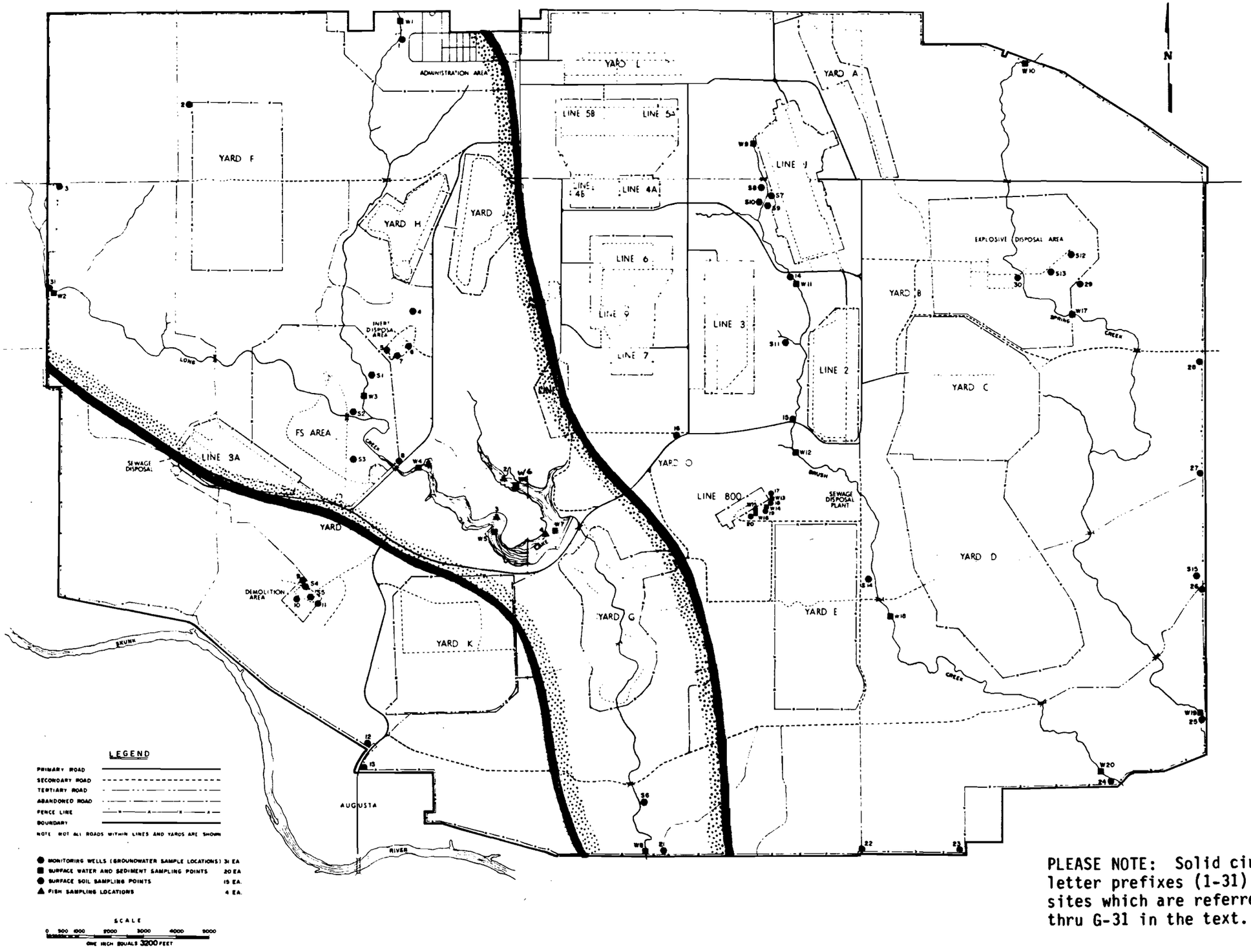
EPA: Water Quality Criteria Documents; Availability. 45FR79318, Nov. 28, 1980. Estimated cancer risk; varies to represent levels which may result in incremental increase of cancer over a lifetime.

**USAMBRDL: Recommended Interim Environmental Criteria for Munition Compounds; Fort Detrick, Maryland.

[1]National Interim Primary Drinking Water Regulations, 40 CFR141.11.

[2]National Secondary Drinking Water Regulations, 40CFR143.3.

[t]For the purpose of assessing technology, a value of not greater than 60 ug/L would seem appropriate in view of insufficent data for recommending interim environmental criterion.



PLEASE NOTE: Solid circles without letter prefixes (1-31) represent well sites which are referred to as G-1 thru G-31 in the text.

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FIGURE 4-1

Area Studied by Group One Sampling Sites; Long Creek Watershed.

wastewater from the processes was treated and returned to Long Creek below the existing dam. Therefore, at times, the creek's flow was composed of all discharged process water. Currently, water is no longer taken from the Long Creek impoundment, and no process wastewater is discharged to the creek. Thus, all the flow in Long Creek consists of natural runoff, groundwater seepage, or water discharged by a wastewater treatment plant upstream from, and not associated with, the IAAP facility. The water in Long Creek exits the IAAP facility to the south and eventually reaches the Skunk River.

Within the Long Creek watershed, ten groundwater, four soil, eight sediment, and eight surface water samples were collected. Table 4-2 lists the sample site identification numbers. Sample site locations are found in Figure 4-1.

These samples were obtained at sites designated by USATHAMA. The sample points were selected to measure the quality of inflow and outflow of water flowing through the IAAP facility. In addition, several sites were selected along the creek within the area encompassed by the IAAP facility to measure any changes in water quality that may occur downstream from potential contamination sources. The main areas of potential contamination sources were a disposal area containing unknown materials and sediments that may still be present in the creek. These sediments were produced during the time when discharges of waste material were disposed into the creek.

Within Group One, no samples analyzed were found to contain levels of contaminants which exceeded U.S. EPA or USAMBRDL criteria for human health or aquatic life. However, some above average levels of lead were

TABLE 4-2

SAMPLING SITES LOCATED WITHIN THE GROUP ONE AREA

LONG CREEK WATERSHED

Soil	Groundwater	Water and Sediment
S-1	G-1	W-1
S-2	G-2	W-2
S-3	G-3	W-3
S-6	G-4	W-4
	G-5	W-5
	G-6	W-6
	G-7	W-7
	G-8	W-8
	G-21	
	G-31	

detected in the soils at stations S-1 and S-6; 55 mg/Kg and 270 mg/Kg, respectively.

