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SUMMARY OF INTERIM REMEDIAL INVESTIGATIONS JANUARY 1987 THROUGH APRIL 1989 VOLUME 1 OF 3 NAS FORT WORTH TX
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July 19, 1989

SUMMARY OF INTERIM REMEDIAL INVESTIGATIONS
JANUARY 1987 TO APRIL 1989
U.S. AIR FORCE PLANT NO. 4
FORT WORTH, TEXAS

VOLUME I

TEXT, TABLES & ILLUSTRATIONS

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July 19, 1989

VIA FEDERAL EXPRESS

Mr. Luke Gilpin 777-8203
GENERAL DYNAMICS - FORT WORTH DIVISION
USAF PLANT NO. 4
Mail Zone 6293
1500 North Grants Lane
Fort Worth, TX 76108

Re: Summary of Interim Remedial Investigations, January 1987 to April 1989, U.S. Air Force Plant No. 4, Fort Worth, Texas

Dear Mr. Gilpin:

This report was prepared pursuant to Task 6 of Plant Services Contract No. 6049. If you have any questions or require additional information regarding this report, please contact us.

We appreciate the opportunity to be of service to General Dynamics.

Respectfully submitted,

HARGIS + ASSOCIATES, INC.

David R. Hargis
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Enclosure

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SUMMARY OF INTERIM REMEDIAL INVESTIGATIONS

JANUARY 1987 TO APRIL 1989

U.S. AIR FORCE PLANT NO. 4

FORT WORTH, TEXAS

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Minutes of GD Meeting

1. Dr. Dave Hargis and Sam Williams of Hargis and Associates presented the findings from the groundwater investigation at General Dynamics.

2. Debra Richmann presented the findings from the groundwater investigation at Carswell AFB. She also briefly discussed the major contaminants at each site.

3. Surendra Joshi of ASD informed the attendees that an IAG between the USAF and TWC is in the works. This IAG is being reviewed by HQ SAC LEGAL.Carswell AFB knew nothing of this agreement prior to the meeting.

4. HQ SAC Legal is working with legal from GD on the IAG. Hargis and Associates along with Radian Corp. recommended further monitoring of the plume area in order to define boundaries. Currently, there is not enough data to define the extent of the TCE plume and boundaries. Further monitoring must be performed before any determination can be made.

5. In summary, the meeting addressed these particular items:

   (a) Both sides presented their findings.
   (b) No conclusions were drawn on the sources of TCE.
   (c) IAG is being reviewed by HQ SAC Legal.
   (d) Nothing will happen until further monitoring is accomplished.

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SUMMARY OF INTERIM REMEDIAL INVESTIGATIONS
JANUARY 1987 TO APRIL 1989
U.S. AIR FORCE PLANT NO. 4
FORT WORTH, TEXAS

1.0 INTRODUCTION

This report summarizes the interim remedial investigations conducted at U.S. Air Force Plant No. 4 (AFP 4) between January 1987 and April 1989. This report was prepared pursuant to Task 6 of General Dynamics Plant Services Contract No. 6049. Interim remedial investigations have focused on the groundwater conditions in (1) the Paluxy aquifers on the west side of AFP 4 and (2) the upper zone and upper Paluxy Formation on the east side of AFP 4. This report supplements the report detailing investigations in the window area entitled Summary Report, Window Area Investigation, U.S. Air Force Plant No. 4, Fort Worth, Texas (Hargis + Associates, Inc., 1987a).

1.1 INVESTIGATION OBJECTIVES

The objectives of the interim remedial investigations were to:

- Further define the geologic and hydrogeologic conditions at AFP 4 and the western portion of Carswell AFB.

- Provide additional data to determine the directions of groundwater flow and potential causes of anomalous water levels in the upper Paluxy Formation.

- Further delineate the distribution of contaminants in upper zone and Paluxy Formation groundwater.

- Determine the potential for groundwater to migrate from the upper zone into the upper Paluxy Formation.

1.2 BACKGROUND

Interim remedial investigations were performed pursuant to recommendations prepared by the Army Corps of Engineers (ACOE) (1987). Hargis + Associates, Inc. (H+A) also presented results of interim remedial investigations and provided recommendations for additional investigations for concurrence by the technical review committee (TRC). The TRC consists of representatives from the U.S. Environmental Protection Agency Region VI, the Texas Water Commission, the City of Fort Worth, the City of White Settlement, the U.S. Air Force, and General Dynamics. Recommendations to collect the data required to delineate the extent of groundwater contamination in the flight line area were provided at the last TRC meeting held in December 1987. Interim remedial investigations have comprised assessment of lithologic, hydrogeologic, and water quality conditions on the east and west sides of AFP 4.

1.2.1 East Side

Results of investigations conducted through 1985 indicated that the Walnut Formation between the upper zone and Paluxy Formation might be absent in a small area underlying the East Parking Lot. H+A referred to this feature as the window area. Because of the potential absence of the Walnut Formation, groundwater in the upper zone may be in direct contact with the upper Paluxy Formation in this area. The ACOE conducted an investigation of geologic and hydrogeologic conditions in the general vicinity of the window area from July 1985 to March 1986. The ACOE drilled 28 soil borings in the East Parking Lot to define the topography of the top of the Walnut Formation and attempted to further define the extent of the window area.

Based on recommendations prepared by the ACOE and at the request of General Dynamics, H+A installed a suite of three monitor wells adjacent to

the window area in November 1986. The three monitor wells were completed in the upper zone, the upper sand unit of the upper Paluxy Formation, and the upper Paluxy Formation. During this investigation, two water-bearing units were identified in the upper Paluxy Formation. The uppermost water-bearing unit is referred to as the upper sand unit of the upper Paluxy Formation. H+A summarized the results of this investigation and recommended that additional investigations be conducted to assess hydrogeologic conditions in the window area (Hargis + Associates, Inc., 1987b).

Interim remedial investigations on the east side of AFP 4 have comprised drilling soil borings and constructing monitor wells. The purpose of these investigations was to determine if the Walnut Formation was present and delineate areas where upper zone groundwater may be migrating into the Paluxy Formation.

1.2.2 West Side

Paluxy Formation monitor wells P-1, P-2, P-3, and P-4 were the first monitor wells constructed at AFP 4 to assess hydrogeologic conditions in the Paluxy aquifer. These monitor wells were screened in the entire Paluxy Formation. Water quality data obtained from paired monitor wells later constructed in the upper and middle Paluxy aquifers indicated that, in general, contaminants were present only in the upper Paluxy aquifer. Based on this data, monitor wells P-1, P-2, and P-4 were abandoned in September 1986. All PVC pipe was removed and the boreholes were cemented from the bottom up. It was recommended that each of the former composite Paluxy monitor wells be replaced with paired upper and middle Paluxy aquifer monitor wells (Hargis + Associates, Inc., 1986).

Geologic and hydrogeologic data for the west side of AFP 4 indicate that Meandering Road Creek may be a potential source of groundwater recharge for the upper Paluxy aquifer. It was recommended that upper and middle Paluxy aquifer monitor wells be constructed on the east side of Meandering

Road Creek near the P-10 monitor well suite to further define the direction of groundwater flow and characterize the chemical quality of groundwater. (Hargis + Associates, Inc., 1988).

2.0 REGIONAL SETTING

AFP 4 is located in Tarrant County northwest of Fort Worth, Texas (Figure 1). AFP 4 lies within the Western Cross Timbers section and the Grand Prairie section of the Central Lowlands physiographic province.

2.1 PHYSIOGRAPHY

The Grand Prairie section is underlain by sedimentary rock consisting of alternating limestones and marls of the Washita and Fredericksburg group (Nordstrom, 1982). The surface exposures of these rocks define the areal extent of the Grand Prairie physiographic section. The Grand Prairie section is typically a broad, gently sloping terrace mantled by a thin layer of light brown to black loamy soil.

The northwest corner of AFP 4 lies within the Western Cross Timbers physiographic section, west of and adjacent to the Grand Prairie section. The Western Cross Timbers section, underlain by sedimentary rocks of the Trinity Group, is characterized by a rolling to hilly topography that is dissected into steep hills and deep ravines.

2.1.1 Surface Water

AFP 4 is located south of Lake Worth, which is a reservoir created by damming the West Fork of the Trinity River just northeast of AFP 4. The shoreline of this reservoir is the northern boundary of AFP 4. Lake Worth supplies drinking water to the City of Fort Worth. When the lake is full, the elevation of the reservoir water surface is approximately 594 feet mean sea level (msl), the fixed elevation of the dam spillway (CH2M Hill, 1984). Mean annual evaporation from Lake Worth is approximately 57 inches per year. Mean annual precipitation in the vicinity of Lake Worth is approximately 32 inches per year.

Surface drainage at AFP 4 is collected by storm drains and culverts and is discharged either to Lake Worth, Meandering Road Creek, or to a tributary of Farmers Branch. Meandering Road Creek borders AFP 4 to the west and flows northward into Lake Worth. Meandering Road Creek is an ephemeral stream. Farmers Branch is also an ephemeral stream located on the east side of AFP 4.

2.2 REGIONAL GEOLOGY

The geology in northwestern Tarrant County is characterized by a sedimentary sequence of Cretaceous formations underlain by undifferentiated Paleozoic rocks. The Cretaceous sequence forms a broad homocline which dips gently southeastward toward the East Texas structural basin (Nordstrom, 1982). The Cretaceous sequence is wedge-shaped in cross section and increases in thickness downdip from the outcrop areas. The rock units of principal interest in the vicinity of AFP 4 are, in descending order: alluvium, the Fredericksburg Group, the Trinity Group, and the undifferentiated Paleozoic rocks.

2.2.1 Alluvium

Detrital alluvial deposits and fluvial terrace deposits of Quaternary age crop out along stream valleys as a thin veneer overlying Cretaceous rocks in Tarrant County. The deposits are generally unconsolidated and consist of poorly-sorted to well-sorted clay, silt, sand, and gravel. These deposits are referred to as the upper zone.

2.2.2 Fredericksburg Group

The Fredericksburg Group in Tarrant County includes the Goodland Limestone and the underlying Walnut Formation. This group is Cretaceous in age and is part of the homoclinal sequence. The group dips uniformly to the southeast at approximately 38 feet per mile. The thickness of the group increases southward (Leggat, 1957).

2.2.2.1 Goodland Limestone

The Goodland Limestone crops out over a large area west of Fort Worth. This formation has been removed by erosion in several areas at AFP 4. The Goodland Limestone typically forms large rounded hills capped by alluvium, low rounded buttes in the floodplains, or steep west-facing escarpments. The Goodland Limestone consists of chalky, fossiliferous, thinly to massively bedded, resistant limestone, and blue to yellowish-brown marl. The formation is extensively jointed and weathered. Thickness of the Goodland Limestone increases southward, ranging from 70 to 130 feet in Tarrant County (Leggat, 1957).

2.2.2.2 Walnut Formation

The Walnut Formation is overlain conformably by the Goodland Limestone. The Walnut Formation crops out west and northwest of Fort Worth, where it forms resistant ridges. The formation consists of an indurated fossiliferous limestone and shell coquina interbedded with brown sandy clay, thin-bedded fossiliferous clay, fissile shale, and iron-stained earthy limestone (Leggat, 1957).

2.2.3 Trinity Group

The Trinity Group in Tarrant County includes, in descending order: the Paluxy Formation, the Glen Rose Formation, and the Twin Mountains Formation. This group is Cretaceous in age and is overlain by the Fredericksburg Group in the homoclinal sequence.

2.2.3.1 Paluxy Formation

The Paluxy Formation is overlain unconformably by the Walnut Formation. The Paluxy Formation crops out over large areas northwest of Fort Worth and forms the bed of Lake Worth. The Paluxy Formation consists of fine- to coarse-grained white quartz sand interbedded with sandy to silty, calcareous, waxy clay and shale (Nordstrom, 1982). The formation grades upward from coarse-grained sand to fine-grained sand with variable thicknesses of interbedded shale and clay. The sand is typically well-sorted, poorly consolidated, and cross-bedded. Iron and pyrite nodules occur in the sand, imparting a red stain to individual beds. Lignite is present locally. The thickness of the Paluxy Formation ranges from 140 to 190 feet in Tarrant County. The average thickness of the Paluxy Formation is approximately 160 feet (Leggat, 1957).

2.2.3.2 Glen Rose Formation

The Glen Rose Formation is overlain conformably by the Paluxy Formation and is not reported to crop out in Tarrant County. The Glen Rose Formation consists of limestone with some sand, clay, sandy clay, and anhydrite. The thickness of the Glen Rose Formation is reported to be approximately 250 feet in the area of Lake Worth. The Glen Rose Formation dips to the southeast at approximately 40 feet per mile and has been encountered at depths ranging from 130 to 1,050 feet below land surface (bls) in Tarrant County.

2.2.3.3 Twin Mountains Formation

The Twin Mountains Formation, formerly known as the Travis Peak Formation, is overlain conformably by the Glen Rose Formation. The contact is gradational in some areas. The Twin Mountains Formation is not exposed in Tarrant County. The Twin Mountains Formation grades upward from a basal conglomerate of chert and quartz to a fine- to coarse-grained sand interbedded with shale and clay (Leggat, 1957). The thickness of the Twin Mountains Formation ranges from 250 feet at Lake Worth to 430 feet at Arlington, increasing downdip. Total thickness of the sand strata is reported to be approximately 80 feet in the western part of Tarrant County. The Twin Mountains Formation has been encountered at depths of approximately 550 feet bls at Lake Worth.

2.2.4 Undifferentiated Paleozoic Rocks

Undifferentiated Paleozoic rocks are overlain unconformably by the Twin Mountains Formation and are not exposed in Tarrant County. These rocks consist of shales, limestones, and sandstones, which are reported to be tightly cemented (Leggat, 1957). The Paleozoic sequence is 6,000 to 7,000 feet thick.

3.0 EAST SIDE INVESTIGATION

During the period January 1987 to April 1989, 67 soil borings were drilled and 52 monitor wells were constructed on the east side of AFP 4 (Figure 2). In addition, four existing Paluxy monitor wells were reconstructed.

3.1 EAST SIDE FIELD OPERATIONS

Field operations on the east side of AFP 4 have focused on the upper zone and the upper Paluxy Formation.

3.1.1 East Side Upper Zone Field Operations

Sixty-seven soil borings have been drilled and 31 upper zone monitor wells have been constructed on the east side of AFP 4 since January 1987 (Table 1; Figure 2; Appendices A and B).

Based on the results of the ACOE report (1987), soil borings RSB-1 to RSB-15 were drilled and monitor wells HM-87 to HM-97 were constructed in October 1987. These monitor wells were drilled in the East Parking Lot and flight line area. Concurrent with this drilling program, a shallow soil gas survey was attempted. The soil gas survey was to be a reconnaissance tool to aid in siting potential monitor well locations. The soil gas survey was cancelled after a preliminary calibration survey. The instrumentation utilized was a Photovac gas chromatograph equipped with a photoionization detector. The data obtained indicated that geologic conditions in the vicinity of the East Parking Lot and the flight line area are not conducive to a successful soil gas survey. The occurrence of a thick, dense clay layer at land surface hinders the detection of soil gas and biases the interpretation of soil gas data.

A seismic reflection survey was performed along Grants Lane and the flight line area during the drilling program (Appendix C). The results of the seismic survey were not available until after the drilling program was completed. The purpose of the seismic survey was to delineate an erosional channel incised in the Walnut Formation and to aid in siting potential monitor well locations. Interpretation of the seismic data was aided by correlation with lithologic and hydrogeologic data obtained during the drilling program.

Soil borings RSB-16 to RSB-33 were drilled and monitor wells HM-98, HM-99, HM-110, HM-111, HM-112, and HM-113 were constructed in March 1988. These soil borings and monitor wells are located in the western flight line area (Figure 2). These soil borings and monitor wells were drilled by hollow stem augers.

General Dynamics requested that other exploratory alternatives be evaluated prior to conducting remedial investigations on the east side of the flight line area. Both passive and grab sampling techniques for soil gas were evaluated. It was determined that neither soil gas sampling technique would be a viable reconnaissance tool due to the occurrence of a thick dense clay at land surface in the flight line area. It was recommended that the exploratory program consist of a mobile gas chromatograph in conjunction with an exploratory soil boring program.

Soil borings RSB-34 to RSB-66 were drilled in the eastern flight line area in December 1988 (Figure 2). These soil borings were drilled by hollow stem auger. When groundwater was encountered, fluid on the inside of the augers was purged approximately one hour after the borings were drilled to the total depth. A water sample was collected and analyzed for volatile organic compounds (VOCs) from each of these borings by a mobile gas chromatograph (Appendix D). The field water quality data and the lithologic data were evaluated to determine subsequent soil boring locations.

Based on the data obtained from the exploratory soil boring program, monitor wells HM-114 to HM-127 were constructed in January and February 1989. These monitor wells are located in the eastern flight line area (Figure 2).

Baseline water quality sampling has been conducted in all new monitor wells. Baseline water quality sampling consisted of analyzing groundwater samples from monitor wells at one-month intervals for three months for VOCs. Groundwater samples were also analyzed for base/neutral and acid organics, trace metals, common ions, total fuel hydrocarbons (TFH), and oil and grease at least once during the baseline sampling.

3.1.2 East Side Upper Paluxy Formation Field Operations

Nine upper sand unit and 12 upper Paluxy Formation monitor wells have been constructed, and four existing upper Paluxy formation monitor wells have been reconstructed on the east side of AFP 4 since June 1987 (Table 2; Figure 2; Appendices E and F).

Paluxy monitor well P-8U was screened in the entire upper Paluxy Formation. Based on the data obtained from construction of the P-14 monitor well suite, it was determined that two distinct water-bearing units existed in the upper Paluxy Formation. The uppermost water-bearing unit is located directl· beneath the base of the Walnut Formation and is referred to as the upper sand unit. The other water-bearing unit is the upper Paluxy aquifer. In July 1987 upper Paluxy monitor well P-8U was reconstructed. The reconstruction procedure consisted of removing the PVC pipe from the P-8U borehole and cementing the bottom of the borehole. The resulting monitor well P-8US was screened opposite the upper sand unit of the upper Paluxy Formation. In addition, monitor well P-8UN was constructed and screened only in the upper Paluxy aquifer.

In September 1987, geophysical logs were obtained for monitor wells P-5U, P-7U, P-9U, P-10U, P-12U, P-21U, and P-22U. The purpose of this exercise was to delineate the extent of the upper Sand unit of the upper Paluxy Formation. Also, based on the results of the recommendations from the ACOE (1987), monitor wells P-11US and P-13US were constructed.

Based on the results of geophysical logging, Paluxy monitor wells P-15US, P-15U, P-16US, and P-17US were constructed in October 1987. Monitor wells P-5U, P-9U, and P-12U were abandoned, and monitor wells P-5US, P-9US and P-12US were constructed in the abandoned boreholes, respectively. Monitor wells P-5UN and P-9UN were constructed adjacent to monitor wells P-5US and P-9US, respectively. These monitor wells were constructed to monitor upper Paluxy groundwater quality and replace the former upper Paluxy aquifer monitor wells.

Based on the results of previous drilling activities, Paluxy monitor wells P-12UN, P-18US, and P-19US were constructed in March 1988.

3.2 RESULTS OF EAST SIDE INTERIM REMEDIAL INVESTIGATIONS RESULTS

Results of the east side interim remedial investigations comprise lithologic, geophysical, hydrogeologic, and water quality data collected during the field operations conducted on the east side of AFP 4.

3.2.1 East Side Local Geology

This description of the local geology on the east side of AFP 4 concentrates on the upper zone, Goodland Formation, Walnut Formation, and upper Paluxy Formation. A detailed description of the middle Paluxy Formation is provided in Section 4.2.1 of this report and in the H+A Phase II report (Hargis + Associates, Inc., 1985).

3.2.1.1 Upper Zone

Lithologic data indicate that the upper zone was deposited on a hummocky surface consisting of hills and valleys eroded into the Goodland Limestone, Walnut Formation, and possibly the Paluxy Formation. The thickness of the upper zone is controlled by land surface elevation and bedrock topography. The upper zone alluvium consists of detrital alluvial deposits and fluvial terrace deposits. The alluvium is unconsolidated and poorly to moderately sorted. Lithologic data from monitor wells and soil borings indicate that the alluvium comprises a nonhomogeneous, interbedded sequence of clay, silt, sand and gravel. Although some sandy units consist of quartz grains, most of the clastic material is composed of limestone and fossil shell fragments. Individual beds are laterally discontinuous.

Sand and gravel deposits generally occur as a veneer immediately overlying the Walnut Formation (Figure 3). The thickness of these basal sand and gravel deposits ranges from zero to 18 feet and is greatest in the vicinity of the East Parking Lot.

3.2.1.2 Goodland Limestone

The Goodland Limestone member of the Fredericksburg Group generally underlies the upper zone at AFP 4. The Goodland Limestone consists of dense, thinly to massively bedded fossiliferous limestone interbedded with stiff clay and shale. The top of the unit is highly weathered in places. The Goodland Limestone is not present everywhere beneath AFP 4. Beneath the eastern portion of the East Parking Lot, lithologic logs of soil borings indicate the Goodland Limestone has been completely eroded. The maximum thickness of the Goodland Limestone observed at AFP 4 is approximately 47 feet. The greatest thicknesses of Goodland Limestone occur beneath the western Radar Range and along Clifford Avenue.

No subsurface faults are known to occur in the Goodland Limestone in the vicinity of AFP 4. Extensive jointing of the Goodland Limestone has been reported and can be observed in the outcrop west of monitor well EPA-4 (Leggat, 1957). However, inspection of core samples indicates that jointing is rare in the unweathered Goodland Limestone beneath AFP 4.

3.2.1.3 Walnut Formation

The Walnut Formation member of the Fredericksburg Group is present beneath most of AFP 4. The Walnut Formation consists of indurated fossiliferous limestone and coquinite with thin, interbedded calcareous shale and clay. The coquinite often has a matrix of calcareous shale and clay and is characterized by an abundance of Gryphaea marcoui and Exogyra texana (Leggat, 1957). Black fissile shale has been encountered immediately above the coquinite in several monitor well borings. Dense sandy limestone and silty shale in lower portions of the Walnut Formation have also been observed.

The Walnut Formation crops out along the shoreline of Lake Worth north of AFP 4. In general, the Walnut Formation is overlain conformably by the Goodland Limestone (Leggat, 1957). Where the Goodland Limestone is absent, the upper zone deposits lie directly on the Walnut Formation. The maximum measured thickness of the Walnut Formation is 46 feet to the south of AFP 4. Lithologic data for monitor wells HM-67 and HM-94 indicate that the Walnut Formation is very thin and may be absent in the East Parking Lot along Grants Lane. No faults or prominent fractures are known to occur in the Walnut Formation in the vicinity of AFP 4.

Lithologic data collected from monitor wells and soil borings were used to interpret the elevation of the top of the Walnut Formation (Figures 4 and 5). In areas where the Goodland Limestone has been removed, the top of the Walnut Formation is characterized by erosional channels separated by a series of bedrock highs with intervening saddles. In

general, there are two bedrock highs in the Walnut Formation on the east side of AFP 4. One bedrock high is located near the Parts Plant and Assembly Building where the elevation of the top of Walnut Formation is approximately 625 feet above msl. The other bedrock high is located southeast of the East Parking Lot where the elevation of the top of the Walnut formation is approximately 625 feet above msl.

Based on the lithologic data, an erosional channel appears to have been eroded into the Walnut Formation and Goodland Limestone and subsequently filled by upper zone alluvial deposits. The bedrock channel is located east of the Parts Plant and appears to be a major erosional feature in the subsurface (Figure 4). Results of a seismic refraction survey conducted by D'Appolonia (1983) also indicated the presence of this channel-like feature beneath the East Parking Lot. Soil borings and monitor wells have further delineated the extent of this erosional feature in the area east of AFP 4. The lithologic data indicate that the erosional channel begins as a narrow northeasterly trending feature in the southern portion of the East Parking Lot. The erosional channel widens in the vicinity of Grants Lane. Based on the lithologic data, the southern embankment of the channel trends to the southeast beneath the runways at Carswell AFB. The northern embankment of the channel trends to the northeast beneath the runways at Carswell AFB. A small bedrock mound occurs between the northern and southern embankments.

3.2.1.4 Paluxy Formation

The Paluxy Formation member of the Trinity Group generally underlies the Walnut Formation throughout most of AFP 4. In areas where the Walnut Formation has been extensively eroded, upper zone alluvium may lie directly on the upper Paluxy Formation. The Paluxy Formation consists of two predominantly sandy portions separated by clay and shale: the upper Paluxy Formation and the lower Paluxy Formation. The upper Paluxy Formation is divided into the upper sand unit and the upper Paluxy aquifer (Figures 7 and 8). The lower Paluxy Formation is divided into the middle

Paluxy aquifer and the lower Paluxy aquifer. Only the Paluxy upper sand unit, upper Paluxy aquifer, and middle Paluxy aquifer were investigated as part of these interim remedial investigations. Geologic conditions for the upper Paluxy Formation on the east side of AFP 4 are described in this section. A detailed description of the lower Paluxy Formation is provided in section 4.2.1.2.

3.2.1.4.1 Upper Paluxy Formation

The upper Paluxy Formation is overlain unconformably by the Walnut Formation below most of AFP 4. The upper Paluxy Formation may be overlain by the upper zone in areas where the Walnut Formation has been completely eroded. The upper Paluxy Formation consists predominantly of fine-grained sandstone and clay. On the east side of AFP 4, three distinct lithologic units comprise the upper Paluxy Formation. The uppermost unit is a clayey sandstone, referred to as the "upper sand". The upper sand ranges in thickness from approximately 5 feet to 9 feet. Lithologic data from monitor well P-1 constructed by Radian indicate that the upper sand unit is absent on the west side of Carswell AFB (Radian, 1985). Lithologic and geophysical data from monitor wells P-7U, P-10U, P-20M, P-21U, P-22M, P-23U, P-24EB, P-25EB, and P-26EB indicate that the upper sand unit is absent to the west of AFP 4. Lithologic and geophysical data from monitor wells P-5U, P-8U, P-11U, P-12U, P-13U, P-14U, P-15U, P-16US, P-17US, P-18US, and P-19US indicate that the upper sand unit is present in the vicinity of the East Parking Lot and the area to the east.

Underlying the upper sand unit is a layer of silty claystone ranging in thickness from approximately 5 to 14 feet. The maximum thickness was observed in monitor well P-12UN.

Underlying the silty claystone is a relatively clean, very fine-grained sandstone ranging in thickness from approximately 8 to 40 feet. This unit comprises the upper Paluxy aquifer. The maximum thickness of this sandstone

unit was observed in monitor well P-9M. Beneath the sandstone unit is a clay and shale unit ranging in thickness from approximately 5 to 20 feet. This clay and shale unit appears to be continuous beneath AFP 4.

Beneath the clay and shale unit is a relatively clean, fine- to medium-grained sandstone. This unit comprises the middle Paluxy aquifer.

3.2.2 East Side Hydrogeology

The hydrogeologic units encountered on the east side of AFP 4 are, in descending order: the upper zone, the Walnut aquitard, the upper sand unit, the upper Paluxy aquifer, and the middle Paluxy aquifer.

3.2.2.1 Upper Zone

The upper zone is the uppermost hydrogeologic unit at AFP 4. The upper zone is unconfined and yields small quantities of groundwater to wells. The upper zone comprises the saturated upper zone deposits and the saturated portion of the Goodland Limestone. Based on water level and lithologic data obtained from upper zone monitor wells, the Goodland Limestone beneath much of AFP 4 is sufficiently weathered to store and transmit small quantities of groundwater. Where this occurs, there appears to be hydraulic communication between the upper zone sediments and the Goodland Limestone, suggesting that they act as a single hydrologic unit. The base of the upper zone has therefore been defined as the top of the Walnut Formation (Figure 3). The Walnut Formation has been eroded to form a series of bedrock highs separated by saddles which control the thickness of the upper zone.

The upper zone consists of fine-grained alluvium which generally grades into coarser-grained material with depth. Sand and gravel typically comprise the base of the upper zone (Figure 3). The occurrence of basal sand and gravel deposits is important because these deposits have higher

hydraulic conductivity than the fine-grained material. Areas of greater basal gravel thickness have the potential to rapidly transmit large quantities of contaminated groundwater.

Water level elevations in the upper zone on the east side of AFP 4 range from approximately 595 to 640 feet msl (Figure 9). The highest water level elevations in the upper zone occur beneath the Parts Plant and Assembly Building. The lowest water level elevations in the upper zone occur southeast of AFP 4 beneath Carswell AFB in monitor wells constructed by Radian. Water level elevations in the upper zone are commonly 25 to 60 feet higher than water levels in the underlying Paluxy aquifers. These high water levels and the existence of unsaturated sands in the upper Paluxy Formation indicate that the upper zone is perched throughout much of AFP 4.

Groundwater movement in the upper zone is influenced by the erosional surface of the underlying Walnut Formation, vertical and lateral variations in hydraulic properties, and the proximity to areas of recharge and discharge. A groundwater divide is located in the vicinity of the bedrock high underlying the Assembly Building (Figure 8). In general, groundwater flows to the west and to the east away from the groundwater divide.

Based on April 1989 data, the direction of groundwater flow on the east side of AFP 4 is generally to the east. Northeast of AFP 4, the direction of groundwater flow is generally to the southeast. Southeast of AFP 4, the direction of groundwater flow is generally to the east and southeast.

Hydrologic gradients east of AFP 4 in the vicinity of the Assembly Building and East Parking Lot generally range from about 0.02 to 0.08. In contrast, hydrologic gradients in the vicinity of the Carswell AFB runways are much flatter and generally range from about 0.001 to 0.007.

The saturated thickness of the upper zone was determined based on the water level elevation data collected in April 1989 and on the elevation of the base of the upper zone (Figure 10). The saturated thickness ranges from

zero to approximately 30 feet. Throughout most of AFP 4, the saturated thickness of the upper zone averages approximately 10 feet. Areas of greatest saturated thickness occur east and southeast of the Engineering Office Building. In the vicinity of monitor well HM-106, lithologic data indicate that the Goodland Limestone is unweathered. Monitor well HM-106 is dry, indicating that at this location the Goodland Limestone is not in hydraulic communication with the upper zone.

Two areas were identified on the east side of AFP 4 where upper zone groundwater is absent. These areas were delineated by soil borings that did not encounter groundwater above the Walnut Formation. These areas are located beneath the northern and southern portions of the runways on Carswell AFB (Figure 8).

Recharge to the upper zone is from precipitation and leakage from water supply lines, sanitary sewers, and storm drains. Upper zone groundwater discharges as seeps at various locations along the Meandering Road Creek. Seeps along the creek bank have been observed north of the Radar Range and in the vicinity of monitor wells HM-34, HM-35, and HM-36.

Aquifer tests were not conducted in any upper zone monitor wells constructed during this investigation. Transmissivities were estimated based on aquifer tests conducted in the upper zone on the east side of AFP 4 by Intellus (1986). The results of these aquifer tests indicate that the transmissivity of the upper zone ranges from approximately 5 to 260 gallons per day per foot (gpd/ft). Transmissivities may be higher in areas of greater saturated thickness and basal gravel thickness.

3.2.2.2 Walnut Aquitard

The Walnut Formation beneath AFP 4 is an aquitard between the upper zone and the Paluxy aquifers. The Walnut aquitard retards the vertical movement of groundwater between the upper zone and the Paluxy aquifers. The

principal evidence for this is that the limestone and shale unit of the aquitard is dry and the upper Paluxy Formation is not fully saturated.

The Walnut aquitard beneath the east side of AFP 4 ranges in thickness from approximately zero to 46 feet. The unit is thickest south of the Parts Plant. Lithologic data from soil borings and monitor wells indicate that the Walnut aquitard is very thin and may be absent near Grants Lane in the East Parking Lot. In this area, the potential exists for hydraulic communication between the upper zone and the uppermost Paluxy Formation. The Walnut aquitard dips uniformly to the southeast at approximately 38 feet per mile. These data indicate that the depth to the bottom of the Walnut aquitard increases to the southeast.

3.2.2.3 Paluxy Aquifers

Four separate water-bearing units were identified within the Paluxy Formation on the east side of AFP 4. The upper Paluxy Formation contains the upper sand unit and the upper Paluxy aquifer. The lower Paluxy Formation contains the middle Paluxy aquifer and lower Paluxy aquifer. Monitor wells and exploratory borings drilled on the east side of AFP 4 during this investigation were drilled only to the bottom of the upper Paluxy Formation. For these reasons, the lower Paluxy Formation is not described in this section. A detailed description of lower Paluxy Formation aquifers is provided in Section 4.2.2.2.

3.2.2.3.1 Upper Sand Unit

The upper sand unit has been identified in the southeastern area of AFP 4. Upper sand unit monitor wells P-5US, P-11US, P-12US, P-13US, and P-17US are dry (Figure 11). Upper sand unit monitor wells P-8US, P-9US, P-14US, P-15US, and P-16US have water level elevations above the top of the upper sand unit. These data indicate that the upper sand unit is partially

saturated somewhere between these monitor wells and the dry monitor wells. The upper sand unit is absent to the west of AFP 4 according to lithologic and geophysical data obtained from monitor wells P-7, P-10, P-20U, P-21U, P-22M, P-23U, P-24EB, P-25EB, and P-26EB.

Water level elevations in the upper sand unit range from approximately 590 to 610 feet msl (Figure 11). Based on April 1989 data, water level elevations in the upper zone are approximately 10 to 25 feet higher than upper sand unit water levels, where present. Water level elevations in the upper sand unit at monitor well suites P-15 and P-9 are approximately 25 and 45 feet higher, respectively, than water level elevations in the upper Paluxy aquifer.

Former Paluxy monitor well P-8U was screened in both the upper sand unit and the upper Paluxy monitor well. The water level elevation in monitor well P-8U was higher than other upper Paluxy monitor wells in the area. The water level elevation in the reconstructed P-8U monitor well, P-8US, is higher still than the former P-8U water level. These data indicate that the water levels measured in the former P-8U were influenced by upper sand unit water levels and leakage down the borehole into the upper Paluxy aquifer. Water levels in the newly constructed monitor well P-8UN are comparable to upper Paluxy water levels in the vicinity.

Lithologic and well construction data indicated that former monitor well P-9U was screened in the upper Paluxy aquifer but sand-packed in part of the upper sand unit. The water level elevation in monitor well P-9U was comparable to water levels in other upper Paluxy monitor wells in the area. The water level elevation for the upper sand unit in the reconstructed monitor well P-9US is approximately 45 feet higher than upper Paluxy water levels measured in monitor well P-9UN. Water levels measured in monitor well P-9UN are approximately the same as water levels measured in former monitor well P-9U. These data indicate that even though monitor well P-9U may have been sand-packed in a portion of the upper sand unit, water level elevations were not influenced by the upper sand unit.

The hydraulic properties, direction of groundwater flow, and areas of recharge and discharge of the upper sand unit have not been determined. It appears that the primary source of groundwater in the upper sand unit is leakage from the overlying upper zone in areas where the Walnut Formation is thin or absent. Based on available data, the upper sand unit is saturated in a limited area underlying the East Parking Lot (Figure 11).

A silty claystone unit underlies the upper sand unit. The silty claystone is an aquitard between the upper sand unit and the upper Paluxy aquifer.

3.2.2.3.2 Upper Paluxy Aquifer

The upper Paluxy aquifer underlies the aquitard separating the upper sand unit on the east side of AFP 4. Lithologic and water level data indicate that the upper Paluxy aquifer is partially saturated. The maximum water level elevation in the upper Paluxy aquifer on the east side of AFP 4 is approximately 565 feet msl in monitor well P-15U (Figure 12).

Water level elevation data indicate that the direction of groundwater flow in the upper Paluxy aquifer is generally to the southeast (Figure 12). The principal source of recharge to the upper Paluxy aquifer in the vicinity of AFP 4 is Lake Worth. Vertical seepage from the upper sand unit is a potential source of recharge in the vicinity of the East Parking Lot.

Water level elevations in the upper Paluxy aquifer are typically 25 to 45 feet lower than water level elevations in the upper sand unit (Appendix C). The difference between water level elevations in the upper and middle Paluxy aquifers on the east side of AFP 4 is generally less than 3 feet.

Estimates of transmissivity for the upper Paluxy aquifer generally range from less than 100 gpd/ft at monitor wells P-6U and P-8U to approximately 8,000 gpd/ft at former monitor well P-9U (Hargis + Associates, Inc., 1985). The saturated thickness of the upper Paluxy aquifer is greater at former monitor well P-9U than at other AFP 4 locations and may contribute to the higher transmissivity estimated at that location (Figure 7).

3.2.2.3.3 Middle Paluxy Aquifer

The middle Paluxy aquifer underlies the upper Paluxy aquifer. Water level elevations in the middle Paluxy aquifer range from approximately 594 feet msl near Lake Worth to 560 feet msl at the southeast corner of AFP 4 (Figure 13). Groundwater elevations are generally lower in the middle Paluxy aquifer than in the upper Paluxy aquifer to the northwest of AFP 4. However, groundwater elevations in the upper and middle Paluxy aquifers are similar to the southeast of AFP 4.

Transmissivities were estimated based on aquifer tests conducted in the middle Paluxy aquifer during previous investigations (Hargis + Associates, Inc., 1985). The estimated transmissivity of the middle Paluxy aquifer on the east side of AFP 4 ranges from approximately 8,300 gpd/ft at monitor well P-9M to approximately 23,000 gpd/ft at monitor well P-8M. The variation in transmissivity may reflect facies changes which occur in the middle Paluxy aquifer beneath AFP 4. The middle sand unit of the Paluxy Formation thickens to the southeast and contains coarser, well-sorted material.

Based on April 1989 water level elevation data, the direction of groundwater flow in the middle Paluxy aquifer is to the southeast (Figure 13). Recharge to the middle Paluxy aquifer is primarily from Lake Worth and perhaps leakage from the overlying upper Paluxy aquifer. Discharge from the Paluxy aquifer in the vicinity of AFP 4 is primarily by

pumping of City of White Settlement municipal wells completed in the middle and lower Paluxy aquifers, which are located hydrologically downgradient from AFP 4.

3.2.3 East Side Chemical Quality of Groundwater

This description of the quality of groundwater on the east side of AFP 4 is based on the analytical results of samples collected from monitor wells in April 1989 or the most recent data. Groundwater samples collected from monitor wells constructed during this investigation were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (semi-VOCs), common ions, trace metals, cyanide, total fuel hydrocarbons (TFH), and oil and grease.

3.2.3.1 Upper Zone

Water quality data for all new monitor wells have been summarized (Appendices G through L) In addition, water quality data for monitor wells constructed as part of the Carswell AFB Installation Restoration Program have been evaluated (Radian, 1988).

Chromium, trans-1,2-dichloroethylene (trans-1,2-DCE), and trichloroethylene (TCE) were the most commonly detected contaminants in upper zone groundwater east of AFP 4.

Concentrations of total chromium detected in water samples collected from upper zone monitor wells on the east side at AFP 4 range from 0.015 milligrams per liter (mg/l) to .329 mg/l in monitor wells HM-115 and HM-94, respectively (Figure 14). The highest total chromium concentrations were detected in monitor wells HM-82 and HM-94.

The distribution of total chromium detected in water samples collected from upper zone monitor wells on the east side is controlled by the erosional channel in the Walnut Formation (Figure 14). In the vicinity of the East Parking Lot, the distribution of total chromium in upper zone groundwater is a narrow northeasterly trending feature. In the area east of Grants Lane, the chromium plume divides into two plumes. One plume trends northeast while the other plume trends southeast. The concentrations of total chromium in upper zone groundwater underlying the runway at Carswell AFB has been defined by surrounding monitor wells with no detectable chromium.

The source of chromium contamination appears to be from the south portion of AFP 4. It has been suggested that two former chrome pits were located at the south portion of AFP 4 (CH2M Hill, 1984). These chrome pits may be the source of chromium detected in water samples collected from upper zone monitor wells on the east side of AFP 4.

Total chromium was also detected in water samples collected and analyzed by Radian Corporation on Carswell AFB southeast of the runways (Figure 14). The southern extent of total chromium has not been defined in this area. The distribution and concentration of total chromium detected in water samples collected from these wells indicate a different source for the chromium in this area.

Concentrations of trans-1,2-DCE detected in water samples collected from upper zone monitor wells on the east side of AFP 4 range from 1 microgram per liter (ug/l) to 6,700 ug/l in monitor wells HM-68 and HM-94, (Figure 15). Trans-1,2-DCE was not detected in any water samples collected and analyzed from the Radian monitor wells at Carswell AFB. However, detection limits for trans-1,2-DCE were as high as 200 ug/l in water samples collected from these wells. Trans-1,2-DCE may be present in some of these monitor wells at concentrations less than these detection limits.

The distribution of trans-1,2-DCE detected in water samples collected from upper zone monitor wells on the east side of AFP 4 is similar to the distribution of total chromium, but much more widespread. The predominant trans-1,2-DCE plume trends northeast in the vicinity of the East Parking Lot and southeast in the area east of Grants Lane. The northern extent of groundwater contaminated with trans-1,2-DCE above the MCL has not been defined south of AFP 4 and southeast of the runways at Carswell AFB (Figure 15).

The source of trans-1,2-DCE detected in upper zone groundwater on the east side appears to originate from the southern end of the Assembly Building. The wastewater collection basins are also located in this area (Figure 15).

Concentrations of TCE detected in water samples collected from upper zone monitor wells on the east side of AFP 4 range from 1 ug/l to 25,000 ug/l in monitor wells HM-73 and HM-94, respectively (Figure 16). The highest concentrations of TCE were generally detected in water samples collected from monitor wells located in the narrow subsurface channel beneath the East Parking Lot. Concentrations of TCE greater than 10,000 ug/l were detected in groundwater samples collected from monitor wells F-218, HM-82, and HM-94.

TCE was also detected in groundwater samples collected from the monitor wells on Carswell AFB constructed by Radian. TCE was detected in water samples collected from Radian monitor wells constructed hydrologically upgradient of Carswell AFB disposal sites. The highest TCE concentrations were detected in water samples collected from monitor well 10B at 6,400 ug/l. Water samples collected from monitor wells located hydrologically upgradient of monitor well 10B contained TCE at concentrations ranging from 1,100 ug/l to 3,500 ug/l. The distribution of TCE and the direction of groundwater flow indicate that the TCE detected in these upgradient monitor wells may have originated from AFP 4. The higher

TCE concentrations detected in monitor well 10B indicate that another source of TCE may be present in the area southwest of the runways on Carswell AFB.

The extent of TCE contamination east of the runways at Carswell AFB has not been defined. The eastern extent of TCE contamination underlying Carswell AFB is not known.

The distribution of TCE detected in upper zone groundwater on the east side of AFP 4 is similar to the distribution of trans-1,2-DCE. The concentrations of TCE detected, however, are greater than the concentrations of trans-1,2-DCE. The southeasterly extent of TCE appears to be greater than that of trans-1,2-DCE, because the Radian monitor wells located southeast of the runways contained no detectable trans-1,2-DCE.

The source of TCE detected in upper zone groundwater may be the southern portion of the Main Assembly Building and Parts Plant. The wastewater collection basins are also located in this area.

Trans-1,2-DCE and vinyl chloride are degradation products of TCE. The ratio of TCE concentration to trans-1,2-DCE concentration can be used to compare the relative age of contaminants. The ratio of TCE to trans-1,2-DCE ranges from approximately 2 to 20 for water samples collected from wells located on the east side of AFP 4. The ratio of TCE to trans-1,2-DCE in water samples collected from wells located on the west side of AFP 4 ranges from approximately .1 to .01. Vinyl chloride has not been detected on the east side of AFP 4 except in three monitor wells constructed by Radian on Carswell AFB. Conversely, vinyl chloride is a common constituent detected in water samples collected from monitor wells located on the west side of AFP 4. These data indicate that the TCE and trans-1,2-DCE detected on the east side of AFP 4 are probably younger and probably originate from a different source than these same compounds detected in groundwater on the west side of AFP 4.

These data also indicate that the TCE concentrations detected in the Carswell AFB wells constructed by Radian probably originate from a different source than the TCE migrating from AFP 4. The concentrations of TCE detected in water samples analyzed by the mobile gas chromatograph during the exploratory soil boring program generally agree with concentrations detected in water samples collected from monitor wells constructed later.

Several other VOCs were detected in samples collected from upper zone monitor wells (Figure 17). Tetrachloroethylene (PCE) was detected in water samples collected from six upper zone monitor wells on the east side of AFP 4. All of these monitor wells are located in the northern portion of AFP 4.

Benzene and ethylbenzene were detected in water samples collected from monitor well HM-56 at concentrations of 180 ug/l and 5 ug/l, respectively. Monitor well HM-56 is located near underground tank site No. 7. The detection of these compounds may be related to operations associated with the underground diesel tank.

Benzene was detected in only one water sample collected from monitor well HM-126. Benzene was not detected in any other upper zone monitor wells east of Grants Lane.

In addition to TCE and chromium; PCE, 1,4-dichlorobenzene, toluene, and vinyl chloride were detected in water samples collected from the monitor wells constructed by Radian on Carswell AFB. These contaminants were not detected in samples collected from any upper zone monitor wells constructed by H+A in the area east of Grants Lane. These data indicate that the contaminants detected in these Radian monitor wells originate from a different source than the contaminants migrating from AFP 4.

3.2.3.2 Paluxy Aquifers

Groundwater samples were collected and analyzed from monitor wells constructed in the upper sand unit, upper Paluxy aquifer, and middle Paluxy aquifer on the east side of AFP 4.

3.2.3.2.1 Upper Sand Unit

Trans-1,2-DCE and TCE were the only VOCs detected in water samples collected from upper sand unit monitor wells (Figure 18).

Concentrations of trans-1,2-DCE detected in water samples collected from upper sand unit monitor wells P-15US and P-16US range from 2 ug/l to 330 ug/l, respectively. Concentrations of TCE detected in water samples collected from monitor wells P-15US and P-8US range from 7 ug/l to 1,700 ug/l, respectively.

The extent of groundwater contamination in the upper sand unit is partially defined by the extent of saturation. The western and northern extent of saturation in the upper sand unit has not been defined (Figure 11). Water level data for monitor wells P-5US, P-11US, P-12US, P-13US, P-17US, and P-19US indicate that the upper sand unit is not saturated at these locations.

Results of analyses of water samples collected from monitor wells P-8US, P-9US, P-14US, P-15US, and P-16US indicate that the upper sand unit is at least partially saturated and contaminated with TCE and trans-1,2-DCE. Monitor well P-18US is the only upper sand unit monitor well that is partially saturated and does not contain VOCs.

The ratio of concentrations of TCE to trans-1,2-DCE detected in water samples collected from the upper sand unit range from approximately 3 to 10. The ratio of TCE to trans-1,2-DCE ranges from approximately 2 to 20 for

water samples collected from overlying upper zone monitor wells. These data indicate that the contaminants detected in the upper sand unit are from a source similar to the source of the contaminants detected in the overlying upper zone groundwater. The source of groundwater to the upper sand unit is suspected to be from areas where the Walnut aquitard is thin or absent. Lithologic data indicate that one of these areas occurs in the vicinity of monitor wells P-14US and P-16US along Grants Lane. Water level and water quality data indicate that another source of upper zone groundwater to the upper sand unit may occur near monitor well P-9US. The Walnut aquitard is approximately 30 feet thick at monitor well P-9US. These data indicate that the pathway for recharge of groundwater to the upper sand unit may be related to historical industrial operations or facility construction activities at AFP 4.