Average lead levels for most soils is 10 mg/Kg (11). In addition, sample S-15, useful, since it measures background concentrations of elements in soils on the eastern perimeter of the facility, contained 12 mg/Kg lead. These data indicate S-1 and S-6 lead levels are clearly elevated. The higher levels found here may be a local variation in soil conditions due to naturally occurring lead in the rock units, but, because of the singularity of its occurrence, an unknown man-made source is more probable. In any event, this lead does not appear to be migrating to surface waters; analysis of water downstream from this area resulted in non-detectable levels. Also, sediments, which generally contain higher lead concentrations than water, show low levels of lead ranging from 5.7 to 9.7 mg/Kg at sites downstream from sites S-1 and S-6. These sediment lead levels can reasonably be ascribed as originating off the IAAP facility in that sediment lead levels at sampling sites W-1 and W-2 are 26 mg/Kg and 11 mg/Kg respectively; these stations test levels of contamination coming into the facility area (Figure 4-1).

The only other contaminant detected in this watershed was 2,4-DNT; however, the concentration found in water at sampling site W-8 was only 2 ug/l This is well below criteria level for aquatic life, which is 62 ug/l (14).

It has been shown that lake sediments are good indicators of potential contamination from upstream sources. The lake sediments and overlying water in this group did not show any appreciable levels of contaminants; water samples did not exceed criteria levels. This is quite

important since lake sediments usually are formed by decreases in stream velocity and the resulting quiescent zones are conducive to sediment deposition.

No contamination was found in the surface waters at the southern boundary of the IAAP facility. The same was true of groundwater leaving the facility via the glacial zones.

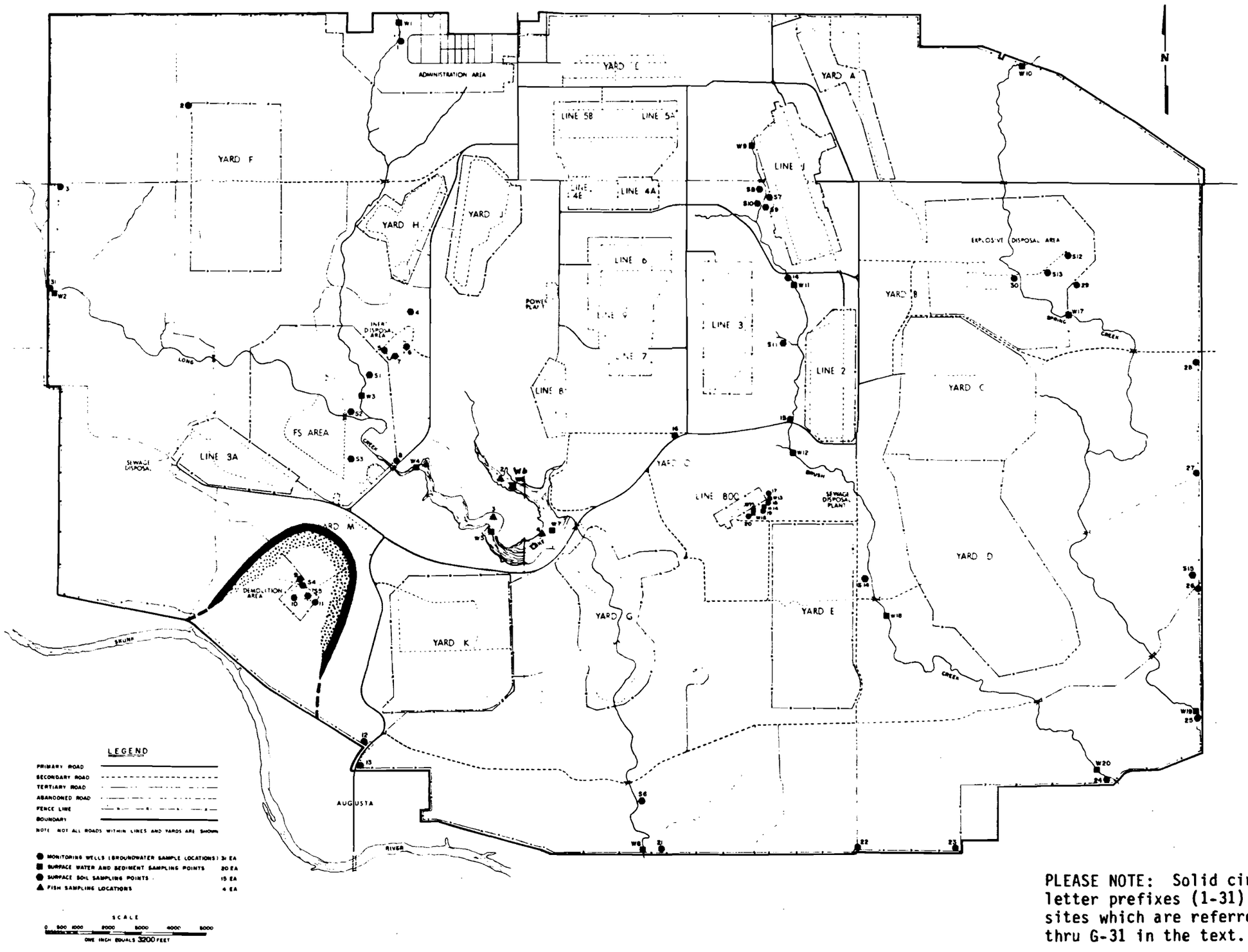
Thus, on the basis of this survey, it is concluded that at the time of this survey no contamination was migrating out of the IAAP facility within the Long Creek watershed.

4.3 Group Two - Demolition Area

This group of sampling sites is in an area previously used for surface detonation of explosive material (Figure 4-2). The area is located on a local watershed divide, such that surface runoff may be to either the north to Long Creek, or south to the Skunk River adjacent to the southwestern boundary of the facility. However, data obtained from the wells indicate a groundwater flow to the south.

The sampling network in this study area consisted of three groundwater wells and two soil samples. Of the groundwater wells, G-10 and G-11 penetrated the bedrock and well G-9 is in glacial material. The sampling sites for this study are listed in Table 4-3.

The analysis of the groundwater showed no levels of contamination which exceed water quality criteria. A trace level (18 ug/L) of RDX was detected in the bedrock well G-11; however, no RDX was found in either of the other wells or in the soil samples collected in the study area.