3.2.3.2.2 Upper Paluxy Aquifer

Acetone, ethylbenzene, trans-1,2-DCE, TCE, toluene, and xylene isomers were detected in groundwater samples collected from upper Paluxy aquifer monitor wells on the east side of AFP 4 (Figure 19).

Acetone and toluene were detected only in water samples collected from monitor wells P-12UN and P-14U. Acetone was detected in water samples collected from monitor wells P-12UN and P-14U at concentrations of 30 ug/l and 400 ug/l, respectively. Toluene was detected in water samples collected from monitor well P-14U at concentrations of 7 ug/l and 10 ug/l, respectively. Ethylbenzene and xylene isomers were also detected in water samples collected from monitor wells P-12UN and P-14U at concentrations of 10 ug/l and 70 ug/l, respectively. Monitor well P-14U is frequently dry or produces small quantities of water. Because of this, these monitor wells have not been adequately developed. Acetone and other fuel-related compounds are not commonly detected in water samples collected from upper Paluxy aquifer monitor wells. These data indicate that the occurrence of

acetone and fuel-related hydrocarbons may be a remnant from monitor well construction.

TCE was detected only in a water sample collected from monitor well P-8UN in April 1989 at a concentration of 9 ug/l. TCE and trans-1,2-DCE were detected at higher concentrations in water samples collected from the original monitor well P-8U. TCE and trans-1,2-DCE have been detected in previous water samples collected from monitor well P-8UN. These compounds have also been detected in the overlying upper sand unit. The source of TCE detected in water samples collected from monitor well P-8UN may be related to the original construction of monitor well P-8U. The source may also be seepage from the upper sand unit to the upper Paluxy aquifer. The source of acetone and fuel-related hydrocarbons detected in monitor wells P-12UN and P-14U may be related to drilling operations since these wells may not be completely developed due to the low yield of the wells.

The extent of TCE contamination in the upper Paluxy aquifer on the east side of AFP 4 has been defined. The source of trans-1,2-DCE and TCE detected in water samples collected from monitor well P-8UN may be seepage from the overlying upper sand unit or may be related to the original construction of monitor well P-8U.

3.2.3.2.3 Middle Paluxy Aquifer

No monitor wells were constructed in the middle Paluxy aquifer on the east side of AFP 4 during this investigation. However, this section provides a brief description of water quality in the nine middle Paluxy monitor wells located on the east side of AFP 4.

TCE was the only organic compound detected in the middle Paluxy aquifer on the east side of AFP 4 (Figure 19). TCE was detected at 2 ug/l in only one water sample collected from monitor well P-11M in April 1989. This was the first time that TCE was detected in water samples collected from monitor

well P-11M. TCE was not detected in any other middle Paluxy aquifer monitor wells on the east side of AFP 4.

Monitor well P-11M is downwind from AFP 4. TCE has been detected in air samples collected downwind from AFP 4. The low concentration of TCE detected in the one water sample collected from monitor well P-11M may have been introduced from the ambient air during sample collection.

VOCs were not detected in any other middle Paluxy aquifer monitor wells on the east side AFP 4.

4.0 WEST SIDE INVESTIGATION

During the period from January 1987 to April 1989, three exploratory borings were drilled and seven monitor wells were constructed on the west side of AFP 4 (Table 2; Figure 2; Appendices E and F).

4.1 WEST SIDE FIELD OPERATIONS

Interim remedial investigations on the west side of AFP 4 have concentrated on the Paluxy Formation. All Paluxy Formation monitor wells were drilled using mud rotary methods.

4.1.1 West Side Paluxy Field Operations

H+A has drilled three exploratory borings and has constructed three upper Paluxy monitor wells and four middle Paluxy monitor wells on the west side of AFP 4 since January 1987.

Middle Paluxy aquifer monitor well P-22M was drilled and constructed in October 1987. This monitor well is located adjacent to monitor well P-22U drilled by Radian (1987).

Three exploratory borings have been drilled and six Paluxy aquifer monitor wells have been constructed from November 1988 to January 1989. The six monitor wells consisted of three pairs of upper and middle Paluxy monitor wells drilled in three separate locations. One exploratory boring was drilled first at each location. Gamma ray, induction resistivity, short normal, and spontaneous potential geophysical logs were performed in each exploratory boring. Geophysical logs were used in conjunction with lithologic logs to determine the depth of steel casing and screened intervals. Exploratory borings were drilled to the base of the Paluxy Formation so that all hydrogeologic units could be delineated. Because of

the difficulty and uncertainty of sealing off the lower portion of the borings, the exploratory borings were not converted into Paluxy monitor wells. Separate boreholes were constructed for the monitor wells to eliminate the potential for cross-contamination between aquifers and to minimize the possibility of grout contamination.

Monitor wells P-24U and P-24M were located north of Landfill No. 3. In this area historical water level elevations in the upper Paluxy aquifer are higher than the Lake Worth Dam spillway. Because Lake Worth is the major source of groundwater recharge for the upper Paluxy aquifer, the higher groundwater levels observed in the vicinity of the monitor well P-24 suite indicate that a groundwater mound caused by hydraulic communication between Meandering Road Creek and the upper Paluxy Formation may exist. This location was selected to provide additional information on the potential source of the mounding and to monitor Paluxy aquifer groundwater quality in the vicinity of Landfill No. 3.

Monitor wells P-25U and P-25M are located downgradient of Landfill Nos. 1 and 3. This location was selected to monitor and delineate groundwater quality in the upper and middle Paluxy aquifers downgradient of these landfills.

Monitor wells P-26U and P-26M are located on the south side of AFP 4 near the former Railroad Gate. This location was selected to replace abandoned Paluxy monitor well P-1.

4.2 RESULTS OF WEST SIDE INTERIM REMEDIAL INVESTIGATIONS

Results of the west side interim remedial investigations comprise lithologic, hydrogeologic, geophysical, and water quality data collected during the field operations conducted on the west side of AFP 4.

4.2.1 West Side Local Geology

This description of the local geology on the west side of AFP 4 concentrates on the Walnut Formation and Paluxy Formation. A more detailed description of the upper zone and Goodland formation can be found in Section 3.2.1 of this report and in the H+A Phase II report (Hargis + Associates, Inc., 1985).

4.2.1.1 Walnut Formation

The Walnut Formation crops out along Meandering Road Creek (Figure 7). Based on the surface topography elevations and lithologic data for Paluxy monitor well suites P-10 and P-24, it appears that the northernmost portion of Meandering Road Creek is incised entirely through the Walnut Formation. Where this occurs, stream deposits directly overlie the Paluxy Formation.

4.2.1.2 Paluxy Formation

The Paluxy Formation underlies the Walnut Formation (Figures 7 and 8). The Paluxy Formation consists of two predominantly sand portions separated by clay and shale. These portions are referred to as the upper and lower Paluxy Formations. The clay and shale unit thickness ranges from 5 to 60 feet. This unit was encountered throughout AFP 4.

The upper Paluxy Formation is overlain unconformably by the Walnut Formation below most of AFP 4. The upper Paluxy Formation crops out along Lake Worth north of AFP 4. Recent alluvium may be deposited directly on the Paluxy Formation on the west side of AFP 4 in Meandering Road Creek. The upper Paluxy Formation consists predominantly of fine-grained sandstone and clay. On the west side of AFP 4, two distinct lithologic units comprise the upper Paluxy. The uppermost unit is a very fine-grained sandstone.

Underlying the sandstone is a layer of dense, silty claystone. Unlike the east side of AFP 4, the upper sand unit is absent on the west side of AFP 4.

The lower Paluxy Formation is thicker and generally coarser-grained than the upper Paluxy Formation. The lower Paluxy Formation comprises interbedded sand, clay, and shale. At some locations, a clay layer separates the sand in the lower Paluxy Formation. Where this occurs, the two sand units are referred to as the middle and lower Paluxy Formations. The thickness of the Paluxy Formation, as noted in AFP 4 monitor well logs, ranges from 133 to 175 feet. Inspection of outcrops and lithologic logs of monitor wells indicates that the Paluxy Formation consists of fine- to medium-grained white quartz sand interbedded with gray to blue-green silty clay and shale and poorly cemented friable sandstone. The sand is moderately- to well-sorted, subangular to subrounded, and cross-bedded. Thin beds of lignite and pyrite nodules have been encountered during drilling.

Analysis of lithologic data obtained during drilling indicates that facies changes occur within the Paluxy Formation beneath AFP 4. In general, the sand units within the Paluxy Formation are more silty and clayey in wells drilled along the western boundary of AFP 4 than in wells drilled along the eastern boundary of AFP 4. The cleanest, best-sorted sand was encountered in wells drilled east of the Assembly Building. The regional dip of the Paluxy Formation is to the southeast.

4.2.1.3 Glen Rose Formation

The Glen Rose Formation member of the Trinity group does not crop out in the vicinity of AFP 4. The Glen Rose Formation is overlain conformably by the Paluxy Formation. Exploratory borings P-24EB, P-25EB, and P-26EB were drilled to the top of the Glen Rose Formation. The upper boundary of the Glen Rose Formation is defined as the first occurrence of a limestone

unit below the Walnut Formation (Leggat, 1957). The top of the Glen Rose Formation was encountered at depths ranging from 213 to 227 feet bls. Thickness of the formation is reported to be about 250 feet in the area of Lake Worth. The formation consists of limestone with some sand, clay, sandy clay, and anhydrite.

4.2.2 West Side Hydrogeology

The hydrogeologic units encountered on the west side of AFP 4 are, in descending order: the upper zone, the Walnut aquitard, the upper Paluxy aquifer, and middle Paluxy aquifer. Interim remedial investigations on the west side of AFP 4 have focused on the Walnut aquitard, the upper Paluxy aquifer, and the middle Paluxy aquifer. Hydrogeologic conditions in the upper zone on the west side are described in Section 3.2.2.1 and the H+A Phase II report (Hargis + Associates, Inc., 1985).

4.2.2.1 Walnut Aquitard

The Walnut Formation in the vicinity of AFP 4 is an aquitard between the upper zone and the upper Paluxy aquifer. The Walnut aquitard retards the vertical movement of groundwater between the upper zone and the upper Paluxy aquifer.

On the west side of AFP 4 the Walnut Aquitard ranges in thickness from zero to approximately 30 feet. The unit is thickest in the vicinity of Landfill Nos. 1 and 3. Lithologic and geologic data indicate that the Walnut aquitard may be absent in the northernmost portion of Meandering Road Creek. In this area, the potential exists for hydraulic communication between water in Meandering Road Creek and the upper Paluxy aquifer.

4.2.2.2 Paluxy Aquifers

Three water-bearing units have been identified in the Paluxy Formation on the west side of AFP 4. These units are, in descending order: the upper Paluxy aquifer, the middle Paluxy aquifer. and lower Paluxy aquifer. The upper sand unit is not present on the west side of AFP 4. The aquitard that separates the middle and lower Paluxy aquifers is not present everywhere beneath AFP 4. Where the middle and lower Paluxy aquifers are merged, monitor wells completed in the upper portion of the merged interval are referred to as middle Paluxy aquifer monitor wells.

Monitor wells P-1 through P-4 were originally designed and constructed to obtain lithologic data and water quality data from the entire thickness of the Paluxy Formation. Monitor wells P-1, P-2, and P-4 were later abandoned because they did not represent a discrete interval within the Paluxy aquifers. Monitor well P-3 is located hydrologically upgradient of AFP 4 and provides water level control and background water quality data for the Paluxy aquifers. Analysis of data obtained from aquifer tests at monitor wells P-1 through P-4 indicates that the composite transmissivity of the Paluxy aquifers ranges from about 6,000 gpd/ft in the vicinity of monitor well P-4 to about 24,000 gpd/ft in the vicinity of monitor well P-1. The range of transmissivities in the Paluxy aquifers reflects local variations in lithology and saturated thickness, as well as facies changes which occur in the middle Paluxy aquifer beneath AFP 4.

4.2.2.2.1 Upper Paluxy Aquifer

The upper Paluxy aquifer underlies the Walnut Formation on the west side of AFP 4. Lithologic and water level data indicate that the upper Paluxy aquifer is partially saturated on the west side of AFP 4 and is therefore unconfined.

Water level elevation data indicate that the direction of groundwater flow in the upper Paluxy aquifer is generally to the east and southeast (Figure 12). The principal source of recharge to the upper Paluxy aquifer in the vicinity of AFP 4 is Lake Worth. Lithologic and hydrogeologic data indicate that Meandering Road Creek may contribute some recharge to the upper Paluxy aquifer due to the absence of the Walnut aquitard (Figure 7). The direction of groundwater flow beneath the westernmost portion of AFP 4 is more easterly due to the proximity of these potential recharge sources.

Water level elevations in the upper Paluxy aquifer are generally 40 to 60 feet lower than upper sand water level elevations. The difference between water level elevations in the upper and middle Paluxy aquifers on the west side of AFP 4 is generally less than 5 feet. West of Meandering Road Creek at monitor well suite P-10, the water level elevation in the upper Paluxy aquifer is approximately 16 feet higher than in the middle Paluxy aquifer. The water level elevation at this location may reflect its close proximity to an area of recharge from Meandering Road Creek. It appears that Meandering Road Creek may be a source of recharge to the upper Paluxy in this area because the water levels in monitor well P-10U are higher than the elevation of the Lake Worth spillway.

The transmissivity of the upper Paluxy aquifer is estimated to range from less than 100 gpd/ft at monitor well P-6U to about 8,000 gpd/ft at monitor well P-9U (Hargis + Associates, Inc. 1985).

4.2.2.2.2 Middle Paluxy Aquifer

The middle Paluxy aquifer underlies the upper Paluxy aquifer. Water level elevations in the middle Paluxy aquifer on the west side of AFP 4 range from approximately 590 feet msl near Lake Worth to 560 feet msl on the southern border of AFP 4 (Figure 13). Groundwater elevations are generally lower in the middle Paluxy aquifer than in the upper Paluxy aquifer.

Transmissivities were estimated based on aquifer tests conducted in the middle Paluxy aquifer during previous investigations (Hargis + Associates, Inc., 1985). The estimated transmissivity of the middle Paluxy aquifer on the west side of AFP 4 ranges from approximately 4,000 gpd/ft at monitor wells P-7 and P-10 to approximately 24,000 gpd/ft at former Paluxy monitor well P-1. The variation in transmissivity may reflect facies changes which occur in the middle Paluxy aquifer beneath AFP 4. The middle sand unit of the Paluxy Formation thickens to the southeast and contains coarse, well-sorted material.

Based on April 1989 water level elevation data, the direction of groundwater flow in the middle Paluxy aquifer is to the southeast (Figure 13). Recharge to the middle Paluxy aquifer is primarily from Lake Worth and may also include some leakage from the overlying upper Paluxy aquifer. Discharge from the Paluxy aquifer in the vicinity of AFP 4 is primarily from pumping of City of White Settlement municipal wells completed in the middle and lower Paluxy aquifers which are located hydrologically downgradient from AFP 4.

4.2.3 West Side Chemical Quality of Groundwater

This description of Paluxy aquifer groundwater quality on the west side of AFP 4 is based on the analytical results of samples collected from upper and middle Paluxy aquifer monitor wells in April 1989 or the most recent data. Groundwater samples collected from monitor wells constructed during this investigation have been analyzed for VOCs, semi-VOCs, common ions, trace metals, cyanide, TFH, and oil and grease. VOCs are the only contaminants detected in groundwater samples collected from Paluxy aquifer monitor wells.

4.2.3.1 Upper Paluxy Aquifer Groundwater Quality

VOCs detected in water samples collected from upper Paluxy aquifer monitor wells are acetone, methylene chloride, methyl ethyl ketone, trans-1,2-DCE, toluene, TCE, and vinyl chloride (Figure 19). Trans-1,2-DCE, TCE, and vinyl chloride are the most commonly detected VOCs. In general, the highest concentrations of VOCs were detected in groundwater samples collected from monitor well P-22U.

Methyl ethyl ketone was detected in one groundwater sample collected from monitor well P-5UN. This compounds was not detected in groundwater samples previously collected from any other upper Paluxy monitor wells. These data indicate that methyl ethyl ketone may have been a laboratory contaminant.

Trans-1,2-DCE was detected in water samples collected from monitor wells P-5UN and P-22U at concentrations of 23 and 230 ug/l, respectively. TCE was detected only in water samples collected from monitor well P-22U at 78 ug/l. Vinyl chloride was detected only in water samples collected from monitor wells P-5UN and P-22U at concentrations of 22 ug/l and 44 ug/l, respectively.

Trans-1,2-DCE and vinyl chloride are breakdown products of TCE. TCE was probably the dominant solvent used in manufacturing operations at AFP 4. Trans-1,2-DCE and vinyl chloride are detected more often than TCE. These data indicate that the compounds detected are probably from an older source than the compounds detected in upper Paluxy groundwater on the east side of AFP 4. The extent of upper Paluxy aquifer contamination is approximately defined. However, additional assessment may be required to evaluate remedial alternatives. The TCE/trans-1,2-DCE ratios are similar to those in the overlying upper zone groundwater. These data indicate that the contaminants in the upper Paluxy aquifer have migrated from the upper zone.

4.2.3.2 Middle Paluxy Aquifer Groundwater Quality

Methylene chloride, methyl ethyl ketone, and trans-1,2-DCE were detected in water samples collected from middle Paluxy aquifer monitor wells (Figure 19). Trans-1,2-DCE is the most commonly detected VOC. In general, the highest concentrations of VOCs were detected in water samples collected from monitor well P-6M.

Methylene chloride was detected in water samples collected from monitor wells P-5M and P-6M at concentrations of 6 ug/l and 4 ug/l, respectively. Methyl ethyl ketone was detected in only one water sample collected from monitor well P-6M at 10 ug/l. These compounds were not detected in groundwater samples previously collected from Paluxy monitor wells. Methylene chloride and methyl ethyl ketone may be laboratory contaminants.

Concentrations of trans-1,2-DCE detected in water samples collected from middle Paluxy monitor wells P-22M and P-6M range from 2 ug/l to 12 ug/l, respectively.

No VOCs were detected in water samples collected from middle Paluxy aquifer monitor wells located on the southwestern portion of AFP 4.

The extent of middle Paluxy aquifer contamination is approximately defined. Additional assessment may be required to evaluate remedial alternatives. Based on the lower concentrations detected, the source of contaminants in the middle Paluxy aquifer appears to be vertical leakage from the overlying upper Paluxy aquifer.

5.0 CONCLUSIONS

Based on analysis of geologic, hydrologic, and water quality data obtained during the interim remedial investigations at AFP 4, the following are concluded:

5.1 EAST SIDE

- Basal sand and gravel deposits in the upper zone are potential pathways for contaminant migration.

- In general, groundwater in the upper zone on the east side of the Main Assembly Building flows to the east.

- Chromium, trans-1,2-DCE, and TCE are the most commonly detected contaminants in upper zone groundwater on the east side of AFP 4.

- The distribution of chromium, trans-1,2-DCE, and TCE in the upper zone is influenced by the direction of groundwater flow and the erosional channel in the Walnut Formation.

- The extent of total chromium contamination in the upper zone has been defined in the area east of Grants Lane. The extent of trans-1,2-DCE and TCE has not been defined in the area east of Grants Lane.

- The source of contaminants detected in upper zone groundwater has not been determined but appears to originate from the southern portion of the Assembly Building and Parts Plant. Former Chrome Pit Nos. 1 and 2 and the wastewater collection basins may be the source of these contaminants.

. . Contaminants detected in the monitor wells constructed on Carswell AFB by Radian originate from a different source than the contaminants migrating from AFP 4.

. . The Walnut Formation is thin and may be absent below the East Parking Lot along Grants Lane. The potential exists for hydraulic communication between the upper zone and the uppermost Paluxy Formation in this area.

. . The primary source of recharge to the Paluxy upper sand unit appears to be vertical leakage from the overlying upper zone in the vicinity of Grants Lane where the Walnut Formation is thin or absent. Another source of recharge to the upper sand unit may exist in the vicinity of the Main Assembly Building near monitor well P-9US.

. . Trans-1,2-DCE and TCE were the only contaminants detected in water samples collected from the Paluxy upper sand unit. The concentrations of these compounds are generally lower than the concentrations in the upper zone.

. . The upper Paluxy aquifer is unconfined. The direction of groundwater flow in the upper Paluxy aquifer is generally to the southeast.

. . Lake Worth is the principal source of recharge to the upper Paluxy aquifer in the vicinity of AFP 4. Vertical seepage from the upper sand unit is a potential source of recharge to the upper Paluxy aquifer in the vicinity of the East Parking Lot.

. . The extent of TCE contamination in the upper Paluxy aquifer on the east side of AFP 4 has been defined. The source of TCE detected in the upper Paluxy aquifer may be leakage from the upper sand unit.

5.2 WEST SIDE

- The Walnut Formation is an aquitard between the upper zone and the upper Paluxy aquifer.

- The potential exists for hydraulic communication between surface water in Meandering Road Creek and the upper Paluxy aquifer.

- The Paluxy upper sand unit is absent on the west side of AFP 4.

- The upper Paluxy aquifer is unconfined on the west side of AFP 4. The direction of groundwater flow in the upper Paluxy aquifer is east and southeast.

- Lake Worth is the principal source of recharge to the upper Paluxy aquifer. Water level data indicate that Meandering Road Creek contributes some recharge to the upper Paluxy aquifer.

- The concentrations of contaminants detected in the upper Paluxy aquifer are generally less than those detected in the upper zone. Trans-1,2-DCE, TCE, and vinyl chloride are the most commonly detected VOCs in upper Paluxy aquifer groundwater.

- The extent of upper Paluxy aquifer contamination is approximately defined.

- Contaminants detected in water samples collected from the upper Paluxy aquifer on the west side of AFP 4 appear to have migrated from the overlying upper zone.

- The direction of groundwater flow in the middle Paluxy aquifer is to the southeast. Recharge to the middle Paluxy aquifer is from Lake Worth and leakage from the overlying upper Paluxy aquifer.

- The concentrations of contaminants detected in the middle Paluxy aquifer are generally less than those detected in the upper Paluxy aquifer. Trans-1,2-DCE was the most commonly detected VOC in middle Paluxy aquifer water samples.

- The approximate extent of middle Paluxy aquifer contamination has been defined.

- The source of contaminants in the middle Paluxy aquifer appears to be vertical leakage from the overlying upper Paluxy aquifer.

6.0 RECOMMENDATIONS

Results of interim remedial investigations indicate that additional data are required to evaluate remedial alternatives at AFP 4.

6.1 EAST SIDE

Based on the results of interim remedial investigations conducted during this study, the following additional investigations are recommended for the east side of AFP 4 (Figure 20):

- Conduct 10 aquifer tests in upper zone monitor wells to collect the data required to estimate upper zone hydrologic parameters. Upper zone hydrologic parameters will be required to evaluate remedial alternatives, estimate flow volumes and to characterize contaminant pathways and receptors. The monitor wells selected should be a representative distribution of upper zone hydrologeologic conditions.

- Drill, construct, and sample 12 upper zone monitor wells in the southern portion of AFP 4, on the east side of AFP 4, and in the area east of Grants Lane to further define the extent of contamination in upper zone groundwater. These monitor wells should be sampled three times at one-month intervals for VOCs and chromium.

- Sample all Carswell AFB upper zone monitor wells constructed by Radian in the area southeast of the runways once for VOCs concurrently with all other monitor wells. The collection of this data will facilitate the development of updated plume maps. This information is necessary to determine the extent of contamination, the total mass of contaminants, and to further delineate potential source areas.

. . Conduct five aquifer tests in upper sand unit monitor wells to collect the data required to estimate upper sand unit hydrologic parameters. Upper sand unit hydrologic parameters will be required to evaluate remedial alternatives, estimate flow volumes and to characterize contaminant pathways and receptors.

. . Drill and geophysically log 12 exploratory borings to the base of the upper Paluxy Formation. Geophysical logs will aid in delineating where the upper sand unit is present.

. . Based on the results of geophysical logs, drill, construct, and sample nine upper sand unit monitor wells to further define the extent of contamination in the upper sand unit. These monitor wells will also aid in determining the direction of groundwater flow and potential source areas of recharge to the upper sand unit.

. . Conduct three aquifer tests in middle Paluxy aquifer monitor wells P-11M, P-12M, and P-13M along the southern boundary of AFP 4 to collect the data required to estimate middle Paluxy aquifer parameters. Middle Paluxy aquifer parameters will be required to evaluate remedial alternatives, estimate flow volumes and to characterize contaminant pathways and receptors. Hydrologic response will be monitored in adjacent upper Paluxy aquifer monitor wells to determine if there is hydraulic communication between the upper and middle Paluxy aquifers.

. . Evaluate additional water quality data for monitor well P-11M to determine if the concentration of TCE detected is due to groundwater contamination or airborne contaminants.

6.2 WEST SIDE

Based on the results of interim remedial investigations conducted during this study, the following additional investigations are recommended for the west wide of AFP 4 (Figure 20):

- Drill nine borings spaced 200 feet apart in the Meandering Road Creek bed between ST5-Outfall and monitor well P-24M to delineate areas where the Walnut Formation is thin or absent. Soil samples should be screened with an organic vapor analyzer to determine if contaminants are present. A minimum of one soil sample per boring should be analyzed for VOCs and oil and grease. These data will identify areas where surface water in the creek may be recharging the upper Paluxy aquifer.

- Drill and geophysically log three exploratory borings to the base of the Paluxy Formation. Geophysical and lithologic logs will aid in defining monitor well construction specifications.

- Drill, construct, and sample three suites of paired upper and middle Paluxy aquifer monitor wells in the West Parking Lot to further define the extent of contamination in the middle Paluxy aquifer. These monitor wells should be sampled three times at one-month intervals for VOCs.

- Conduct aquifer tests in upper and middle Paluxy aquifer monitor wells P-22U, P-22M, P-25U, P-25M and two of the proposed new Paluxy monitor wells on the west side of AFP 4 to collect the data required to estimate Paluxy aquifer parameters. This information is required to evaluate remedial alternatives, estimate flow volumes, and to characterize contaminant pathways and receptors. Hydrologic response will be monitored in adjacent Paluxy aquifer monitor wells to determine if there is hydraulic communication between the upper and middle Paluxy aquifers at each location.

7.0 REFERENCES CITED

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TABLE 1

MONITOR WELL CONSTRUCTION DATA
UPPER ZONE

WELL IDENTIFIER	DATE DRILLED	MEASURING POINT ELEVATION	.....BOREHOLE..... DIAMETER (inches)	DEPTH (ft bls)	.....PVC CASING..... INSIDE DIAMETER (inches)	DEPTH (ft bls)	SCREENED SEAL (ft bls)	FILTER PACK INTERVAL (ft bls)	BENTONITE SEAL (ft bls)	CEMENT SEAL (ft bls)
HM-87	09-19-87	647.17	7-7/8	42.0	4	40.0	30.0-40.0	20.5-40.5	16.0-20.5	0.0-5.0
HM-88	09-22-87	650.58	7-7/8	47.0	4	45.8	35.8-45.8	17.0-45.8	13.6-17.0	0.0-13.6
HM-89	09-21-87	649.66	7-7/8	52.0	4	50	30.0-50.0	21.0-50.0	18.0-21.0	0.0-18.0
HM-90	09-26-87	646.88	7-7/8	59.5	4	59.0	49.5-58.0	26.0-59.0	23.0-26.0	0.0-10.0
HM-91	10-02-87	645.79	7-7/8	62.0	4	60.0	39.5-59.5	32.0-62.0	27.0-32.0	0.0-2.0
HM-92	10-04-87	649.59	7-7/8	61.8	4	61.0	40.0-60.0	31.0-60.0	27.0-31.0	0.0-15.0
HM-93	10.05-87	649.21	7-7/8	37.0	4	37.0	27.0-37.0	21.0-37.0	17.0-21.0	0.0-17.0
HM-94	10-10-87	646.56	7-7/8	59.0	4	59.0	29.0-59.0	24.5-59.0	21.0-24.5	0.0-21.0
HM-95	10-23-87	641.07	6-1/4	45.0	4	44.7	34.7-44.7	12.0-45.0	9.0-12.0	0.0-9.0
HM-96	10-24-87	642.04	6-1/4	54.0	4	54.0	24.0-54.0	22.0-54.0	19.0-22.0	0.0-19.0
HM-97	10-26-87	641.73	6-1/4	80.0	4	50.0	30.0-50.0	28.0-50.0	25.0-28.0	0.0-25.0
HM-98	03-23-88	640.52	6-3/4	31.5	4	30.0	20.0-30.0	14.5-31.5	11.0-14.5	0.0-16.0
HM-99	03-24-88	642.01	10-1/4	44.0	4	43.0	23.0-43.0	23.5-44.0	20.5-23.5	0.0-20.5
HM-110	03-25-88	637.38	6-3/4	37.0	4	36.5	26.5-36.5	21.5-37.0	18.5-21.5	0.0-18.5
HM-111	03-25-88	636.30	6-3/4	53.0	4	49.0	29.0-49.0	22.0-49.0	16.0-22.0	0.0-4.0
HM-112	03-25-88	638.15	10-1/4	50.5	4	50.5	20.0-50.0	18.0-50.5	14.0-18.0	0.0-4.0
HM-113	03-26-88	639.37	10-1/4	49.0	4	48.0	28.0-48.0	27.0-49.0	22.0-27.0	0.0-4.0
HM-114	01-31-89	627.84	10-3/4	36.5	4	34.5	14.5-34.5	12.0-34.5	10.0-12.0	0.0-4.0
HM-115	01-31-89	625.80	10-3/4	27.0	4	27.0	7.3-26.2	6.0-27.0	4.5-6.0	0.0-3.0
HM-116	01-31-89	633.92	10-3/4	33.0	4	33.0	23.0-33.0	20.0-33.0	18.0-20.0	0.0-4.0
HM-117	02-01-89	633.16	10-3/4	39.5	4	38.5	18.5-38.5	17.0-38.5	15.0-17.0	0.0-4.0
HM-118	02-01-89	626.04	10-3/4	27.0	4	26.2	6.2-26.2	6.0-26.2	4.0-6.0	0.0-4.0
HM-119	02-02-89	624.79	10-3/4	32.0	4	29.0	9.0-29.0	6.5-29.0	5.0-6.5	0.0-3.0
HM-120	02-02-89	616.50	10-3/4	18.0	4	17.6	7.6-17.6	6.7-17.6	4.5-6.7	0.0-4.5
HM-121	02-08-89	627.47	10-3/4	31.5	4	31.5	11.5-31.5	8.6-31.5	6.5-8.6	0.0-3.0
HM-122	02-15-89	619.20	10-3/4	28.5	4	26.9	16.9-26.9	16.0-28.5	14.9-16.0	0.0-4.0

ft bls = Feet below land surface

TABLE 1 (continued)
MONITOR WELL CONSTRUCTION DATA
UPPER ZONE

WELL IDENTIFIER	DATE DRILLED	MEASURING POINT ELEVATION	.....BOREHOLE..... DIAMETER (inches)	DEPTH (ft bls)	.....PVC CASING..... INSIDE DIAMETER (inches)	DEPTH (ft bls)	SCREENED SEAL (ft bls)	FILTER PACK INTERVAL (ft bls)	BENTONITE SEAL (ft bls)	CEMENT SEAL (ft bls)
HM-123	02-15-89	624.69	10-3/4	40.5	4	39.5	19.5-39.5	16.0-19.5	14.5-16.0	0.0-4.0
HM-124	02-16-89	623.03	10-3/4	25.0	4	24.0	9.0-24.0	7.5-25.0	5.0-7.5	0.0-4.0
HM-125	02-16-89	629.06	10-3/4	33.0	4	33.0	13.0-33.0	10.8-33.0	8.5-10.8	0.0-4.0
HM-126	02-17-89	622.82	10-3/4	37.0	4	36.0	16.0-36.0	12.0-37.0	10.0-12.0	0.0-4.0
HM-127	02-18-89	623.82	10-3/4	38.5	4	38.5	18.5-38.5	15.0-18.5	13.0-15.0	0.0-4.0

ft bls = Feet below land surface

TABLE 2

MONITOR WELL CONSTRUCTION DATA
PALUXY AQUIFER

WELL IDENTIFIER	DATE COMPLETED	MEASURING POINT ELEVATION	.....BOREHOLE..... DIAMETER (inches)	DEPTH (ft bls)	.....STEEL CASING..... INSIDE DIAMETER (inches)	DEPTH (ft bls)	CEMENT SEAL (ft bls)	.....PVC WELL SCREEN.... INSIDE DIAMETER (inches)	DEPTH INTERVAL (ft bls)
P-5US	10-14-87	654.15	28 18 12-1/4	36.0 61.5 74.0	19-1/8 12-3/4	36.0 61.5	0.0-36.0 0.0-61.5	4	64.0-74.0
P-5UN	10-15-87	653.89	12-1/4 7-7/8	80.0 98.0	8	79.0		4	78.0-89.0
P-8US	06-03-87	644.6	24 18	38.0 58.0	19-1/8 12-3/4	38.0 58.0	0.0-38.0 0.0-58.0	4	55.0-65.0
P-8UN	06-05-87	645.7	12 3/4 8	77.0 96.0	8-5/8	77.0	0.0-77.0	4	84.0-94.0
P-9US	10-06-87	655.98	24 18 12-1/4	39.5 63.0 73.0	19-1/8 13-3/8	39.5 63.0	0.0-39.5 0.0-63.0	4	63.0-73.0
P-9UN	10-08-87	654.84	12-1/4 7-7/8	80.0 112.0	8	80.0	0.0-80.0	4	90.0-110.0
P-11US	09-16-87	639.95	12-1/4 7-7/8	51.5 62.0	8	50.5	3.0-51.5	4	52.0-62.0
P-12US	10-03-87	642.99	14 9-7/8	54.5 61.5	10	54.5	0.0-54.5	4	51.5-61.5
P-12UN	03-01-88	643.31	12-1/4 7-7/8	70.5 97.0	8	70.5	0.0-70.5	4	77.0-97.0
P-13US	08-19-87	638.07	12-1/4 7-7/8	54.5 64	8	54.5	0.0-54.5	4	54.0-64.0
P-15US	09-26-87	646.98	12-1/4 7-7/8	62.0 69.0	8	61.0	0.0-62.0	4	59.0-69.0
P-15U	09-24-87	646.29	12-1/4 7-7/8	75.0 91.0	8	75.6	0.0-75.0	4	71.0-91.0

ft bls = Feet below land surface

TABLE 2 (continued)
MONITOR WELL CONSTRUCTION DATA
PALUXY AQUIFER

WELL IDENTIFIER	DATE COMPLETED	MEASURING POINT ELEVATION	.....BOREHOLE..... DIAMETER (inches)	DEPTH (ft bls)	.....STEEL CASING..... INSIDE DIAMETER (inches)	DEPTH (ft bls)	CEMENT SEAL (ft bls)	.....PVC WELL SCREEN.... INSIDE DIAMETER (inches)	DEPTH INTERVAL (ft bls)
P-16US	10-11-87	646.36	12-1/4 7-7/8	61.0 70.5	8	61.0	0.0-62.0	4	60.0-70.0
P-17US	10-27-87	641.89	12-1/4 7-7/8	61.0 71.0	8	61.0	0.0-61.0	4	60.0-70.0
P-18US	03-07-88	640.58	12-1/4 7-7/8	55.0 75.0	8	55.0	0.0-55.0	4	60.0-75.0
P-19US	03-05-88	637.83	12-1/4 7-7/8	58.0 70.5	8	56.8	0.0-56.8	4	60.0-70.0
P-22M	10-30-87	632.44	12-1/4 7-7/8	91.0 136.0	8	90.0	0.0-91.0	4	101.0-136.0
P-24U	12-01-88	626.82	7-7/8	61.0			0.0-17.0	4	28.0-58.0
P-24M	12-02-88	625.88	12-3/4 7-7/8	76.0 134.0	8	74.0	0.0-76.0	4	84.0-134.0
P-25U	12-05-88	627.25	12-1/4 7-7/8	60.0 115.0	8	59.0	0.0-59.0	4	55.0-115.0
P-25M	12-14-88	655.56	14 123	123.0 160.0	8	123.0	0.0-123.0	4	118.0-158.0
P-26U	01-03-89	652.24	12-1/4 7-7/8	69.0 93.0	8	69.0	0.0-69.0	4	62.0-92.0
P-26M	01-06-89	652.33	12-1/4 7-7/8	102.0 171.5	8	102.0	0.0-102.0	4	101.5-171.5

ft bls = feet below land surface

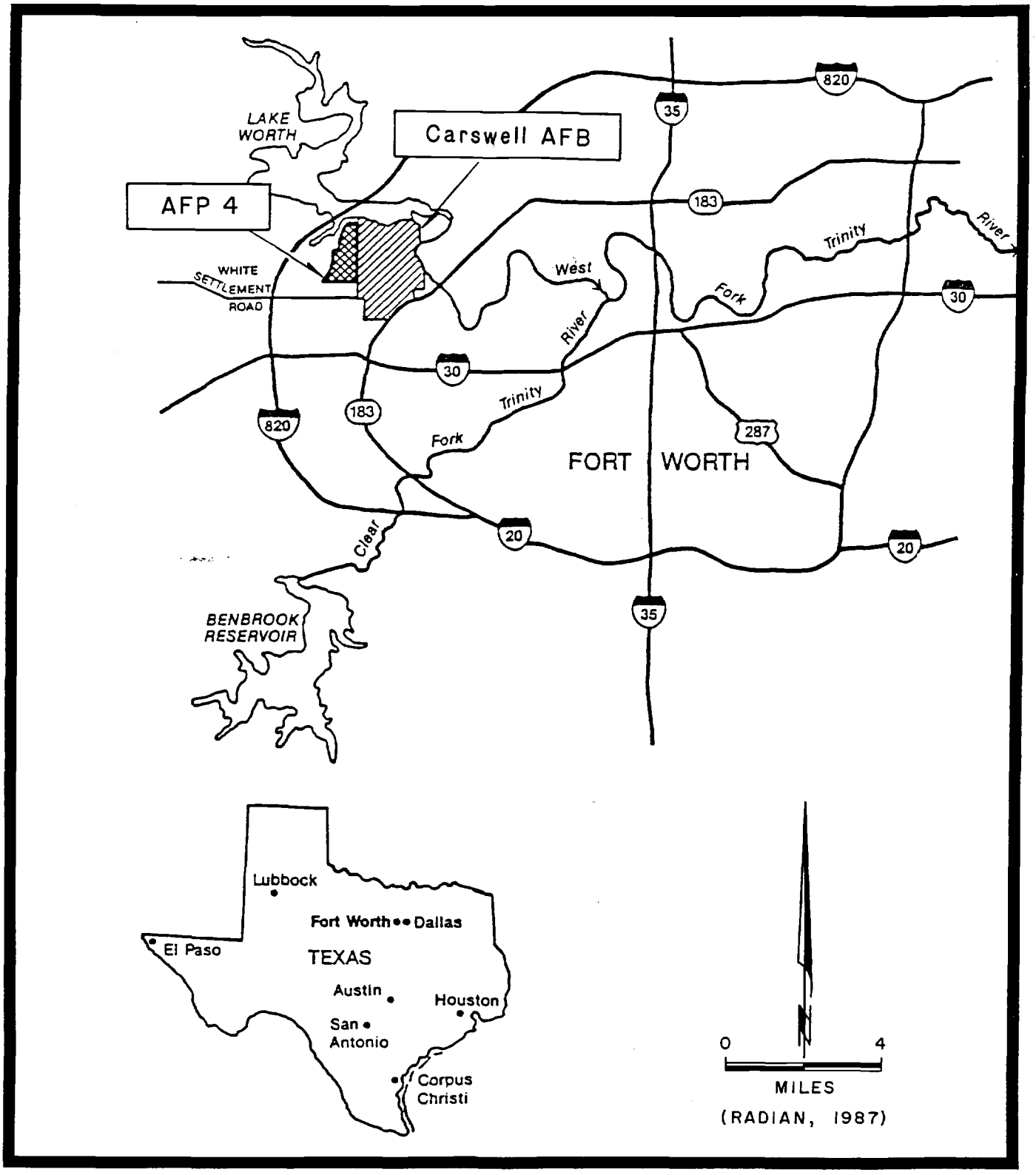
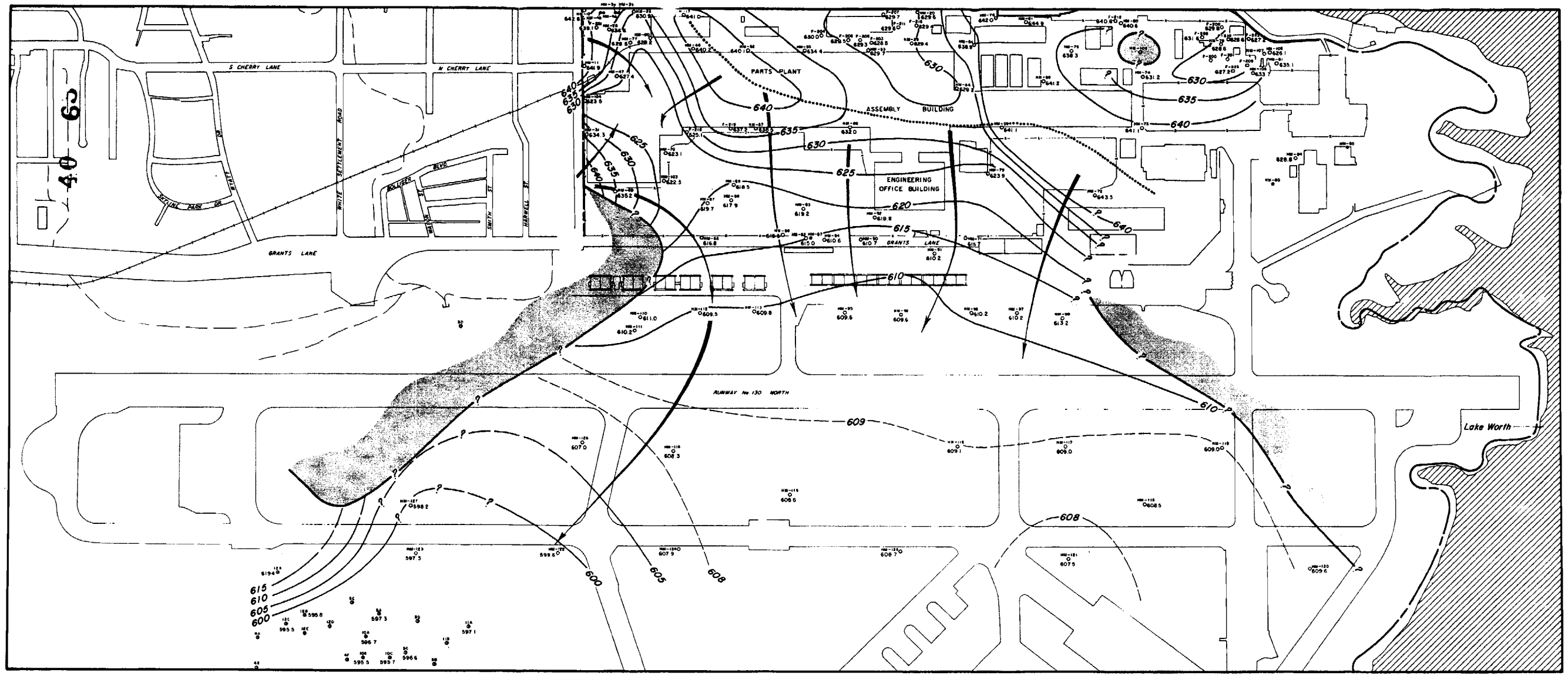


FIGURE 1. LOCATION OF AFP 4, FORT WORTH, TEXAS



EXPLANATION

- ○ UPPER ZONE MONITOR WELL
- • ABANDONED UPPER ZONE MONITOR WELL
- • UPPER ZONE MONITOR WELL CONSTRUCTED BY RADIAN CORPORATION
- HW-96 / 610.2 — IDENTIFIER / WATER LEVEL ELEVATION IN FEET, MEAN SEA LEVEL
- 600 — CONTOUR OF EQUAL WATER LEVEL ELEVATION IN FEET, MEAN SEA LEVEL DASHED WHERE APPROXIMATE, QUERIED WHERE INFERRED
- APPROXIMATE LOCATION OF GROUNDWATER DIVIDE
- DIRECTION OF GROUNDWATER FLOW
- APPROXIMATE AREA OF ABSENCE OF UPPER ZONE GROUNDWATER

NOTE: BASED ON MEASUREMENTS APRIL 1989 OR MOST RECENT DATA

0 400 800
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No 4
FORT WORTH, TEXAS

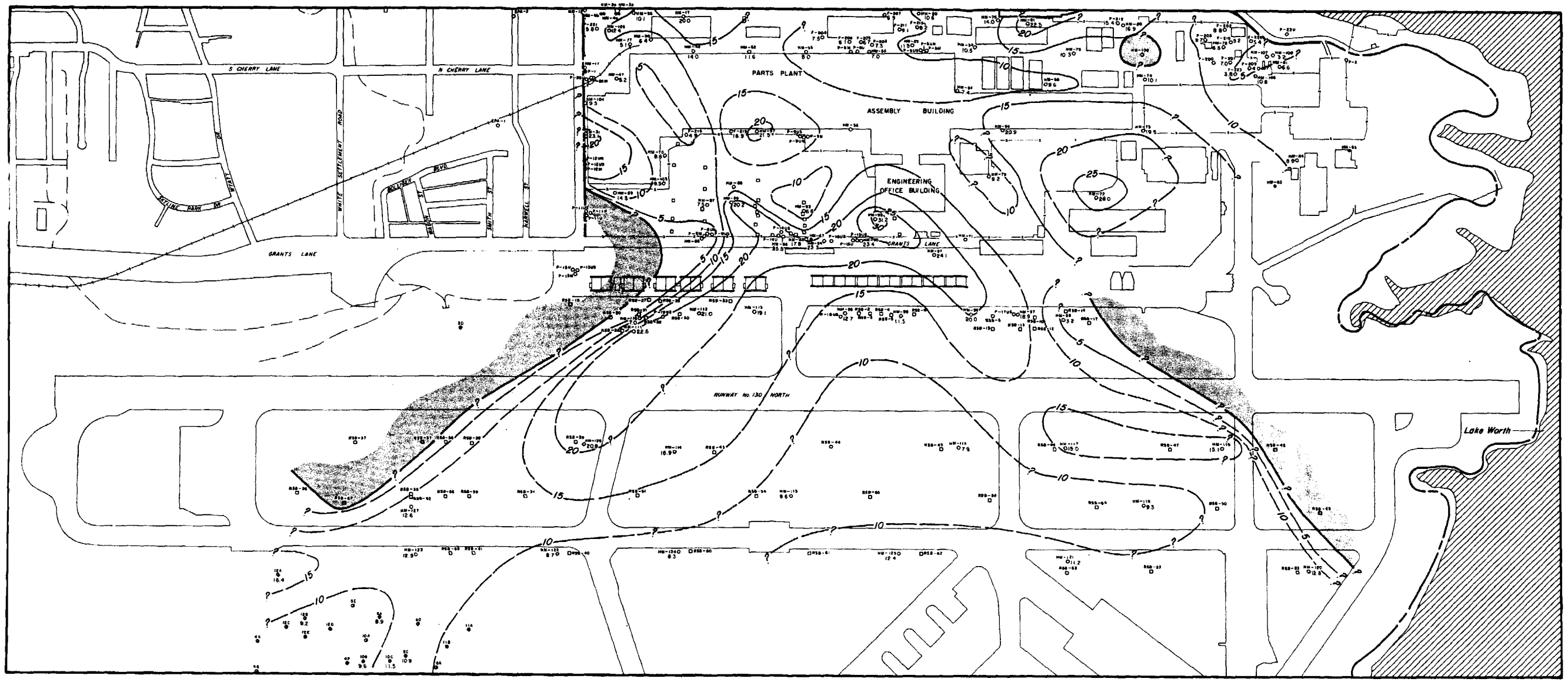
WATER LEVEL CONTOURS
UPPER ZONE

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 9

PREPARED BY: REVIEWED BY:



EXPLANATION

- ○ UPPER ZONE MONITOR WELL
- • ABANDONED UPPER ZONE MONITOR WELL
- ○ PALUXY AQUIFER MONITOR WELL
  - US Completed in upper sand unit
  - U Completed in upper Paluxy aquifer
  - UN Reconstructed in upper Paluxy aquifer
  - M Completed in middle Paluxy aquifer
  - P-3 Completed in multiple Paluxy aquifers
- ● ABANDONED PALUXY AQUIFER MONITOR WELL
- □ SOIL BORING
- ● UPPER ZONE MONITOR WELL CONSTRUCTED BY RADIAN CORPORATION
- HN-96 IDENTIFIER
- 200 SATURATED THICKNESS, UPPER ZONE IN FEET, MEAN SEA LEVEL

10 — CONTOUR OF EQUAL SATURATED THICKNESS, UPPER ZONE IN FEET, DASHED WHERE APPROXIMATE QUERIED WHERE INFERRED

APPROXIMATE AREA OF ABSENCE OF UPPER ZONE GROUNDWATER

NOTE: BASED ON MEASUREMENTS APRIL 1989 OR MOST RECENT DATA

0 400 800
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

SATURATED THICKNESS UPPER ZONE

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 10

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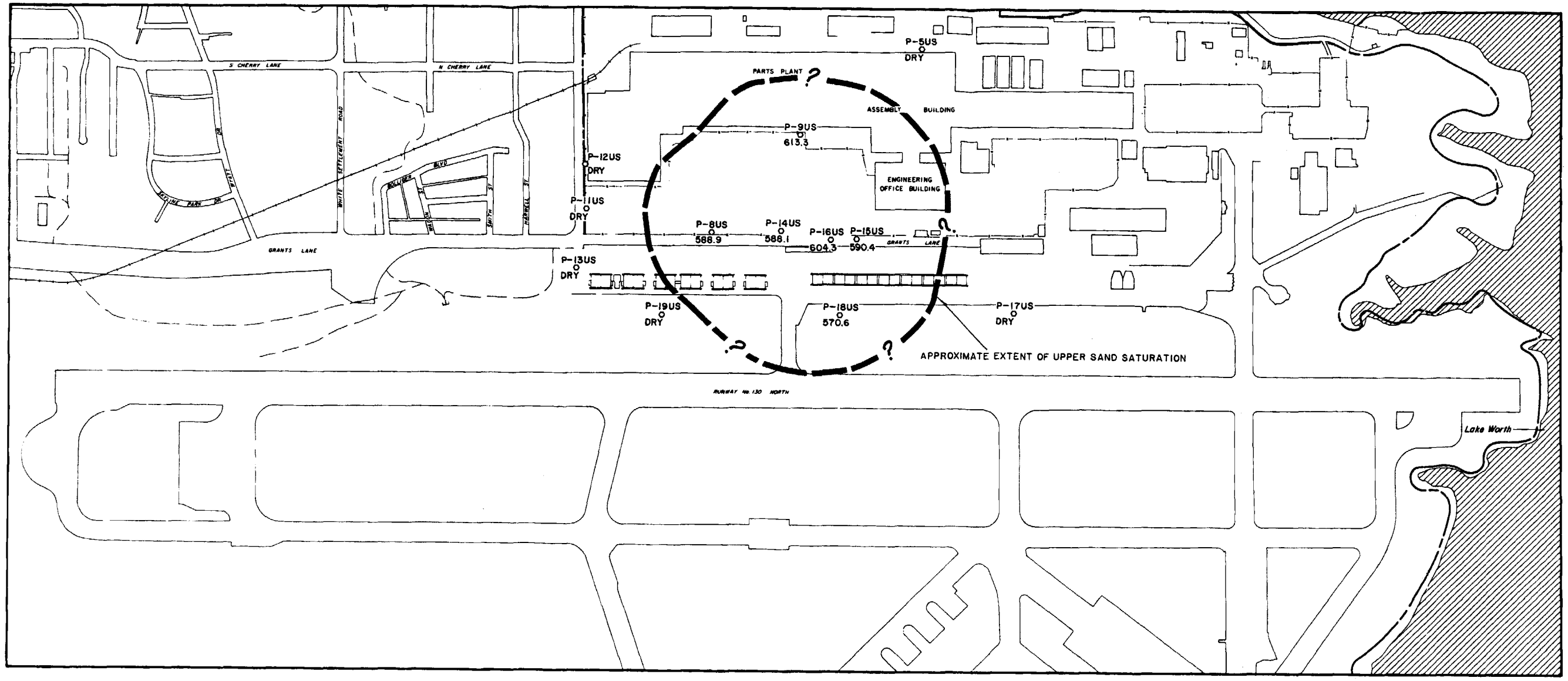

EXPLANATION

○ PALUXY FORMATION MONITOR WELL
US Completed in upper sand unit

P-9US IDENTIFIER
613.3 WATER LEVEL ELEVATION, APRIL 1989 IN FEET, MEAN SEA LEVEL

0 400 800
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

WATER LEVEL ELEVATIONS
UPPER SAND UNIT

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 11

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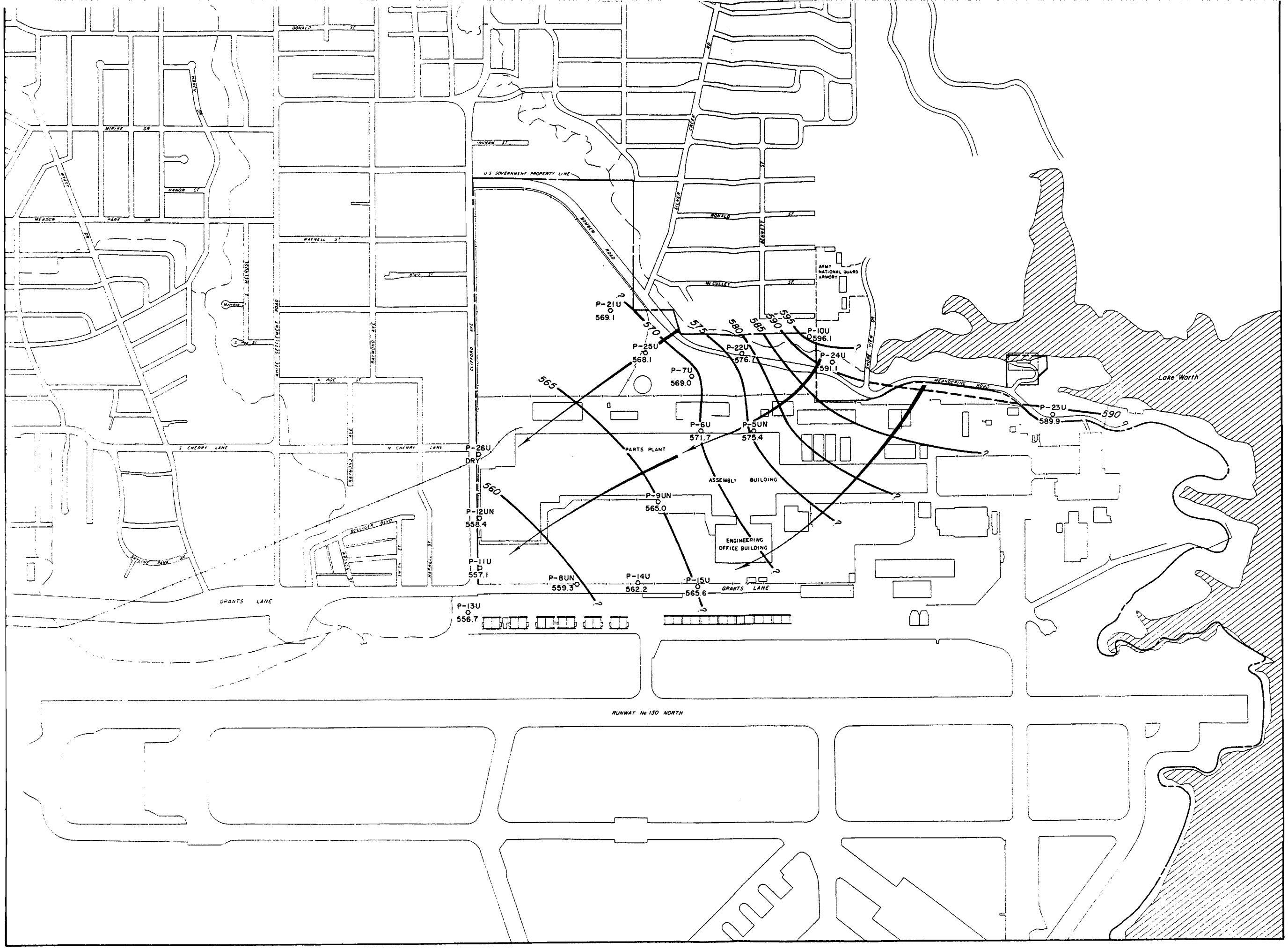

EXPLANATION

O PALUXY AQUIFER MONITOR WELL

U Completed in upper Paluxy aquifer
UN Reconstructed in upper Paluxy aquifer

P-6U IDENTIFIER
O
561.7 WATER LEVEL ELEVATION, APRIL 1989 UPPER PALUXY AQUIFER IN FEET, MEAN SEA LEVEL

570 — — — — ?
CONTOUR OF EQUAL WATER LEVEL ELEVATION UPPER PALUXY AQUIFER IN FEET, MEAN SEA LEVEL, APRIL 1989 DASHED WHERE APPROXIMATE QUERIED WHERE INFERRED

DIRECTION OF GROUNDWATER FLOW

0 400 800
FEET

GENERAL DYNAMICS CORPORATION
U S AIR FORCE PLANT No 4
FORT WORTH, TEXAS

WATER LEVEL CONTOURS
UPPER PALUXY AQUIFER

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 12

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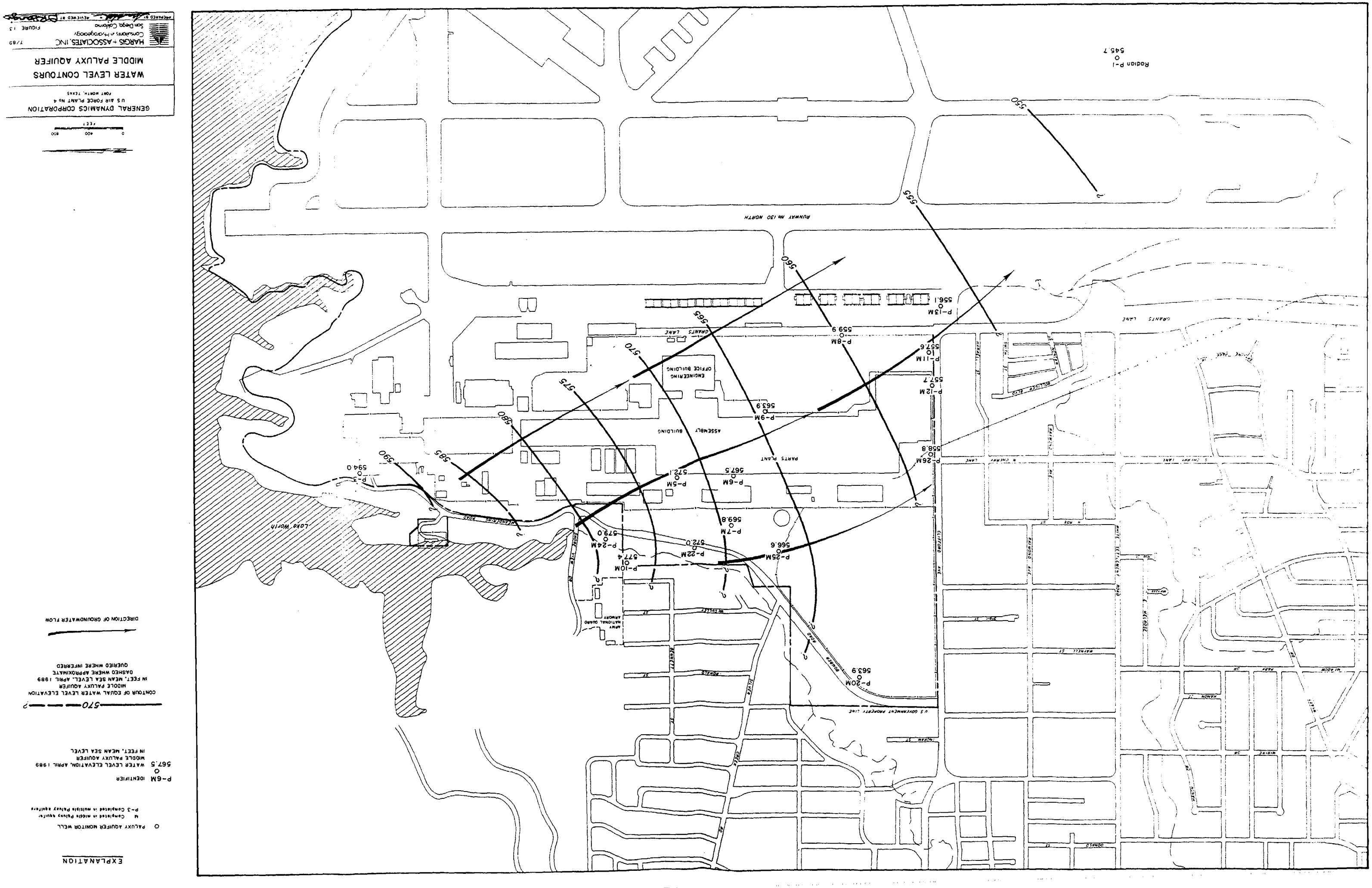


GENERAL DYNAMICS CORPORATION
U S AIR FORCE PLANT No 4
FORT WORTH, TEXAS
WATER LEVEL CONTOURS
MIDDLE PALUXY AQUIFER
HARGIS + ASSOCIATES, INC
Consultants in Hydrogeology
San Diego, California
7/89
FIGURE 13
PREPARED BY
REVIEWED BY
EXPLANATION
PALUXY AQUIFER MONITOR WELL
M Completed in middle Paluxy aquifer
P-3 Completed in multiple Paluxy aquifers
P-6M IDENTIFIER
567.5 WATER LEVEL ELEVATION, APRIL 1989
MIDDLE PALUXY AQUIFER
IN FEET, MEAN SEA LEVEL
570 ?
CONTOUR OF EQUAL WATER LEVEL ELEVATION
MIDDLE PALUXY AQUIFER
IN FEET, MEAN SEA LEVEL, APRIL 1989
DASHED WHERE APPROXIMATE
QUERIED WHERE INFERRED
DIRECTION OF GROUNDWATER FLOW
Radian P-1
545.7
RUNWAY No 130 NORTH
GRANTS LANE
ENGINEERING OFFICE BUILDING
ASSEMBLY BUILDING
PARTS PLANT
Lake Worth
U S GOVERNMENT PROPERTY LINE
P-3
594.0
P-5M
572.1
P-6M
567.5
P-7M
569.8
P-8M
559.9
P-9M
563.9
P-10M
577.4
P-11M
557.6
P-12M
557.7
P-13M
556.1
P-20M
563.9
P-22M
572.0
P-24M
579.0
P-25M
566.6
P-26M
558.8
550
555
560
565
570
575
580
585
590

40 69

OFFICE OF THE BASE CIVIL ENGINEER
7th Civil Engineering Squadron (SAC)
Carswell Air Force Base, Texas 76127

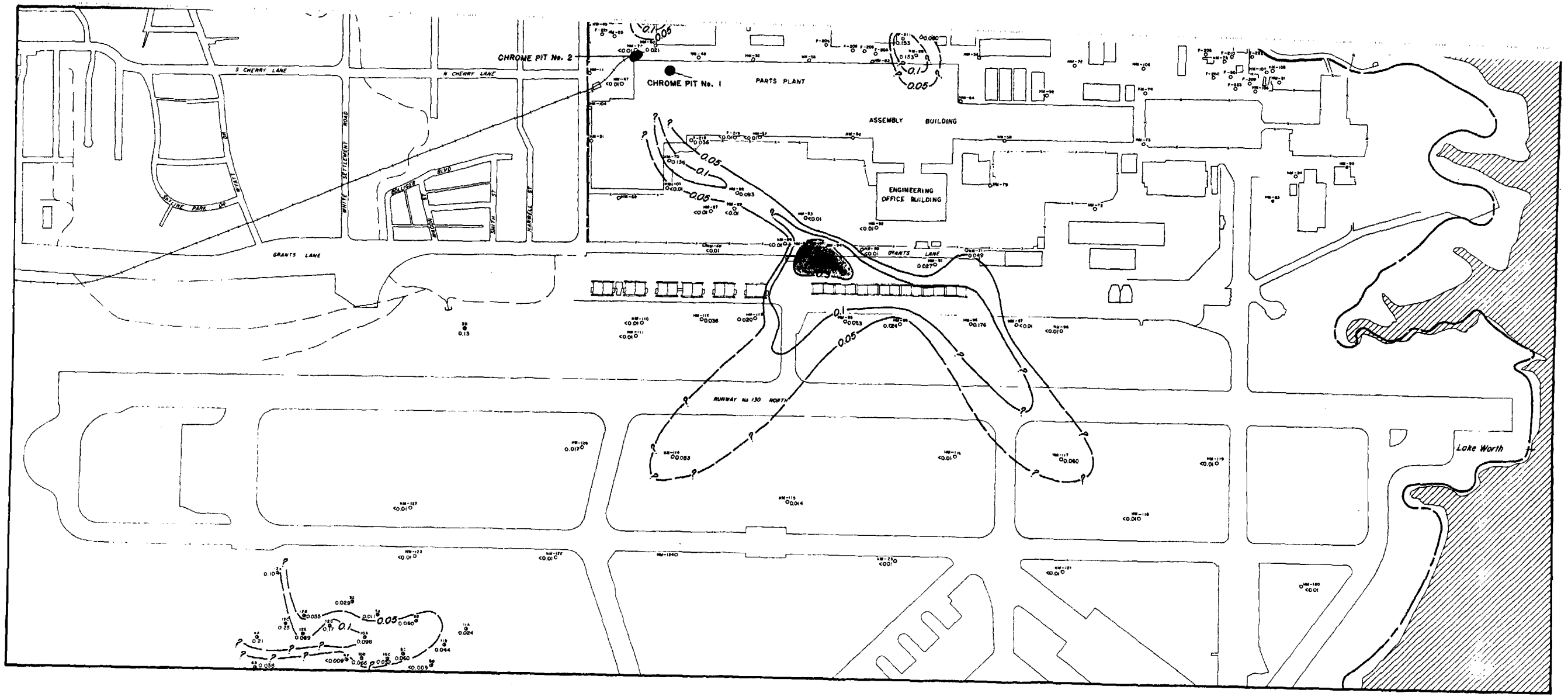
11 Jun

TO: 7CSG/CC

Re GD and the TCE spill.

Attached data relative to Carswell TCE usage / hydrogeology and AF Plant 4 IRP. I've clipped some pages in the book which may be of interest. I've marked the location of the Assembly bldg with "." at the top of the cross section pages. Interesting that the release this week is in the same area that the "TCE Concentration" map indicates that the plume originates.

Base Civil Engineer



- ○ UPPER ZONE MONITOR WELL
- • ABANDONED UPPER ZONE MONITOR WELL
- ● UPPER ZONE MONITOR WELL CONSTRUCTED BY RADIAN CORPORATION

HW-96 IDENTIFIER
0.176 CONCENTRATION OF TOTAL CHROMIUM IN MILLIGRAMS PER LITER

0.1 — P
CONTOUR OF EQUAL CONCENTRATION OF TOTAL CHROMIUM IN MILLIGRAMS PER LITER
DASHED WHERE APPROXIMATE, QUERIED WHERE INFERRED

NOTE: BASED ON SAMPLES COLLECTED APRIL 1989 OR MOST RECENT DATA

0 400 800
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

TOTAL CHROMIUM CONCENTRATIONS
UPPER ZONE

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 14

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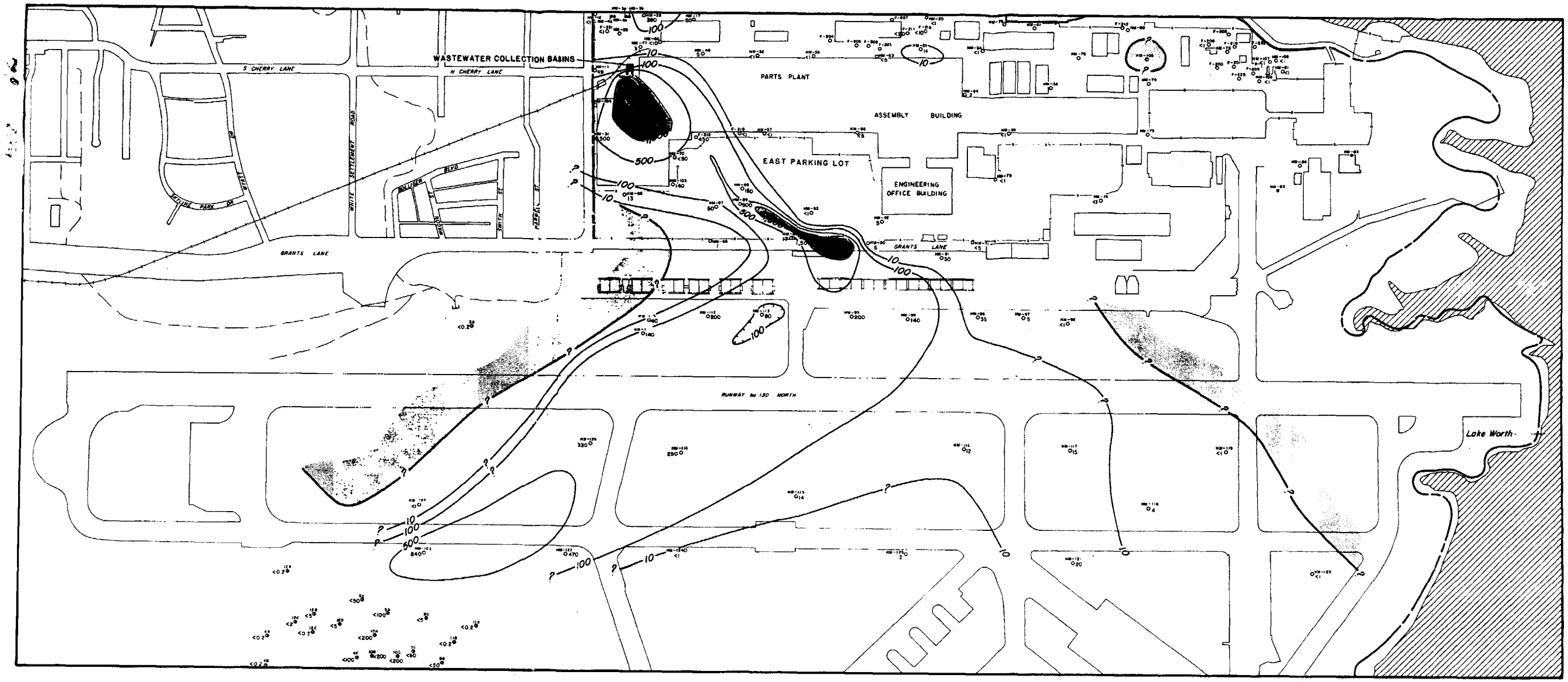

EXPLANATION

- UPPER ZONE MONITOR WELL
- ABANDONED UPPER ZONE MONITOR WELL
- UPPER ZONE MONITOR WELL CONSTRUCTED BY RADIAN CORPORATION