PLEASE NOTE: Solid circles without letter prefixes (1-31) represent well sites which are referred to as G-1 thru G-31 in the text.

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FIGURE 4-2

Area Studied by Group Two Sampling Sites; Demolition Area.

TABLE 4-3
SAMPLING SITES LOCATED WITHIN THE GROUP TWO AREA
THE DEMOLITION AREA

Soil	Groundwater	Water and Sediment
S-4	G-9	none
S-5	G-10	
	G-11	

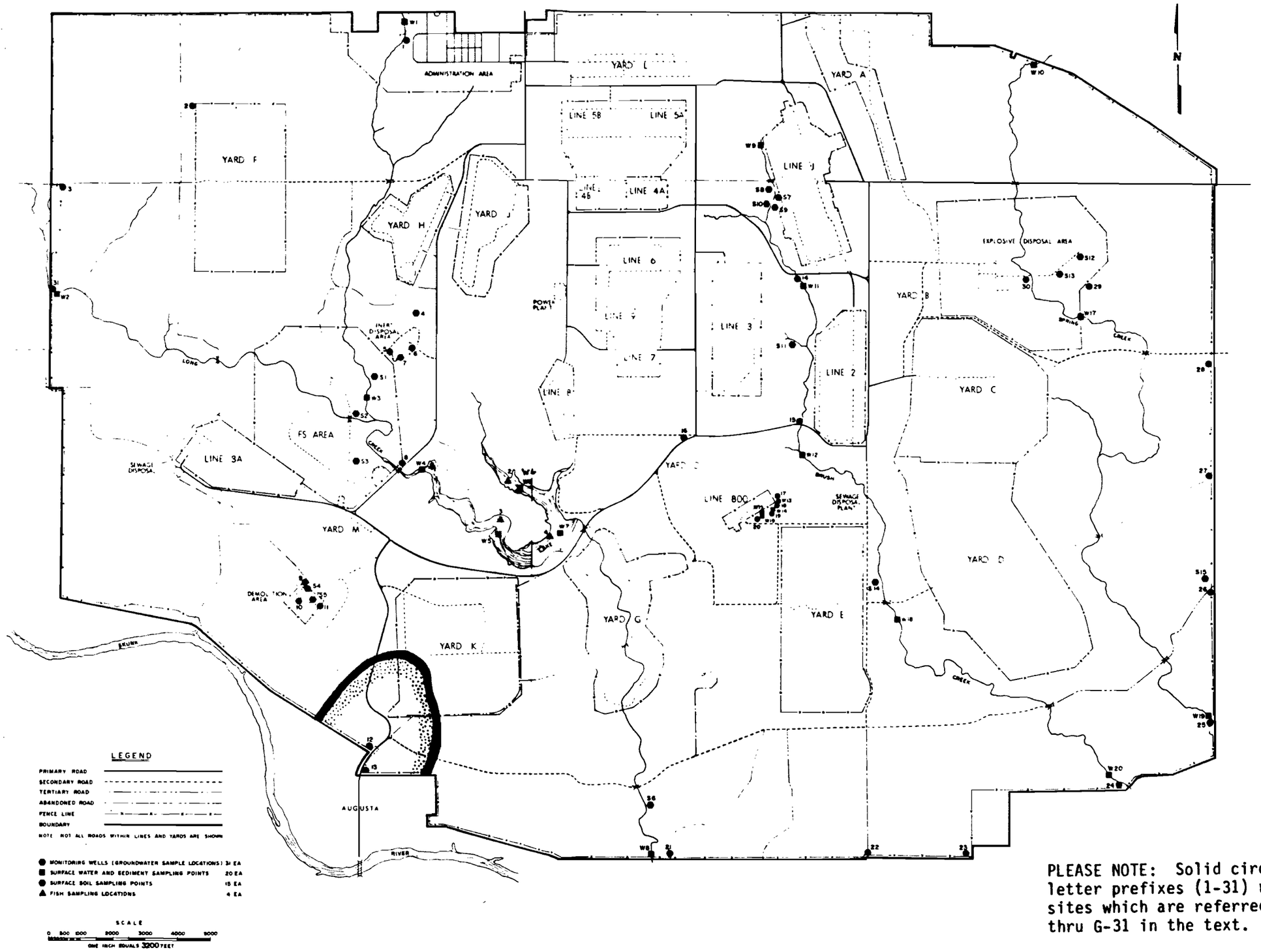
The lead level found in the soil of this area (S-4, 110 mg/Kg) may have been caused by demolition activities. However, there does not appear to be any resulting contamination problem with lead in groundwater; well G-10 showed only a trace amount (11 ug/L).

It appears from the geotechnical data that groundwater in this area moves to the south. It also appears that infiltration through the soil to the groundwater, monitored by the wells, is minimal due to the clay aquitards and other low permeability zones which lie between the surface and the first aquifer in this area. The cause of the trace amounts (18 ug/L) of RDX in the bedrock aquifer is not apparent. Even though extreme care was taken while obtaining water samples, the RDX contamination may have been introduced during sampling, drilling, or from some other source of contamination. It does not appear that contamination of the groundwater in this area is a problem, since the RDX level measured is below the USAMBRDL human health criteria (33.68 ug/L). The infiltration rate is slow and the groundwater movement appears very slow.

Slug test data indicated a flow rate of 2.4×10^{-2} meters/day, which is quite low. Additionally, recharge data obtained from well development data (Geotechnical Report) indicate that flow rates for the other two wells of this study area (not slug tested) would be less than the figure shown above.

4.4 Group Three - Storage Yard K

Group Three consists of two groundwater wells downgradient of Storage Yard K and north of the City of Augusta (Figure 4-3). These wells monitor water which flows from the IAAP facility into the Skunk



PLEASE NOTE: Solid circles without letter prefixes (1-31) represent well sites which are referred to as G-1 thru G-31 in the text.

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FIGURE 4-3

Area Studied by Group Three Sampling Sites; Storage Yard K, Adjacent to City of Augusta.

River floodplain. The two wells, G-12 and G-13, monitor groundwater in the glacial material and bedrock, respectively. No contamination was found in this area. Because these two wells monitor both upper and lower water zones, it is reasonable to conclude that no contamination exists in the groundwater within this area nor is presently moving through the area toward Augusta or the Skunk River.