HW-99 IDENTIFIER
30 CONCENTRATION OF TRANS-1,2-DICHLOROETHYLENE IN MICROGRAMS PER LITER

100 — CONTOUR OF EQUAL CONCENTRATION OF TRANS-1,2-DICHLOROETHYLENE IN MICROGRAMS PER LITER DASHED WHERE APPROXIMATE, QUERIED WHERE INFERRED

APPROXIMATE AREA OF ABSENCE OF UPPER ZONE GROUNDWATER

NOTE: BASED ON SAMPLES COLLECTED APRIL 1989 OR MOST RECENT DATA

0 400 800
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

TRANS-1,2-DICHLOROETHYLENE CONCENTRATIONS UPPER ZONE

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 15

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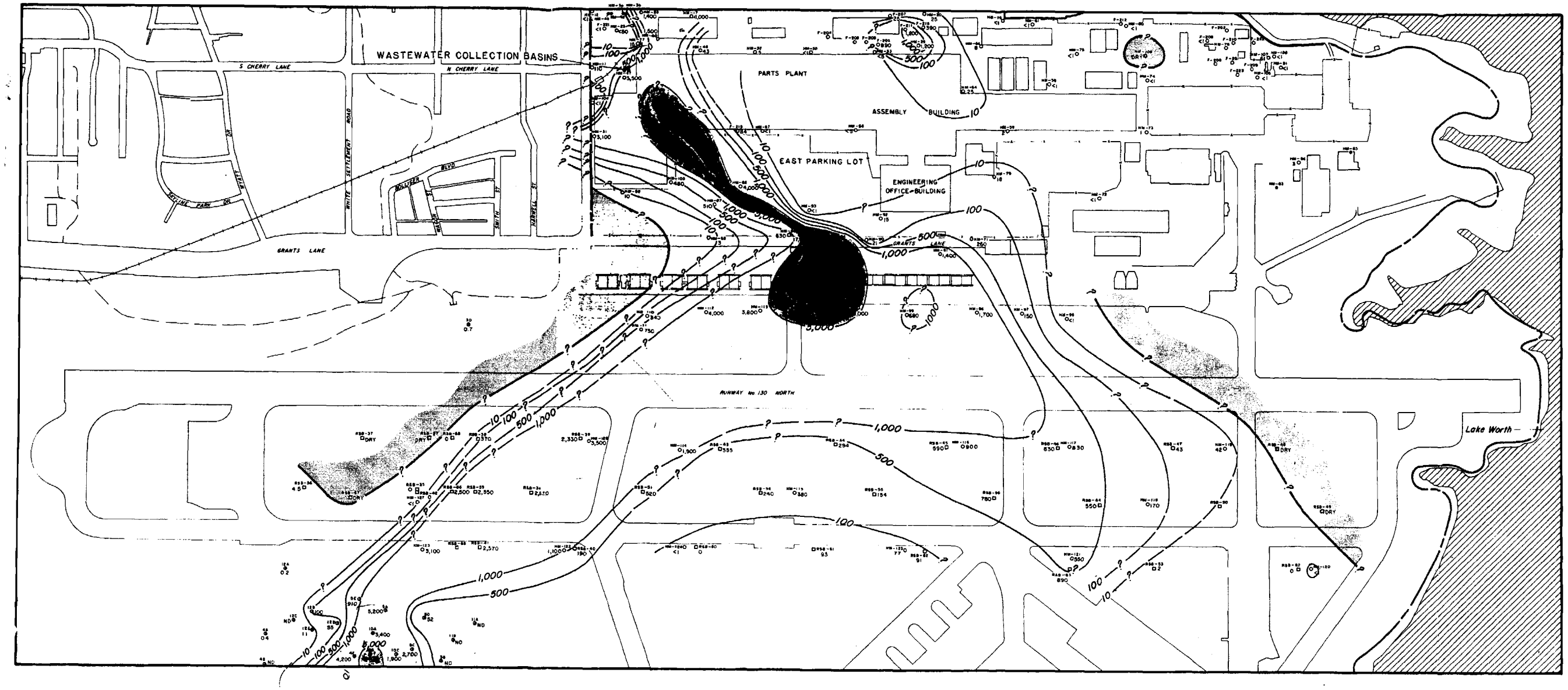


EXPLANATION

- UPPER ZONE MONITOR WELL
- ABANDONED UPPER ZONE MONITOR WELL
- UPPER ZONE MONITOR WELL CONSTRUCTED BY RADIAN CORPORATION
- SOIL BORING
- IDENTIFIER / CONCENTRATION OF TRICHLOROETHYLENE IN MICROGRAMS PER LITER
- IDENTIFIER / CONCENTRATION OF TRICHLOROETHYLENE IN MICROGRAMS PER LITER AS DETERMINED BY MOBILE GAS CHROMATOGRAPH
- 100 — CONTOUR OF EQUAL CONCENTRATION OF TRICHLOROETHYLENE IN MICROGRAMS PER LITER DASHED WHERE APPROXIMATE, QUERIED WHERE INFERRED
- APPROXIMATE AREA OF ABSENCE OF UPPER ZONE GROUNDWATER

NOTE: BASED ON SAMPLES COLLECTED APRIL 1989 OR MOST RECENT DATA

0 400 800 FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

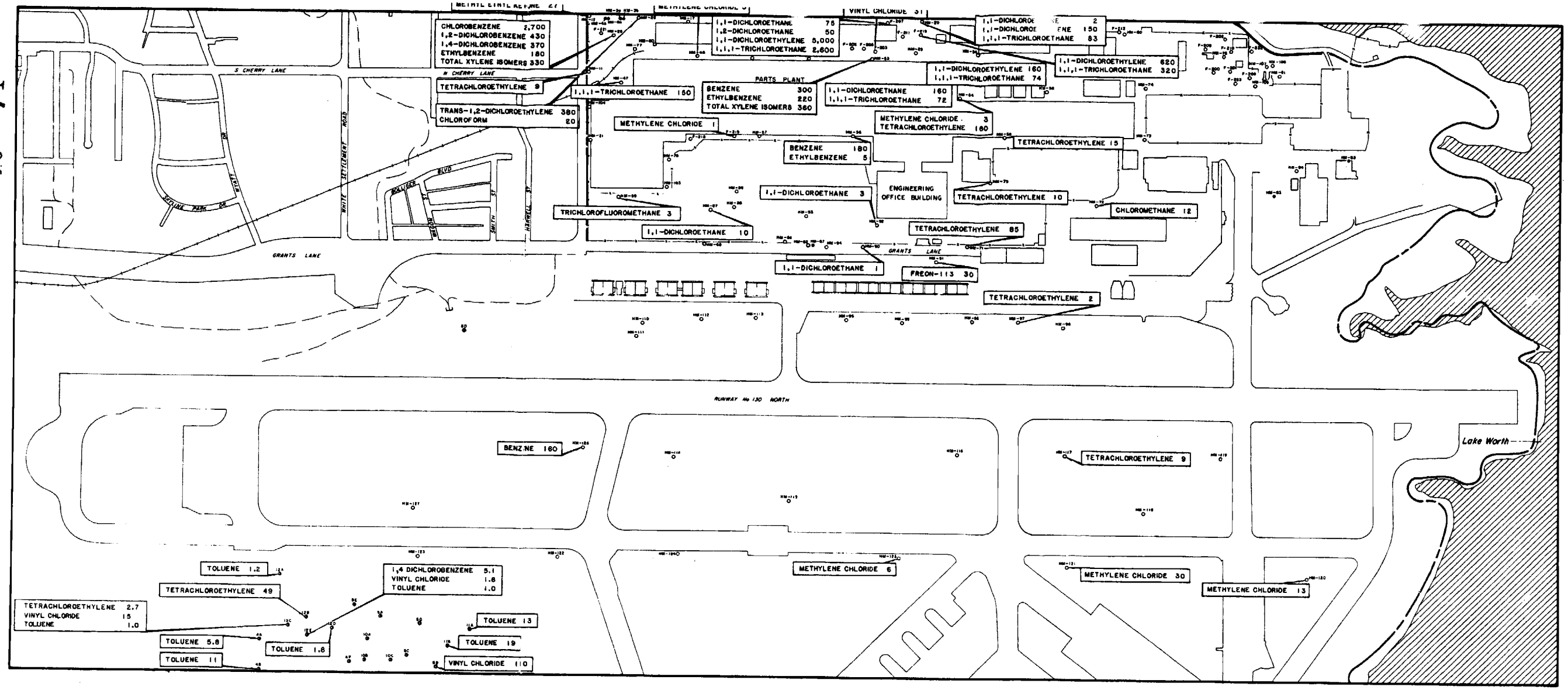
TRICHLOROETHYLENE CONCENTRATIONS UPPER ZONE

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 16

PREPARED BY _____ REVIEWED BY _____



EXPLANATION

- ○ UPPER ZONE MONITOR WELL
- • ABANDONED UPPER ZONE MONITOR WELL
- ● UPPER ZONE MONITOR WELL CONSTRUCTED BY RADIAN CORPORATION

MW-189 — IDENTIFIER

BENZENE 160 — CONCENTRATION, IN MICROGRAMS PER LITER; VOLATILE ORGANIC COMPOUND

NOTE: BASED ON SAMPLES COLLECTED APRIL 1989 OR MOST RECENT DATA

0 400 800
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

VOLATILE ORGANIC COMPOUNDS
UPPER ZONE

HARDIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 17

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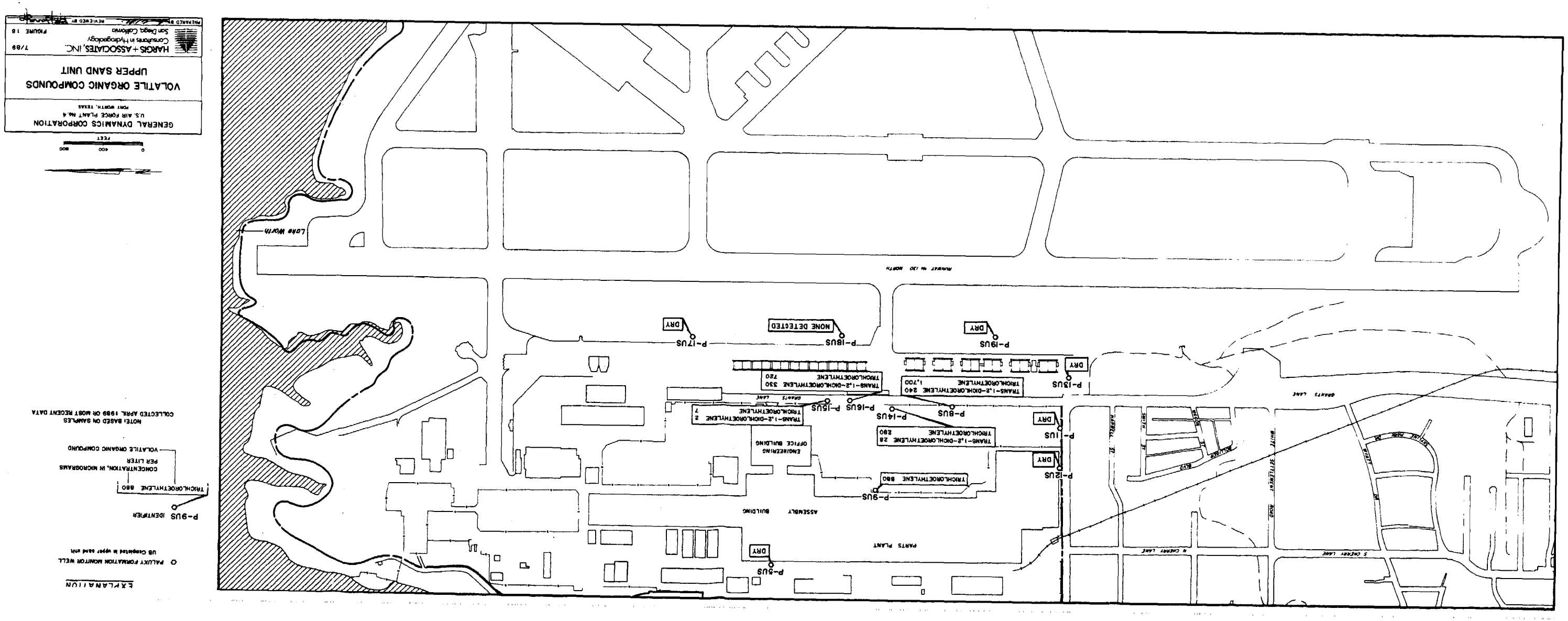
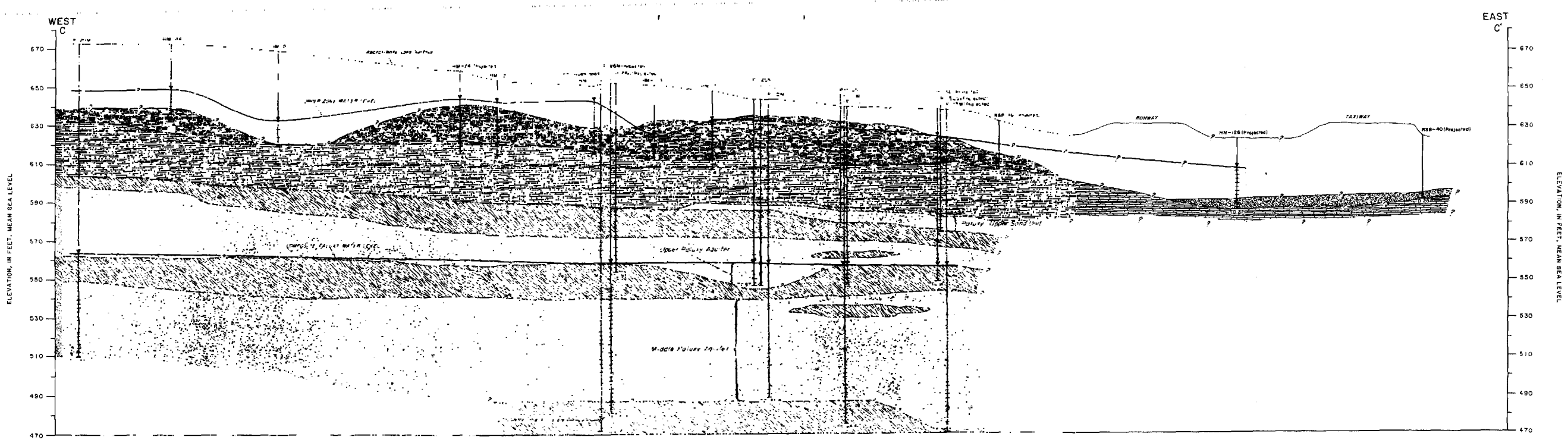
40 7.4



GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS
VOLATILE ORGANIC COMPOUNDS
UPPER SAND UNIT
HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California
7/89
FIGURE 18
PREPARED BY
REVIEWED BY
0
400
800
FEET
EXPLANATION
PALUXY FORMATION MONITOR WELL
UB Completed in upper sand unit
P-9US IDENTIFIER
TRICHLOROETHYLENE 880
CONCENTRATION, IN MICROGRAMS PER LITER
VOLATILE ORGANIC COMPOUND
NOTE: BASED ON SAMPLES COLLECTED APRIL 1989 OR MOST RECENT DATA
Lake Worth
RUNWAY No 130 NORTH
P-17US
DRY
P-18US
NONE DETECTED
P-19US
DRY
P-13US
DRY
TRANS-1,2-DICHLOROETHYLENE 330
TRICHLOROETHYLENE 720
TRANS-1,2-DICHLOROETHYLENE 240
TRICHLOROETHYLENE 1,700
P-15US
P-16US
P-14US
P-8US
TRANS-1,2-DICHLOROETHYLENE 2
TRICHLOROETHYLENE 7
TRANS-1,2-DICHLOROETHYLENE 28
TRICHLOROETHYLENE 280
P-1US
DRY
P-12US
DRY
TRICHLOROETHYLENE 880
P-9US
ENGINEERING OFFICE BUILDING
ASSEMBLY BUILDING
PARTS PLANT
P-5US
DRY
GRANTS LANE
N CHERRY LANE
S CHERRY LANE
WHITE SETTLEMENT ROAD

40 75



EXPLANATION

UPPER ZONE
Alluvium and fill/sand and gravel

GOODLAND FORMATION
Limestone interbedded with sandy shale

WALNUT FORMATION
Fossiliferous limestone interbedded with shale

PALUXY FORMATION
Fine grained sand/clay and shale

P-1215 — WELL IDENTIFIER

WATER LEVEL ELEVATION, APRIL 1989

SCREENED INTERVAL

T065 — TOTAL DEPTH, IN FEET

ABANDONED BOREHOLE

RSB-40 — IDENTIFIER

SOIL BORING DRILLED BY HARGIS+ASSOCIATES, INC.

0 200 400
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

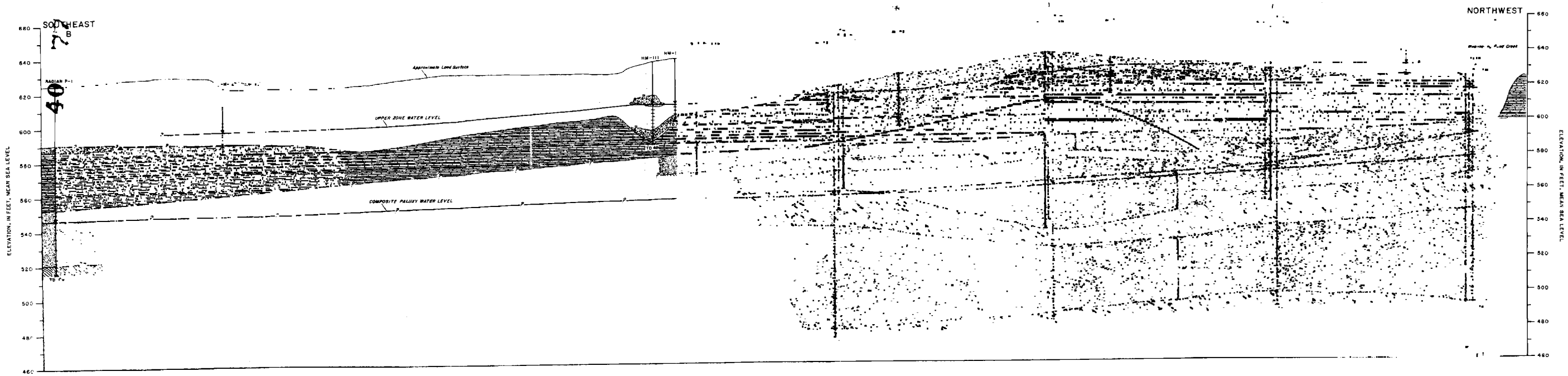
HYDROGEOLOGIC
CROSS SECTION C–C'

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 8

PREPARED BY REVIEWED BY



EXPLANATION

UPPER ZONE
Alluvium and fill/sand and gravel

GOODLAND FORMATION
Limestone interbedded with sandy shale

WALNUT FORMATION
Fossiliferous limestone interbedded with shale

PALUXY FORMATION
Fine grained sand/clay and shale

P-SUS WELL IDENTIFIER

WATER LEVEL ELEVATION, APRIL 1989

SCREENED INTERVAL

TD 74 TOTAL DEPTH, IN FEET

ABANDONED BOREHOLE

P-24ES IDENTIFIER

SOIL BORING DRILLED BY HARGIS + ASSOCIATES

0 200 400
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

HYDROGEOLOGIC
CROSS SECTION B-B'

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 7

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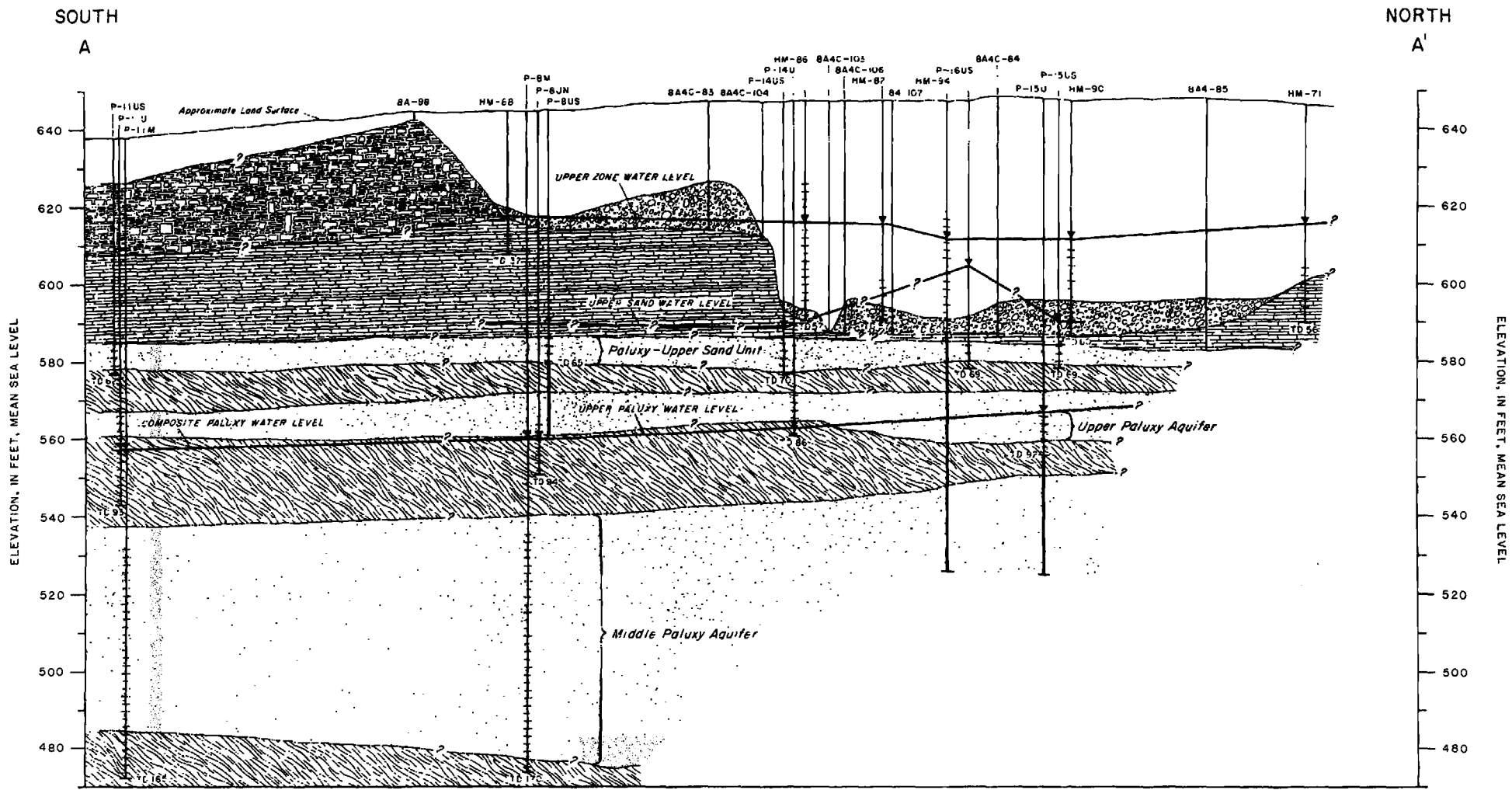
40 78



EXPLANATION

UPPER ZONE
Alluvium and fill/sand and gravel

GOODLAND FORMATION
Limestone interbedded with sandy shale

WALNUT FORMATION
Fossiliferous limestone interbedded with shale

PALUXY FORMATION
Fine grained sand/clay and shale

HM-94 WELL IDENTIFIER

WATER LEVEL ELEVATION, APRIL 1989

SCREENED INTERVAL

TD 80 TOTAL DEPTH, IN FEET

ABANDONED BOREHOLE

8A4C-84 IDENTIFIER

SOIL BORING DRILLED BY ARMY CORPS OF ENGINEERS (1986)

0 200 400
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

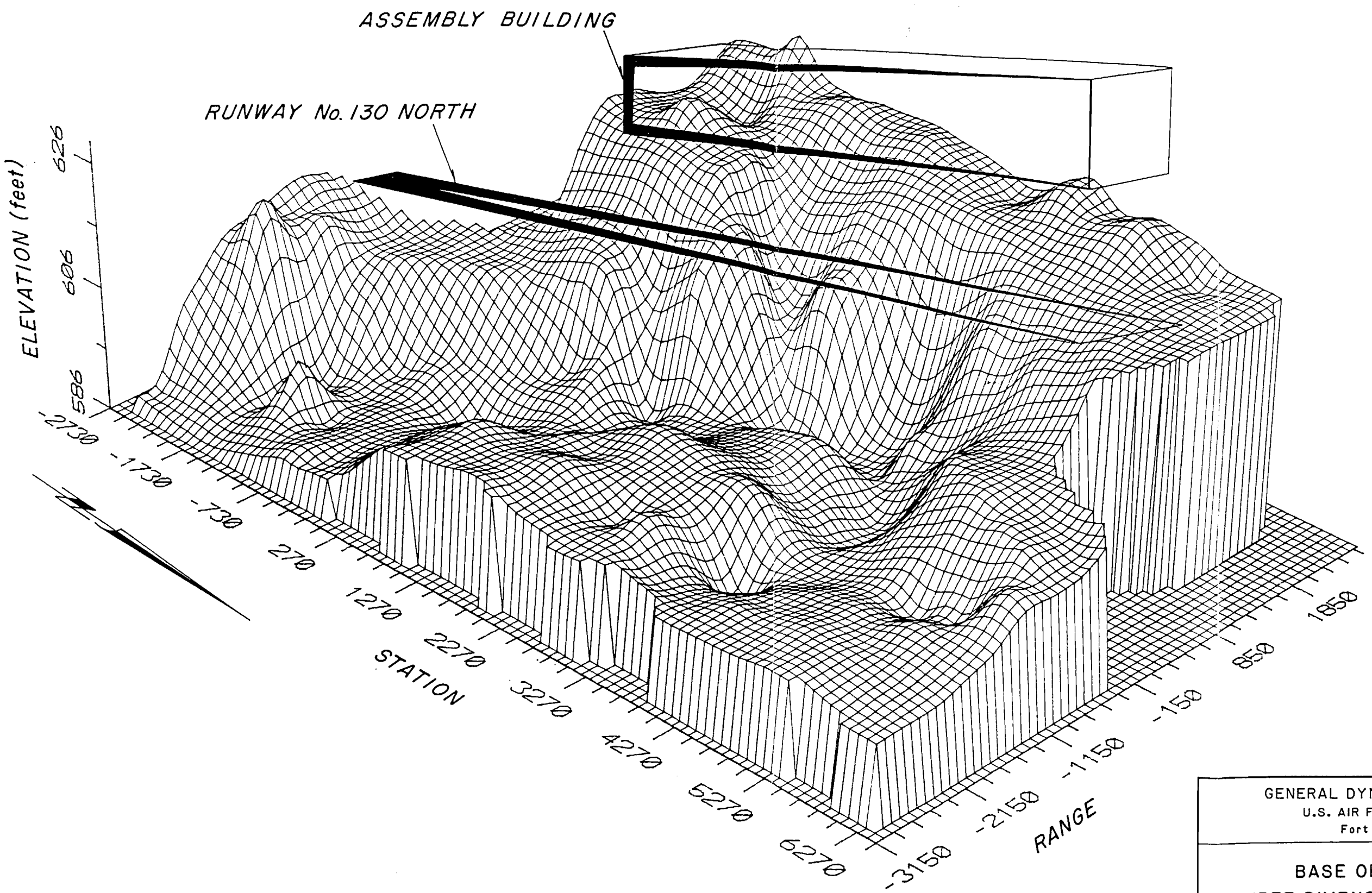
HYDROGEOLOGIC
CROSS SECTION A-A'

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 6

PREPARED BY REVIEWED BY

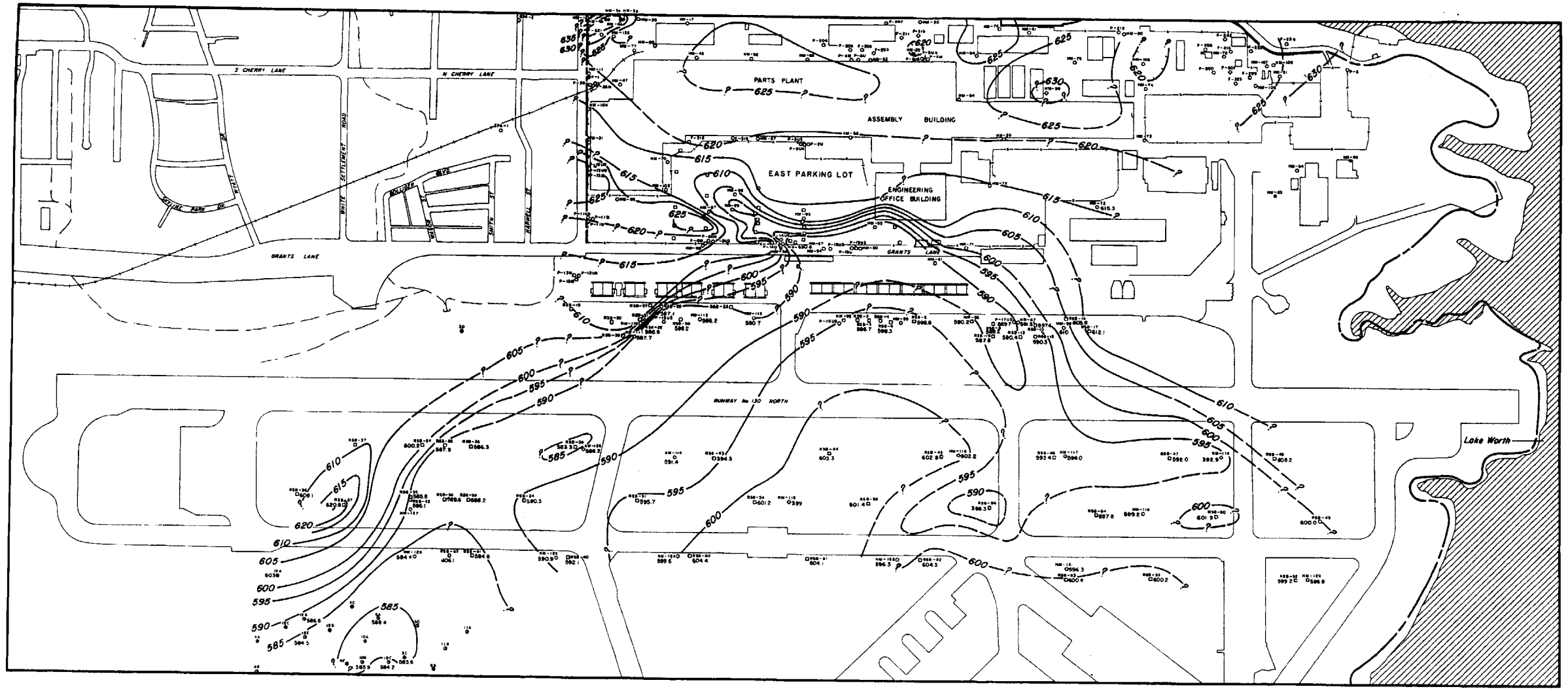


GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
Fort Worth, Texas

BASE OF UPPER ZONE
THREE DIMENSIONAL PERSPECTIVE

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89
FIGURE 5



EXPLANATION

- UPPER ZONE MONITOR WELL
- ABANDONED UPPER ZONE MONITOR WELL
- PALUXY AQUIFER MONITOR WELL
  - US Completed in upper sand unit
  - U Completed in upper Paluxy aquifer
  - UN Reconstructed in upper Paluxy aquifer
  - M Completed in middle Paluxy aquifer
  - P-3 Completed in multiple Paluxy aquifers
- ABANDONED PALUXY AQUIFER MONITOR WELL
- SOIL BORING
- UPPER ZONE MONITOR WELL CONSTRUCTED BY RADIAN CORPORATION

RW-00 IDENTIFIER
590.2 BASE OF UPPER ZONE ELEVATION IN FEET, MEAN SEA LEVEL

600 CONTOUR OF EQUAL ELEVATION, BASE OF UPPER ZONE IN FEET, MEAN SEA LEVEL
DASHED WHERE APPROXIMATE, QUERIED WHERE INFERRED

0 400 800
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No 4
FORT WORTH, TEXAS

BASE OF UPPER ZONE

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

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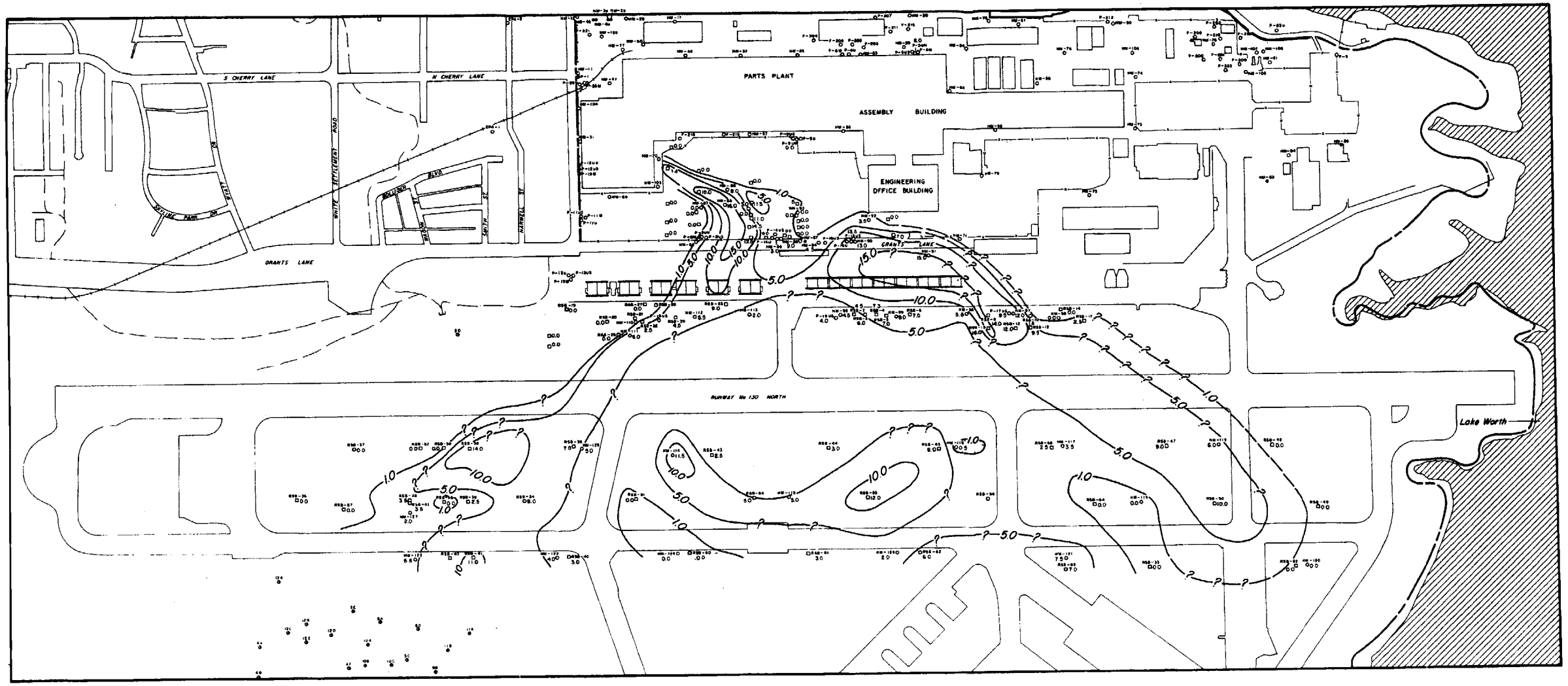
FIGURE 4

PREPARED BY REVIEWED BY

40 81



EXPLANATION

- UPPER ZONE MONITOR WELL
- ABANDONED UPPER ZONE MONITOR WELL
- PALUXY AQUIFER MONITOR WELL
  - UB Completed in upper sand unit
  - U Completed in upper Paluxy aquifer
  - UN Reconstructed in upper Paluxy aquifer
  - M Completed in middle Paluxy aquifer
  - P-3 Completed in multiple Paluxy aquifers
- ABANDONED PALUXY MONITOR WELL
- SOIL BORING
- UPPER ZONE MONITOR WELL CONSTRUCTED BY RADIAN CORPORATION

HW-14 IDENTIFIER
3.5 BASAL GRAVEL ISOPACH THICKNESS, IN FEET

5.0 ? CONTOUR OF EQUAL THICKNESS: BASAL GRAVEL ISOPACH IN FEET, DASHED WHERE APPROXIMATE QUERIED WHERE INFERRED

0 400 800
FEET

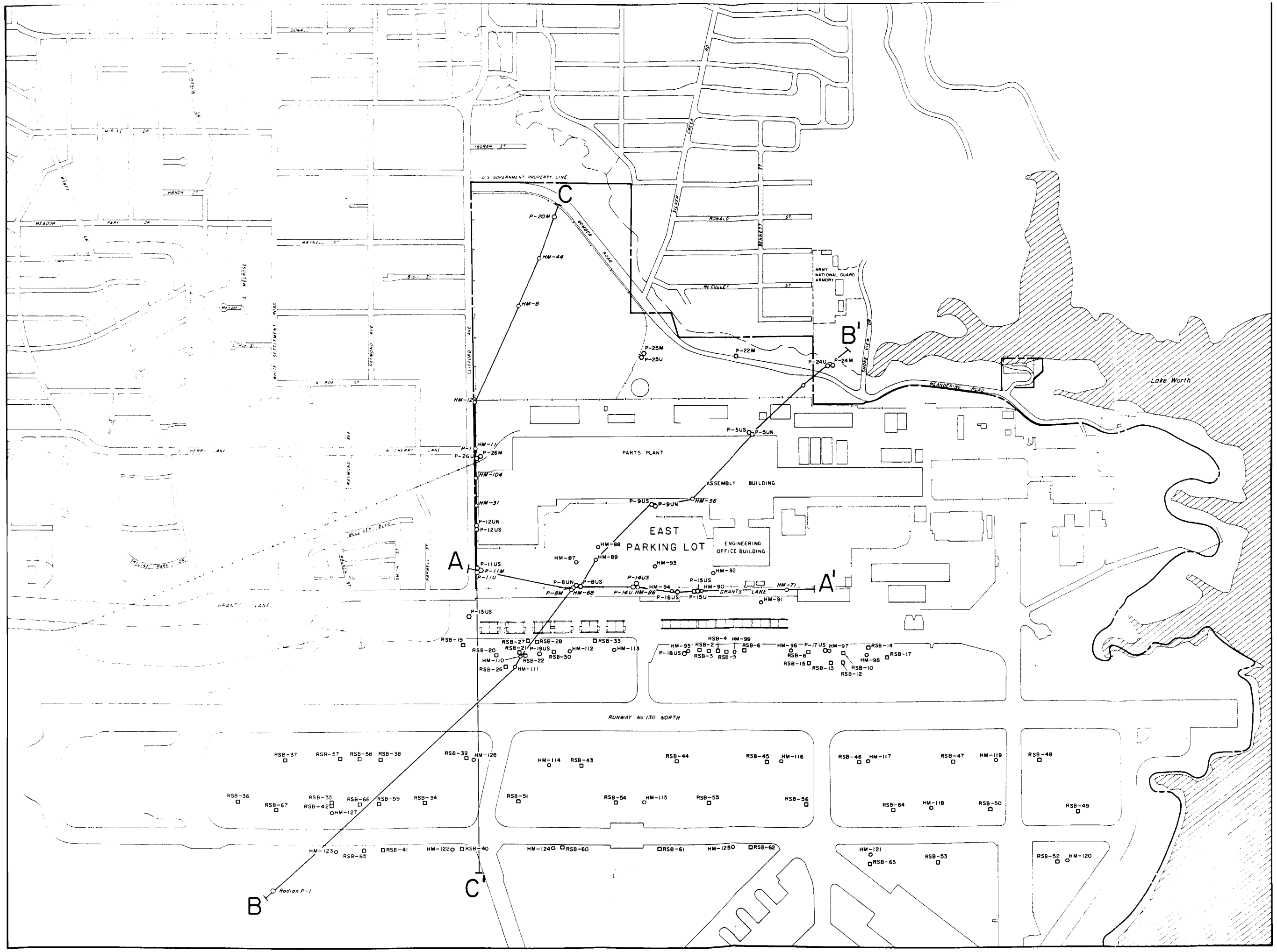
GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

BASAL GRAVEL ISOPACH

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89
FIGURE 3

PREPARED BY REVIEWED BY



EXPLANATION

CONSTRUCTED APRIL 1987 TO APRIL 1989
BY HARGIS+ASSOCIATES, INC.

- ○ UPPER ZONE MONITOR WELL
- ○ PALUXY AQUIFER MONITOR WELL
  - US Completed in upper sand unit
  - U Completed in upper Paluxy aquifer
  - UN Reconstructed in upper Paluxy aquifer
  - M Completed in middle Paluxy aquifer
- □ SOIL BORING
- HM-11 CONSTRUCTED PRIOR TO INDICATED DATES
- ● ABANDONED UPPER ZONE MONITOR WELL

A — A'

LINE OF HYDROGEOLOGIC CROSS SECTION

0 4½ 8½
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No 4
FORT WORTH, TEXAS

NEW MONITOR WELLS AND SOIL BORINGS

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/89

FIGURE 2

PREPARED REVIEWED BY

40 83

News Release

United States Air Force

AERONAUTICAL SYSTEMS DIVISION, OFFICE OF PUBLIC AFFAIRS (ASD/PA)
WRIGHT-PATTERSON AFB, OH 45433 (513) 255-2725/2726

PAM #91-060

24 ~~[illegible]~~
767-4650

TCE LEAK AT AIR FORCE
PLANT NO. 4

WRIGHT-PATTERSON AFB, Ohio, June 10, 1991--On June 3 General Dynamics Corp., the contract operator of Air Force Plant No. 4, Fort Worth, Texas, reported that approximately 800 gallons of trichloroethylene (TCE), a probable carcinogen, had leaked from a 1,000-gallon vapor degreaser tank, during May 31 to June 1.

A cement catchment sump beneath the tank is supposed to contain leaks or spills, but the sump also leaked, allowing the TCE to escape into the soil below. The tank was immediately drained to prevent further leakage. The TCE appears to be contained beneath the production plant. No immediate threat to public health or safety is anticipated.

General Dynamics notified the Environmental Protection Agency's National Response Center and State of Texas environmental agencies late on June 3. Any TCE spill greater than 8.5 gallons must be reported. General Dynamics is in the process of developing an emergency response plan that will include what cleanup actions are necessary and when they will begin.

A subsequent review of operational records for the last 18 months revealed that between 10,000 to 20,000 gallons of TCE may have leaked from the tank.

--more--

Data is being reviewed now to determine if the recent spill may have affected the quality of the ground water. It is known that there are two ground water aquifers beneath the plant, one below the other. Fort Worth takes its drinking water from the lower of the two aquifers. The upper one is not used for drinking water.

Given the quantity of the leak and the time over which it apparently occurred, it is probable that TCE has entered the ground water of the upper aquifer. There is no indication that TCE could have reached the lower one. Information concerning the soil formation, however, indicates that the TCE likely is still within the boundaries of Plant No. 4.

The degreaser tank, identified as T-544, is used by General Dynamics to clean F-16 parts prior to surface treatments. It is one of several that sits in a large, below-grade pit in the chemical processing building.

General Dynamics manufactures the F-16 aircraft under contract to the Air Force at the Fort Worth plant.

--30--

CONTACT: Mike Wallace, (513) 255-2725

Qs and As re the TCE release

Q1 Is the groundwater beneath the tank/sump part of the drinking water supply for any part of Ft. Worth?
A1 There are two aquifers--upper and lower--separated by a layer of shale; Ft. Worth drinking water is drawn from only the lower aquifer.

Q2 Are you sure that no TCE has migrated from the Air Force Plant No. 4?
A2 No we're not sure. However, knowledge of the soil formation indicates that the TCE is probably still within the boundries of AF Plant 4.

Q3 How will you get the TCE out of the soil before it does seep into the water?
A3 GD is currently developing a plan to mitigate the spill. However, an Air Force environmental contractor, Chem Nuclear Geotech of Grand Junction, Col., who is conducting an IRP groundwater investigation for the hazardous waste sites cleanup located at Plant 4 could be asked to direct their attention to the TCE problem.

Q4 Why don't you handle this spill under the Installation Restoration Program?
A4 IRP deals only with historical spills.

Q5 What's the normal usage rate from that tank of TCE over a 24-hour period?
Over a 12-18 month period?
A5 TBD

Q6 Are there other tanks near the one that leaked, and how many?
A6 Yes, two others: T-534 and T-526 share the same containment area with T-544.

Q7 What is their condition? Is anyone now inspecting them?
A7 Currently they are being inspected by General Dynamics.

Q8 If there was a high use rate over the last 12-18 months, why wasn't someone suspicious before now?
A8 TBD

Q9 What's the "hazardous waste site cleanup" you refer to in the news release?
A9 Air Force Plant 4 has several contaminated sites which are being addressed by the Air Force IRP.

Q10 What is the on-site environmental contractor doing?
A10 Conducting a remedial investigation/feasibility study to support cleanup of historic contamination at Plant 4.

Q11 When was the last time the tank that leaked was inspected?
A11 GD is examining the inspection records.

Q12 What are the health effects of too much TCE?
A12 The primary health effect would be on the central nervous system. The symptoms from large, short-term exposure are similar to those produced by alcohol intoxication. Long-term exposure to low levels of TCE can produce liver enlargement and can impair liver function. EPA concludes there is "inadequate human evidence" but "sufficient animal evidence" to label TCE as a "probable human carcinogen." Animal studies have not shown TCE to produce cancer in rats; only one species of mice has shown an increased cancer rate.

Q13 Do you have an estimate yet of how much total cleanup would cost?
A13 The cost estimate will be established when the cleanup plan is finalized.

Q14 Has GD and the Air Force ever done anything to try to replace the tanks?
A14 The Air Force and GD had identified the need to replace this and other tanks as part of a general upgrade of the chemical processes. The tank replacement was also part of an overall initiative for reducing volatile organic compound air emissions from the plant. Unfortunately, the tank had not been replaced yet.

Q15 What options were open to GD besides using the tank(s)?
A15 They could have acquired "severable" equipment--equipment that GD buys and takes with them when they vacate Plant 4 or subcontracted the degreasing work.

Q16 Explain the GOCO relationship.
A16 Air Force owns the plant; GD operates the F-16 manufacturing function.

Q17 What have you found re pollutants migrating to White Settlement in that other investigation?
A17 No indication to date of any contaminants reaching White Settlement.

Q18 Which Texas agencies did you report to?
A18 The Texas Water Commission and Local Emergency Planning Committee.

Additional Qs and As

Q19 Is there a hood above the tank to draw out the vapors?
A19 No, but there is a lid on the tank; a cooling system liquifies the vapors.

Q20 Who discovered the tank was leaking?
A20 General Dynamics operational personnel.

Q21 When did they discover it?
A21 May 31

Q22 How often does GD put TCE into the tank to refill it?
A22 As required

Q23 Has the NRC assigned a case number?
A23 Yes. 74265

Q24 Is production continuing in Plant 4?
A24 Yes

Q25 If cleanup involves disturbing the area around the tank, will it impact F-16 production?
A25 Only if the cleanup plan requires major activities on the F-16 "line."