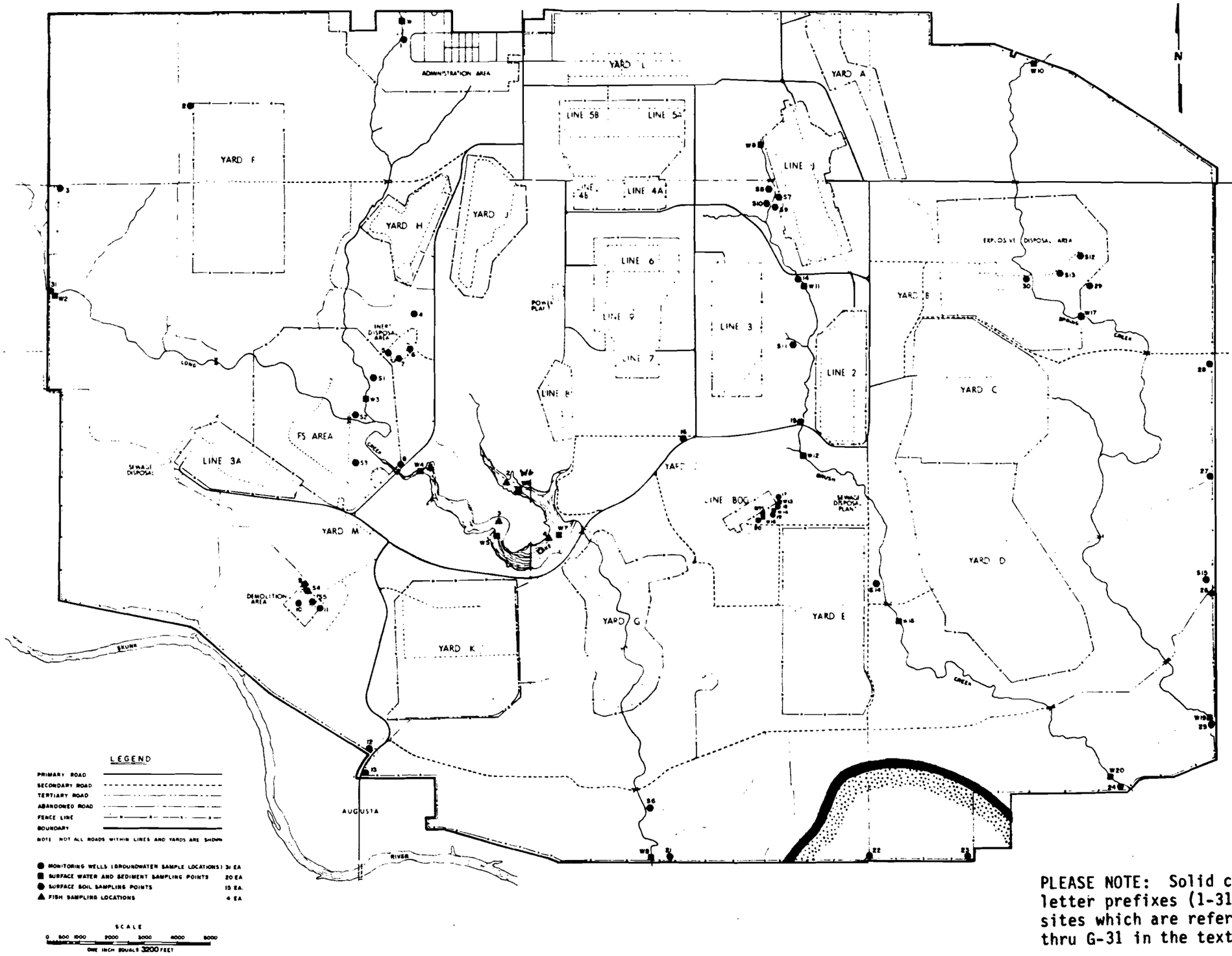
4.5 Group Four - Southern Boundary

There are only two wells, G-22 and G-23, in this group; they are located along the southern boundary of the IAAP facility (Figure 4-4). No soil, surface water or sediment samples were collected from this small study area. The wells tested glacial aquifer water that appears, from the geotechnical data, to be moving to the south.

The results of the analysis of this groundwater indicate that no contamination is present.

4.6 Group Five - Spring Creek

Group Five sampling locations are located in the Spring Creek watershed (Figure 4-5). This watershed drains land to the north of the facility prior to entering the IAAP facility. The main area of concern as a source of contamination is the explosive disposal area in the northeast corner of the facility. The sampling locations included six groundwater wells, three soil sample sites, and three surface water and sediment sampling sites (Table 4-4). Three of the groundwater wells and one soil sample, G-26, G-27 and G-28, and S-15, are located in areas which were determined by this study to be zones where groundwater is



PLEASE NOTE: Solid circles without letter prefixes (1-31) represent well sites which are referred to as G-1 thru G-31 in the text.

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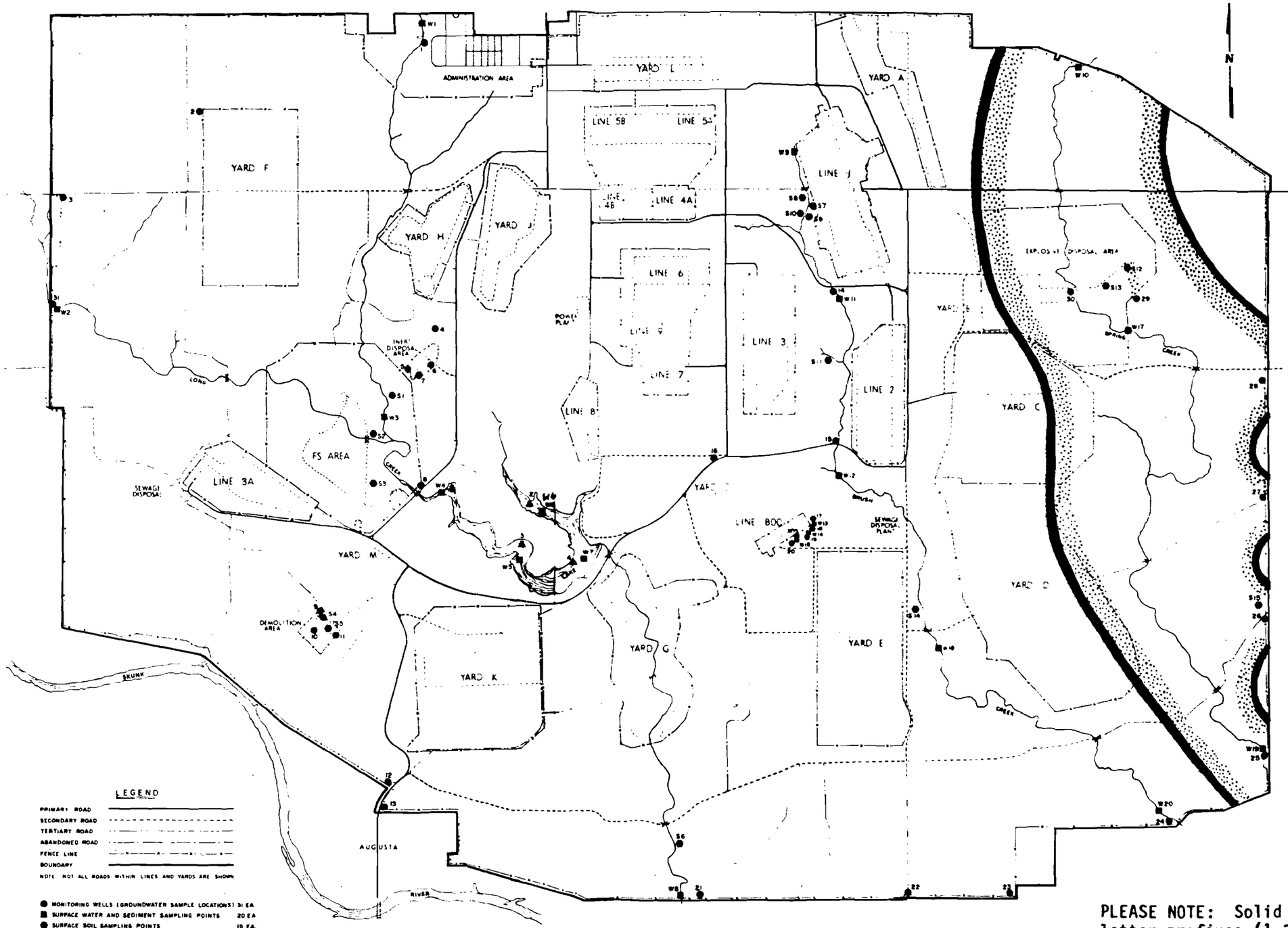
FIGURE 4-4

Area Studied by Group Four Sampling Sites; Southern Boundary.

42.1



PLEASE NOTE: Solid circles without letter prefixes (1-31) represent well sites which are referred to as G-1 thru G-31 in the text.

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FIGURE 4-5

Area Studied by Group Five Sampling Sites; Spring Creek Watershed.

TABLE 4-4

SAMPLING SITES LOCATED WITHIN THE GROUP FIVE AREA

SPRING CREEK WATERSHED

Soil	Groundwater	Water and Sediment
S-12	G-25	W-10
S-13	G-26	W-17
S-15	G-27	W-19
	G-28	
	G-29	
	G-30	

moving into the facility from the east. No contamination was detected in these samples.

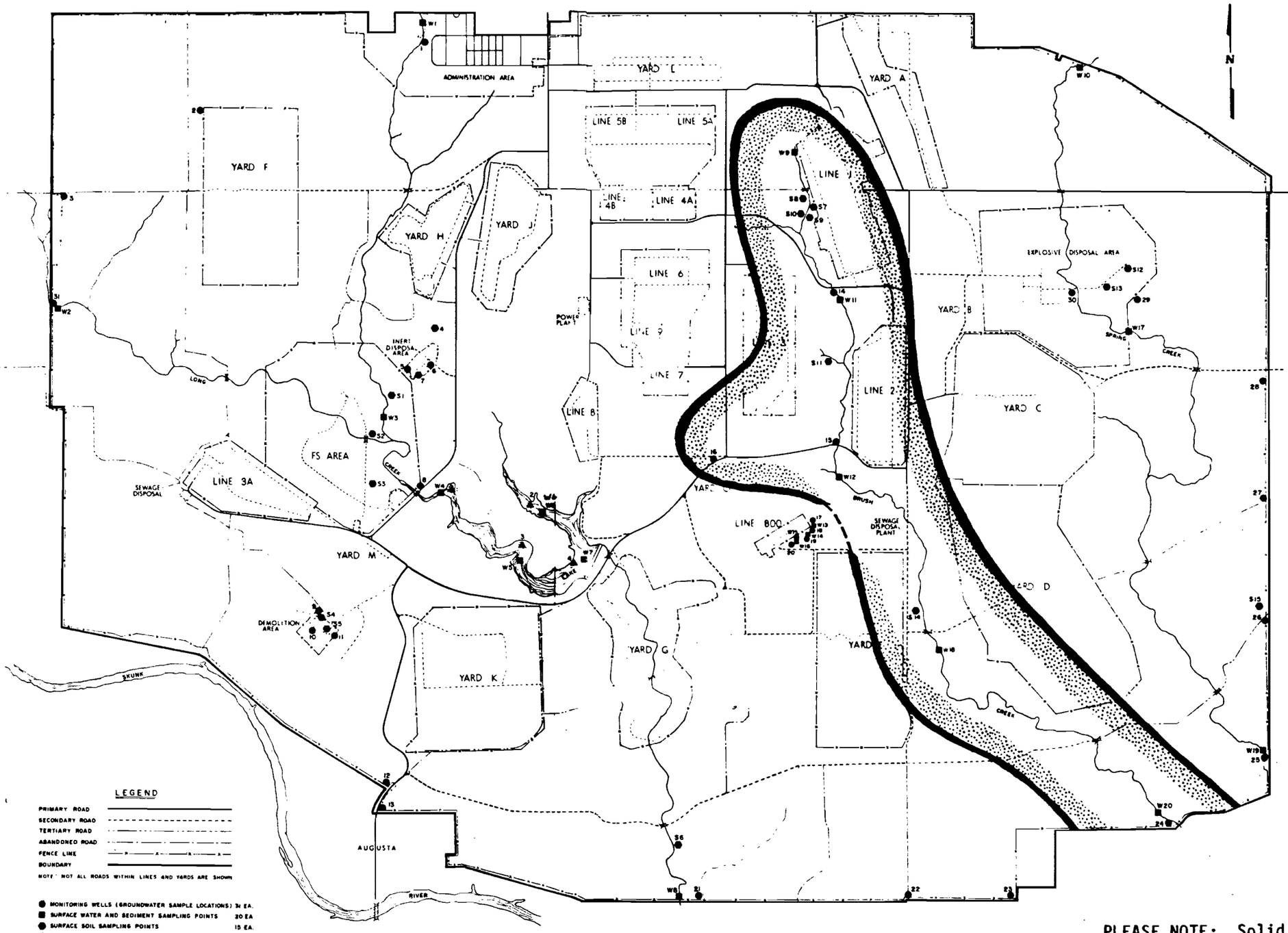
The results of the analyses for the other sample points indicate that levels of explosive materials exist in Spring Creek. RDX was detected in the surface water sample taken at W-19, which is located at the southern boundary of the facility. The discharge of Spring Creek leaves the facility at this point. The amount of RDX found in surface water at W-19 was 62 ug/L, which does not exceed the USAMBRDL recommended aquatic life criteria, 300 ug/L.

Also, trace quantities of 2,4,6-TNT were detected in surface waters at W-17, which is immediately downstream of the disposal area (Figure 4-5). On the other hand, no explosives were found in surface waters collected at W-10 which is located upstream of the disposal area. Thus, water quality data alone indicate that the probable source of the 2,4,6-TNT measured at site W-17 is the disposal area.

Only one soil sample collected in the disposal area, S-12, contained explosive material. In this sample, both RDX and 2,4,6-TNT were found (5 mg/Kg and 4 mg/Kg, respectively).

Unless another source for explosive material can be found in this watershed, it is reasonable to conclude that the disposal area is the source of this contamination.

None of the tested groundwater contained explosive material. Therefore, groundwater flow does not appear to be a pathway for migration of contaminants in this watershed. Spring Creek, on the other hand, appears to be a pathway for the migration of contamination off the IAAP site. The transportation of contamination appears limited to



PLEASE NOTE: Solid circles without letter prefixes (1-31) represent well sites which are referred to as G-1 thru G-31 in the text.

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FIGURE 4-6

Area Studied by Group Six Sampling Sites; Brush Creek Watershed.

water-soluble material, in that sediments in this section of the creek do not exhibit similar contamination.

This finding is consistent with the fact that RDX is readily soluble in water (16). It would certainly account for the non-detection of RDX or other explosives in sediments.

4.7 Group Six - Brush Creek

Group Six comprises those sampling locations within the Brush Creek watershed, excluding the Pink Water Lagoon, or Line 800, area which will be discussed in the next section. The Brush Creek watershed is almost entirely within the IAAP facility (Figure 4-6). Very little of its flow originates outside the facility. Within this area are four wells, five surface water and sediment sampling sites, and six soil sampling sites (Table 4-5).

The results of the analysis of surface water samples from Brush Creek watershed indicate the absence of TNT and presence of RDX at levels below those recommended by USAMBRDL for aquatic life (Table 4-6). Wells G-15 and G-24 contained 1500 ug/L and 21 ug/L RDX, respectively. Also found were trace levels of 2,4-6-TNT in the sediments at W-11 and W-12 (1.9 mg/Kg and 1.2 mg/Kg, respectively); however, RDX was not present. This is probably due to the high solubility of RDX (16) as discussed in Section 4.6.

There are several possible sources of the RDX measured in the surface water and/or groundwater:

1) water discharged under NPDES permits for Lines 1, 2 and 3 operations in the Brush Creek watershed;

TABLE 4-5

SAMPLING SITES WITHIN THE GROUP SIX AREA

BRUSH CREEK WATERSHED

Soil	Groundwater	Water and Sediment
S-7	G-14	W-9
S-8	G-15	W-11
S-9	G-16	W-12
S-10	G-24	W-18
S-11		W-20
S-14		

TABLE 4-6

DATA ON CONCENTRATIONS OF RDX IN GROUND AND SURFACE WATERS, SEDIMENTS, AND SOILS FOR SAMPLING SITES IN THE GROUP SIX AREA BRUSH CREEK WATERSHED

Groundwater		Water		Sediment		Soil	
Site	ug/L	Site	ug/L	Site	ug/g	Site	ug/g
G-14	ND[1]	W-9	ND	W-9	ND	S-7	ND
G-15	1500	W-11	185	W-11	ND	S-8	ND
G-16	ND	W-12	166	W-12	ND	S-9	ND
G-24	21	W-18	130	W-18	ND	S-10	ND
		W-20	86	W-20	ND	S-11	ND
						S-14	ND

[1]ND = not detected

2) groundwater near well G-15;

3) past activities at upper Brush Creek near Line 1; and

4) the Pink Water Lagoon at Line 800.

An NPDES-regulated discharge consisting of treated process water exists on Brush Creek. Discharge is permitted for RDX at 25 mg/L, maximum, and for TNT at 1 mg/L, maximum. It is possible that a permitted discharge of RDX was occurring during the sampling of Brush Creek. If that were the case, then the overall contamination may be limited to a known source; however, additional sources of RDX may have contributed.

Well G-15, located in alluvial deposits within the river floodplain, contained 1500 ug/L RDX. It may be possible that contaminated groundwaters are seeping into Brush Creek. According to the U.S. Army Corps of Engineers' study (9), this group's hydrogeologic conditions are such that development of the subsurface contaminant plumes is unlikely, however.

Additionally, a previous disposal practice may be contributing. It is known that upper Brush Creek near Line 1 was used as an impoundment for process wastewater since 1948 (4). A dam had been constructed upstream of sampling site W-15. This impoundment received untreated contaminated wash waters from operations at Line 1. Considerable amounts of particulate material, much of which was explosives, were deposited in the impoundment. This treatment method was discontinued and the dam and its accumulated sediment were removed in 1957 (9). Consequently, the stream eroded a channel through the remaining contaminated material to a depth approximating its previous gradient. Because all impounded sediments

were not removed from upper Brush Creek (9), the remaining explosives-contaminated sediments may still be contributing RDX into the stream. This is supported by the U.S. Army Corps of Engineers' study. Based upon limited sampling, significant quantities of explosives apparently remain in the sediments deposited during the operation of the dam (3), and these sediments are subject to erosion and scour during periods of high stream flow.

Another potential source of contamination is the seepage of water from aquifers contaminated by processes that were in effect during the time the impoundment existed. The impoundment created a lake which raised the level of Brush Creek from approximately 660 feet MSL (Mean Sea Level) to 680 feet MSL (9). The rise in water level created a hydraulic head pressure of approximately 20 feet. Assuming conditions existing presently were similar to those that existed prior to the creation of the impoundment, the groundwater would have flowed toward Brush Creek. The impoundment, with its 20-foot hydraulic head, created a situation which effectively reversed the groundwater flow direction.

The reversed groundwater flow possibly introduced contaminated water from the pond to the adjacent aquifers. This situation might have existed when the dam was utilized, from the mid-1940's to the mid-1950's (9).

During those nine years, a considerable amount of contaminated water might have entered the local glacial aquifers due to the head created by the impoundment. The removal of the dam reduced the hydraulic head, and thus again reversed the groundwater flow. The contaminated water introduced to the aquifers during the high groundwater condition

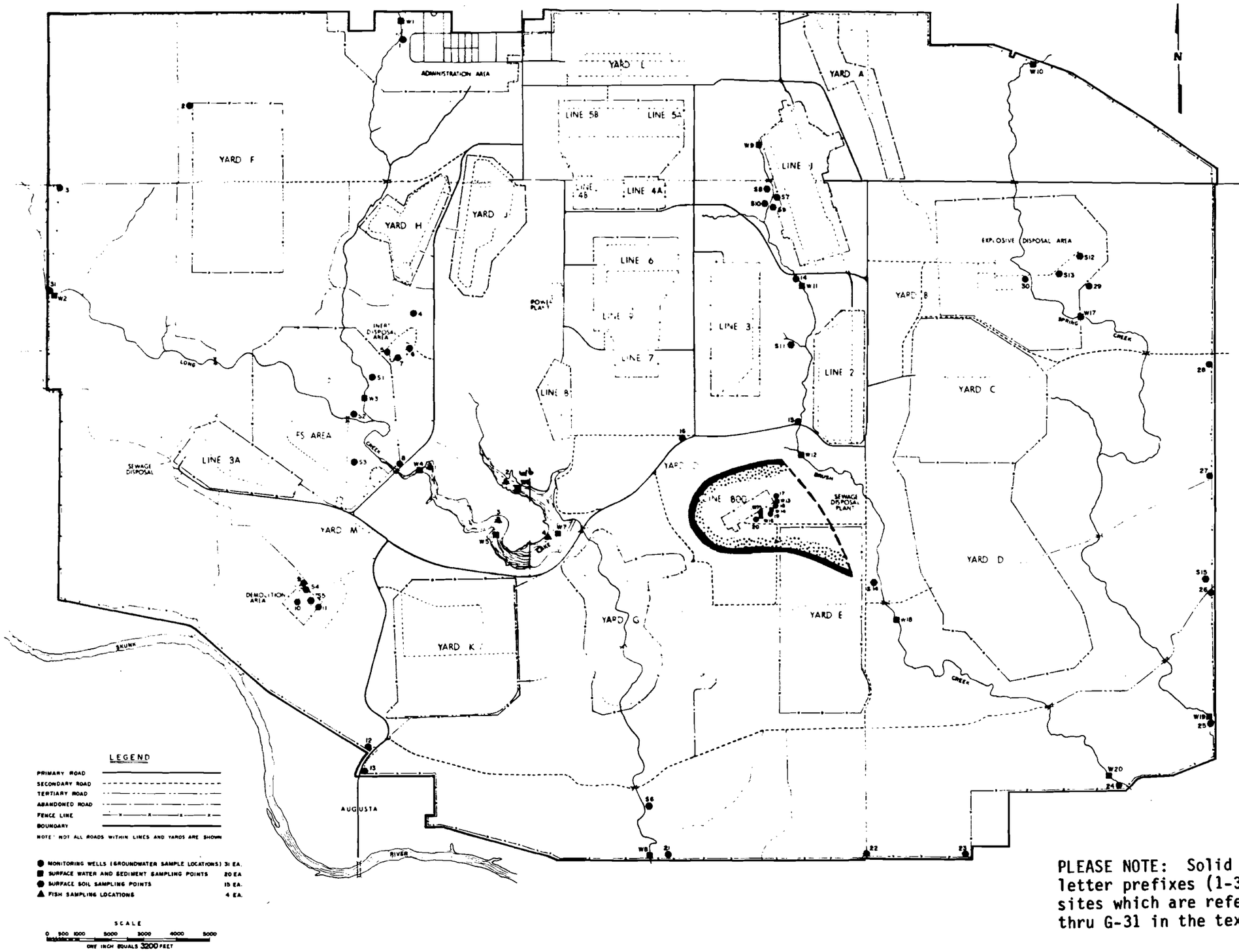
(when the dam was present) began to seep out of the local aquifers back into Brush Creek, thus adding contaminants to the stream. This process of seepage could continue for a considerable period of time due to adsorption of contaminated material to clay particles in the aquifer (17). However, the U.S Army Corps of Engineers' Study concluded that no significant groundwater contamination was detected. This statement was based upon contaminant data, including explosives, obtained from five wells near Line 1; the wells ranged in depth from 10 to 50 feet, approximately.

Finally, another potential source of RDX contamination may be the Pink Water Lagoon at Line 800, which is in the Brush Creek watershed. This area is discussed in greater detail in the next section.

In conclusion, although several sources for the RDX contamination have been surmised, the overall impact of the former impoundment on water quality in the Brush Creek watershed appears insignificant. Groundwater at G-24 near the installation boundary contained 21 ug/L RDX; this level is below the USAMBRDL recommended human health criteria, 33.68 ug/L. Surface water at W-20 near the installation boundary contained 86 ug/L RDX; this level is below the USAMBRDL recommended aquatic life criteria, 300 ug/L. Nonetheless, explosives-contaminated sediments apparently remaining at the former impoundment (3) are subject to erosion and scour during periods of high stream flow; thus, they may continuously contribute explosives contaminants into the Brush Creek watershed.

4.8 Group Seven - Pink Water Lagoon/Line 800

The Pink Water Lagoon is located within the Brush Creek watershed, approximately 1000 feet from the creek itself (Figure 4-7). It is about



PLEASE NOTE: Solid circles without letter prefixes (1-31) represent well sites which are referred to as G-1 thru G-31 in the text.

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FIGURE 4-7

Area Studied by Group Five Sampling Sites; Pink Lagoon/Line 800 Area.

one acre in size; ammunition renovation was the primary activity here from 1943-1955. No discharge pipes currently exist from the lagoon to the creek, and it has not been reported that the pond had ever overflowed, allowing liquid to reach the creek.

The lagoon was used as a holding pond for wastewater chiefly from Line 800 operations. These wastes contained explosive material which in solution turned pink due to decomposition by ultraviolet light; hence the name, pink water. Currently, the lagoon has been posted with the U.S. EPA according to RCRA regulations.

The sampling locations were selected to define the quality of the groundwater near the lagoon. Surface water and sediment samples were obtained from within the lagoon. Sediment samples were obtained at between 15 and 33 cm. There were four groundwater, four surface water, four sediment samples, but no soil samples collected at this site (Table 4-7). The groundwater wells were all 20 feet deep and situated within 20 to 30 feet of the lagoon on the apparent downgradient side of the lagoon. The downgradient direction was conjectured based on topography, which indicated movement should occur to the southeast.

The well log data obtained during drilling of the bore holes indicated the near surface glacial strata in this area near the lagoon were predominantly clays with multiple thin layers of sand and gravel. Furthermore, these sand layers were very erratic and apparently discontinuous. Slug test data also confirmed the discontinuous nature of these sand lenses as shown by the results obtained from wells G-18 and G-20. Flow rates for these two wells were 9.3×10^{-2} meters/day and 1.3 meters/day, respectively. Although the wells are less than 200 feet

TABLE 4-7
SAMPLING SITES LOCATED WITHIN THE GROUP SEVEN AREA
THE PINK LAGOON/LINE 800

Soil	Groundwater	Water and Sediment
none	G-17	W-13
	G-18	W-14
	G-19	W-15
	G-20	W-16

apart and are penetrating the same horizon, the slug tests and well logs indicate that these two wells do not appear to penetrate the same aquifer.

The analytical results show considerable RDX contamination at wells G-18 (14,000 ug/L), G-19 (14,000 ug/L), and G-20 (36,000 ug/L). (Well G-17 was not analyzed for RDX.) The 2,4,6-TNT results showed wells G-18, G-19 and G-20 having concentrations of 850 ug/L, 172 ug/L, and 700 ug/L, respectively. Well G-17, on the other hand, showed no 2,4,6-TNT levels (Table 4-8).

A plume, or zone of contamination, does exist in the groundwater near the Pink Lagoon. However, the boundaries of the plume cannot be defined by the existing data, nor is it possible to determine a calculated boundary with the available data. Additionally, it cannot be determined if the bedrock aquifer is being affected.

The source of the groundwater contamination in this area would be expected to be the Pink Water Lagoon. The lagoon is not lined, and leakage from the pond would be expected even considering the low rate of infiltration due to the abundant clay in the area. The analysis of the water which currently is impounded does not show the same levels as found in the groundwater data. The only explosive detected in the pond water was RDX, but at levels much lower than the groundwater, ranging from 166 ug/L to 219 ug/L. The pond has not been active since 1955, and dilution, chemical breakdown, or bacterial action may have reduced the concentrations of explosives now present from concentrations which were originally higher.

Sediments from the pond are equally low in contaminants. The explosives found in detectable quantities in the sediments are 2,4,6-TNT

TABLE 4-8

DATA ON CONCENTRATIONS OF CONTAMINANTS IN GROUND AND SURFACE WATERS AND SEDIMENTS FOR SAMPLING SITES IN THE GROUP SEVEN AREA

PINK WATER LAGOON/LINE 800

Parameter	Matrix:	Groundwater (ug/L or ppb)				Surface Water (ug/L or ppb)				Sediment (ug/g or ppm)			
	Site:	G-17	G-18	G-19	G-20	W-13	W-14	W-15	W-16	W-13	W-14	W-15	W-16
RDX		NA[1]	14,000	14,000	36,000	219	202	166	202	ND	ND	ND	ND
Tetryl		ND[2]	ND	ND	46	ND	ND	ND	ND	ND	ND	ND	ND
1,3-DNB		ND	50	48	36	ND	ND	ND	ND	ND	ND	ND	ND
2,4-DNT		ND	39	35	29	ND	ND	ND	ND	ND	ND	ND	ND
2,6-DNT		ND	60	56	8	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-TNB		ND	10	ND	1,900	ND	ND	ND	ND	ND	ND	9	33
2,4,6-TNT		ND	850	172	700	ND	ND	ND	ND	37	1.2	1.2	210

[1]NA = not analyzed

[2]ND = not detected

and 1,3,5-TNB, with the highest concentration of these two explosives being 210 mg/Kg and 33 mg/Kg (Table 4-8). No RDX is found, however, which is consistent with findings for Long Creek (Section 4.2) and the Demolition Area (Section 4.3). This may be a function of the ready solubility of RDX in water.

As in the case of the lagoon water, the explosives in the sediments may have deteriorated or leached out. The sediments which contained the higher concentrations of explosives may also have been covered with sediments relatively free of contamination and deposited at a later date, which were not penetrated by the sampling.

In summary, it is reasonable that the Pink Water Lagoon is the source of the localized groundwater contamination. However, presently the liquids in the pond, while still containing low levels of RDX probably do not contain as much as they did in the past, and therefore are not as great a source for additional groundwater pollution. The most immediate problem is that the pond liquid is creating a hydrostatic head which increases the potential to move the contaminated groundwater further and faster than would be the case if the lagoon were removed and natural forces alone were to operate on the groundwater levels.

No supportable estimates can be made of the rate of movement of the contaminated groundwater plume due to the limited data and the complex subsurface geology at this site. However, it may be inferred that a plume is migrating in a southeasterly direction. Finally, the horizontal rate of movement is slow, possibly in the range of meters per year. If the aquifers are perched, and if additional clay exists beneath the levels measured by existing bore holes, migration may be very limited.

5.0 SUMMARY OF CONTAMINATION INVESTIGATION

5.1 Contamination Migration

The data obtained from the ERG investigation of the IAAP facility indicate that explosive material, RDX, was found in three areas: (1) Spring Creek; (2) Brush Creek; and (3) the Pink Water Lagoon Area (Line 800).

The RDX is migrating off the IAAP site via both Brush and Spring Creeks, however, at levels well below the USAMBRDL aquatic life criteria, 300 ug/L.

Groundwater is contaminated with RDX at levels exceeding the USAMBRDL human health criteria (33.68 ug/L) in two areas: (1) the floodplain of Brush Creek; and (2) the area immediately around the Pink Water Lagoon. There is, however, no evidence that these groundwater contaminants are moving off the IAAP facility.

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