Q26 How often did GD drain the tank and inspect it for corrosion?
A26 TBD

Q27 Describe the tank for me.
A27 The tank resembles a gigantic warming/serving tray area you'd see in a cafeteria. Instead of water to keep food hot, the tank has TCE, which when heated gives off vapors which are actually what cleans the parts placed in a shallow "tray" at the top of the tank. The tank is heated by heating coils. The parts are not immersed in the TCE, but rather the TCE vapors clean them. The various materials that come loose from the parts drop into the tank through holes in the "tray."

Q28 Are the tanks outside or inside?
A28 Inside, located in a concrete pit.

Q29 Why do I have to call Wright-Patterson AFB, ASD/PAM, to get my questions answered?
A29 ASD Public Affairs services any ASD function--including managment of government-owned, contractor operated (GOCO) plants.

Q30 How old is tank T-544?
A30 At least 10 years old.

TCE (TRICHLOROETHANE) AT CAFB.

A check with supply and Bio-Environmental confirmed that liquid TCE in its pure form is not stored or used on Carswell.

TCE, however, is found as a constituent in many products used on the base. Eighty ~~percent~~ percent of these products are aerosal types. To identify each product containing TCE would require a review of the MSDS's at each shop on the base.

Any liquid TCE still on the base would be very small quantities left over from several years ago. (5 gallon containers or less, probably no more than 25 gallons total on the base)

Hydrogeology

(Radian, 1991), combined with information summarized from earlier IRP reports (CH2M Hill, 1984; Radian, 1986, 1989).

Carswell AFB is located six miles west of Fort Worth in Tarrant County, Texas. The base is bordered by Lake Worth to the north, the West Fork of the Trinity River and the community of Westworth to the east and southeast, and Air Force Plant 4 (AF Plant 4) to the west (Figure 1-1). Figure 1-2 shows the location of the Flightline Area IRP sites.

Five major hydrogeologic units exist beneath Carswell AFB. From shallowest to deepest they are: 1) an Upper Zone of unconfined ground water occurring within the alluvial terrace deposits associated with the Trinity River; 2) an aquitard of predominantly dry limestone of the Goodland and Walnut Formations; 3) an aquifer in the Paluxy Sand; 4) an aquitard of relatively impermeable limestone in the Glen Rose Formation; and 5) a major aquifer in the sandstone of the Twin Mountains Formation. The Upper Zone was the only unit studied in this most recent Stage 2 site characterization (1990) effort. Previous IRP reports determined that contaminated ground water was only present in the Upper Zone formation. Figure 1-3 shows the general depth of occurrence and thickness of each of the major hydrogeologic units expected in the Flightline Area. The following subsections present the hydrogeologic characteristics of the Upper Zone formation and the Goodland/Walnut Aquitard that lies beneath it.

The Upper Zone ground water occurs within the alluvial deposits at Carswell AFB. Low permeability is typical of this alluvium, however, there are zones of greater permeability corresponding to sands and gravels of former channel deposits. Recharge to the water-bearing deposits is local, from rainfall and infiltration from stream channels and drainage ditches. The direction of ground-water flow is generally controlled by the bedrock topography of the Walnut Formation, and to a lesser extent by land surface topography.

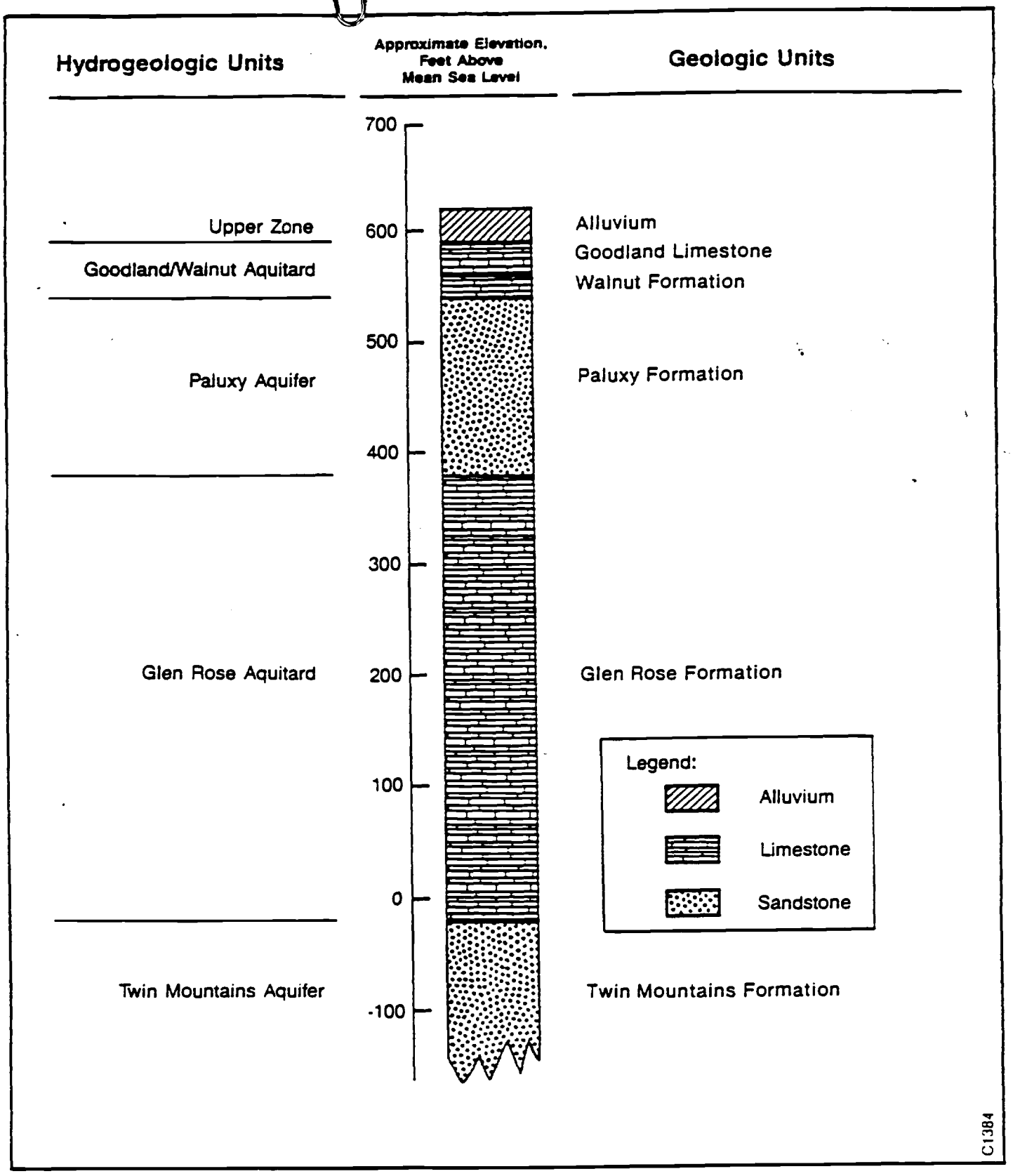


Figure 3-11. Generalized Hydrogeologic Units at Flightline Area, Carswell AFB, Texas

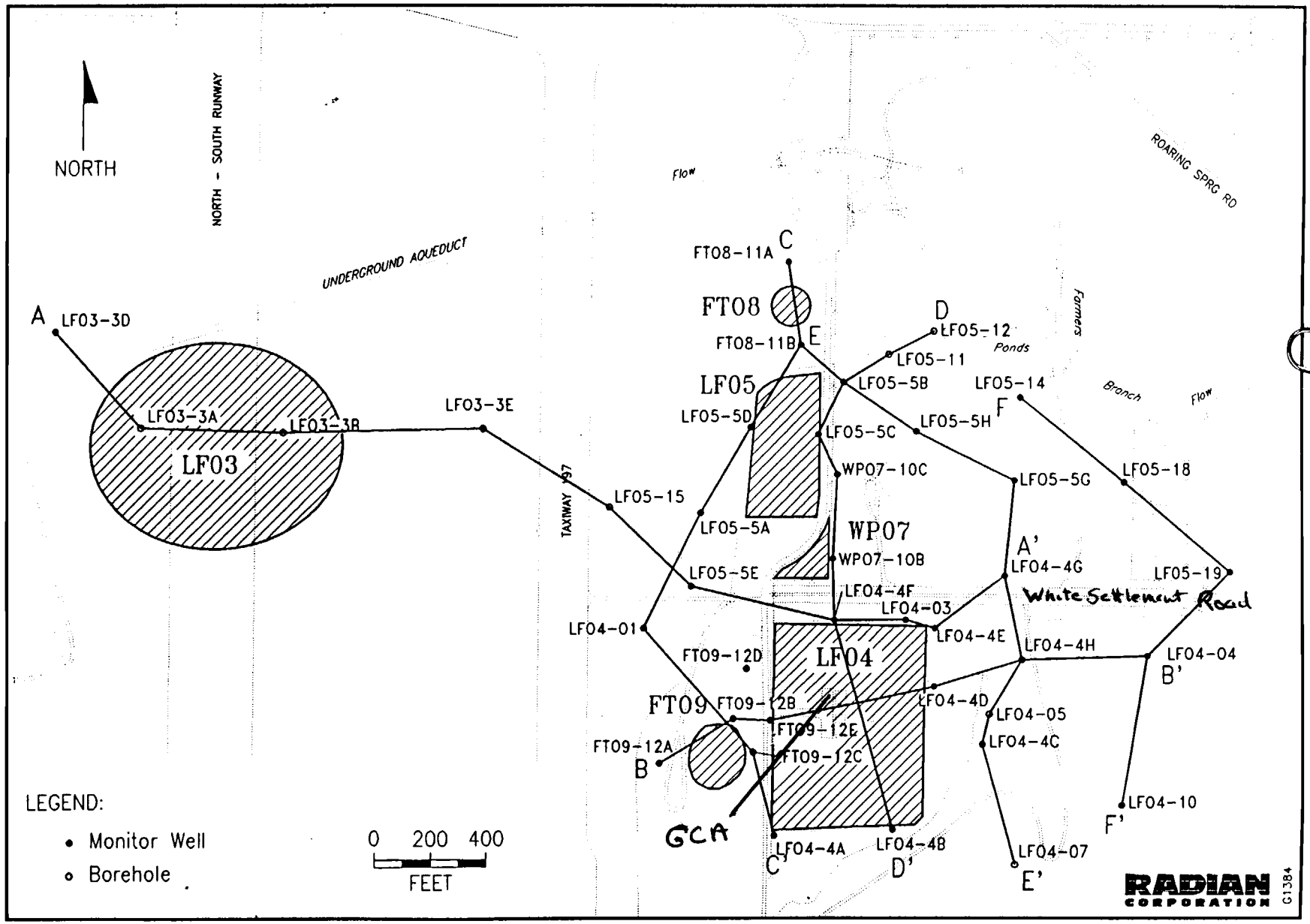


Figure 3-4. Location Map for Geologic Cross-Sections Through the Flightline Area, Carswell AFB, Texas

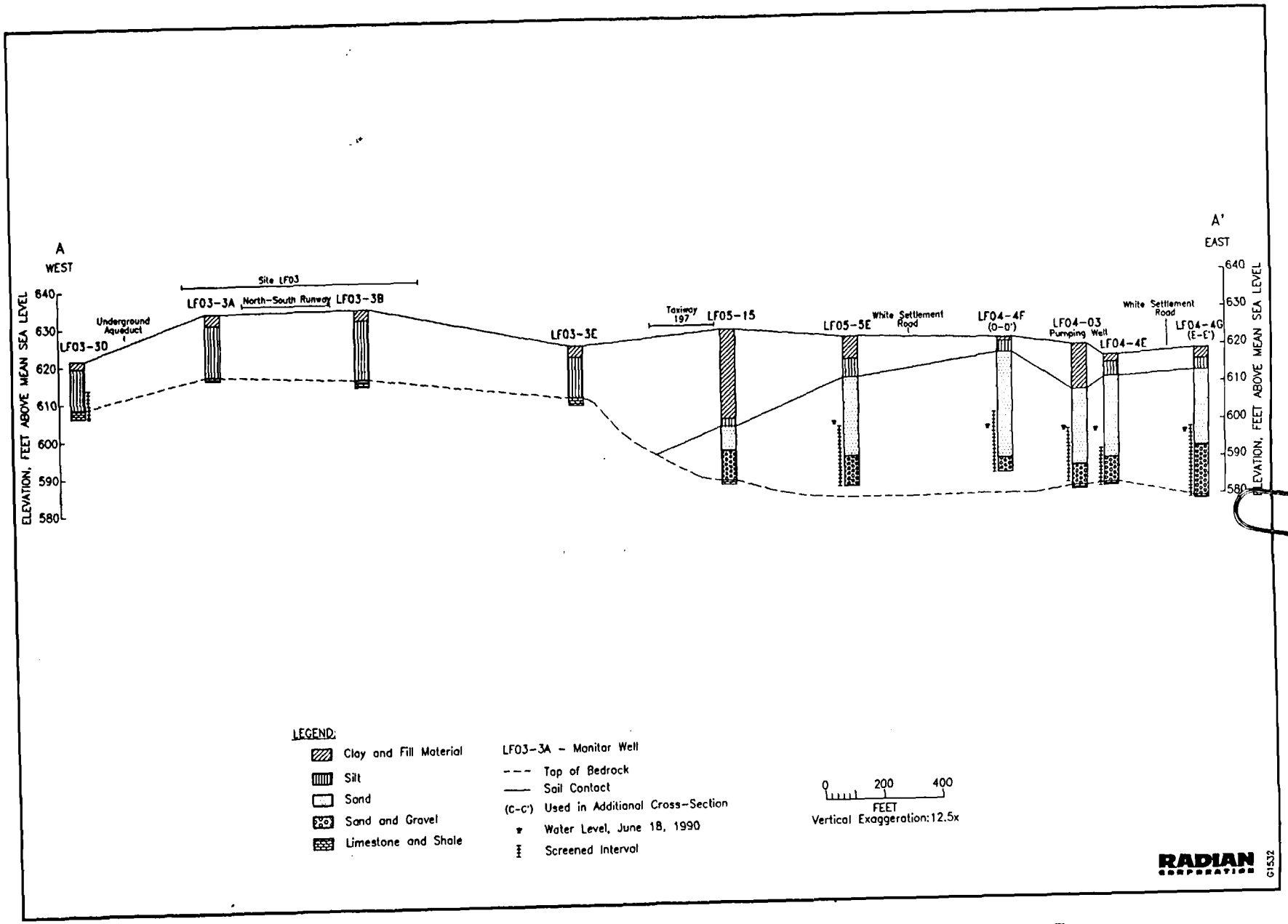


Figure 3-5. Geologic Cross-Section A-A', Flightline Area, Carswell AFB, Texas

Walnut Formations; 3) an aquifer in the Paluxy Sand; 4) an aquitard of relatively impermeable limestone in the Glen Rose Formation; and 5) a major aquifer in the sandstone of the Twin Mountains Formation. Only the first three units were investigated in the Flightline Area during the IRP, with the primary focus being on the Upper Zone. The Upper Zone was the only unit studied in this most recent Stage 2 (1990) effort. Figure 3-11 shows the general depth of occurrence and thickness of each of the major hydrogeologic units expected in the Flightline Area. Descriptions and properties of the hydrogeologic units are summarized in Table 3-2. The following subsections present the hydrogeologic characteristics of each unit based on field data and literature sources.

3.4.1 Upper Zone Aquifer

The Upper Zone ground water occurs within the alluvial deposits at Carswell AFB. Low permeability is typical of this alluvium because of the large amounts of clay and silt. However, there are zones of greater permeability in the sands and gravels of former channel deposits. Recharge to the water-bearing deposits is local, from rainfall and infiltration from stream channels and drainage ditches. The direction of ground-water flow is generally controlled by the bedrock topography of the Walnut Formation.

3.4.1.1 Ground-Water Occurrence and Flow

Table 3-3 shows the results of the synoptic water-level survey performed on 18 June 1990. Figure 3-12 is the resulting potentiometric surface map of the Upper Zone Aquifer. Ground-water flow in the Upper Zone is generally northeastward, toward Farmers Branch, a tributary to the West Fork of the Trinity River.

From the outlet of Farmers Branch from the underground aqueduct (which conveys the stream under the Flightline) the stream flows over bedrock at the Goodland/Walnut Formation until it flows into the Trinity River on the eastern boundary of Carswell AFB. The Upper zone ground-water flow through

is consistent with the lithology for the Upper Zone aquifer. The storage coefficient value calculated also falls within the range for clean, unconfined aquifers.

The hydraulic conductivity calculated from the pumping test analysis was significantly higher than that determined from prior slug testing. Based on the limitations of the slug testing discussed earlier, the aquifer pumping test results are more representative of the Upper Zone Aquifer characteristics.

3.4.2 Goodland/Walnut Aquitard

The ground water present in the alluvium is separated from the aquifers below by the low permeability limestones and shales of the Goodland Limestone and Walnut Formation. The aquitard is composed of moist clay and shale layers interbedded with dry limestone beds. Though the Formations are primarily dry, drillers in the area report that small amounts of water enter the borehole while drilling through the Walnut Formation, suggesting that ground water may be moving through the Walnut Formation along bedding planes (Hargis and Associates, 1985). The thickness of the Goodland/Walnut aquitard is approximately 30-40 feet beneath the Flightline Area at Carswell AFB. This thickness is based on two monitor wells drilled through the aquitard and completed in the Paluxy Aquifer during the initial Stage 2 study (Radian, 1989). However, the top of the aquitard is an erosional surface and erosion may have reduced the thickness of the limestone or eroded it entirely in isolated areas, (e.g., at AF Plant 4 beneath Building 189 along Grants Lane, the Goodland Limestone is completely absent and only three feet of the Walnut Formation are present (Hargis and Associates, 1985)).

3.4.3 Paluxy Aquifer

The Paluxy Aquifer, the areal extent of which is shown in Figure 3-13, is the shallowest bedrock aquifer underlying Carswell AFB. In the Carswell AFB area, water in the uppermost part of the Paluxy Formation would

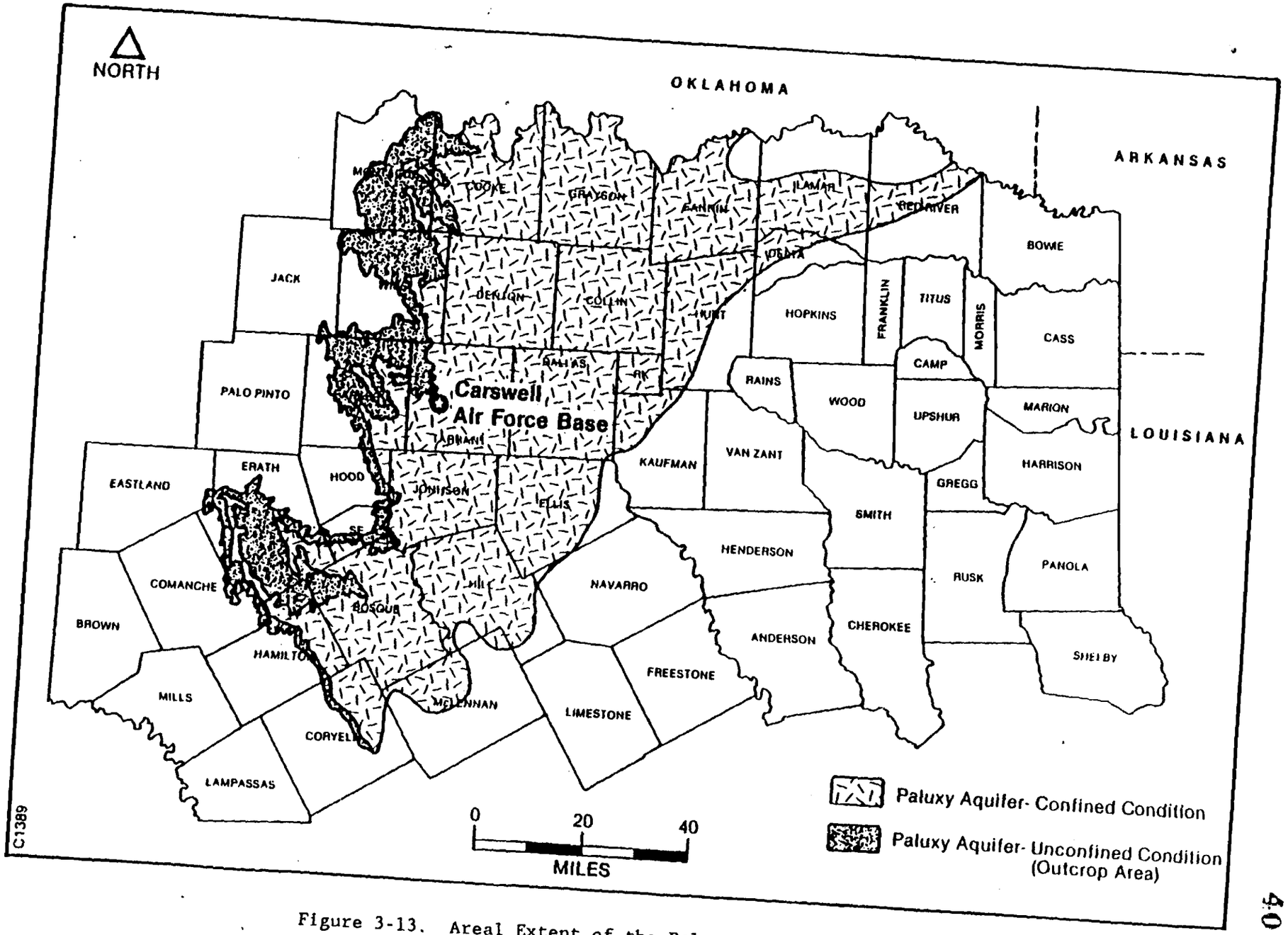


Figure 3-13. Areal Extent of the Paluxy Aquifer, North Texas

naturally occur under confined conditions beneath the Goodland/Walnut aquitard (except where the aquitard has eroded away, as discussed above). However, extensive ground-water pumping in the Fort Worth area, including the City of White Settlement, has lowered the Paluxy Aquifer potentiometric surface below the top of the formation, resulting in unconfined conditions beneath the base. Water-level measurements taken in the Flightline Area Paluxy wells (P-1 and P-2), found the water level to be about five feet below the top of the formation, or about 75 feet below land surface. With the Paluxy Formation having an upper and lower sand member, and the lower member having larger grain size and higher permeability, most water wells are completed in the lower section of the Paluxy Aquifer.

Recharge to the Paluxy Aquifer occurs where the formation crops out west of Carswell AFB in the AF Plant 4 area. The Paluxy Formation also crops out north of the base in the bed of Lake Worth. The lake is a major recharge point for the aquifer and creates a potentiometric high in its vicinity. Regional ground-water flow within the Paluxy Aquifer is southeastward in the direction of the regional dip. At Carswell AFB, ground-water flow is influenced by recharge from Lake Worth, which creates a potentiometric high, and by ground-water withdrawals by the community of White Settlement. This drawdown results locally in a more southerly flow direction within the Paluxy Aquifer.

Transmissivities in the Paluxy Aquifer range from 1,263 to 13,808 gallons per day per foot (gpd/ft), and average 3,700 gpd/ft (CH2M Hill, 1984). The Paluxy Formation thickness ranges from 140 to 190 feet, averaging 160 feet in Tarrant County. The actual water-bearing thickness in the Carswell AFB area probably approximates the formation thickness, but the aquifer is separated into two distinct water-bearing zones, denoted as the upper and middle/lower Paluxy. In some cases, the middle and lower Paluxy are also separated by low-permeability layers. The Paluxy dips uniformly at a rate ranging from 35 to 40 feet per mile and averaging 37 feet per mile. It is encountered at increasing depths eastward, reaching a maximum depth of about 900 feet. During the Phase II Stage 1 Flightline Area investigation (Radian, 1986), short-term aquifer tests (pumping and recovery) were conducted in the

Paluxy Aquifer monitor wells P-1 and P-2. Recovery test data analysis indicates the transmissivity of the upper Paluxy is approximately 1750 gallons per day per foot (235 square feet per day).

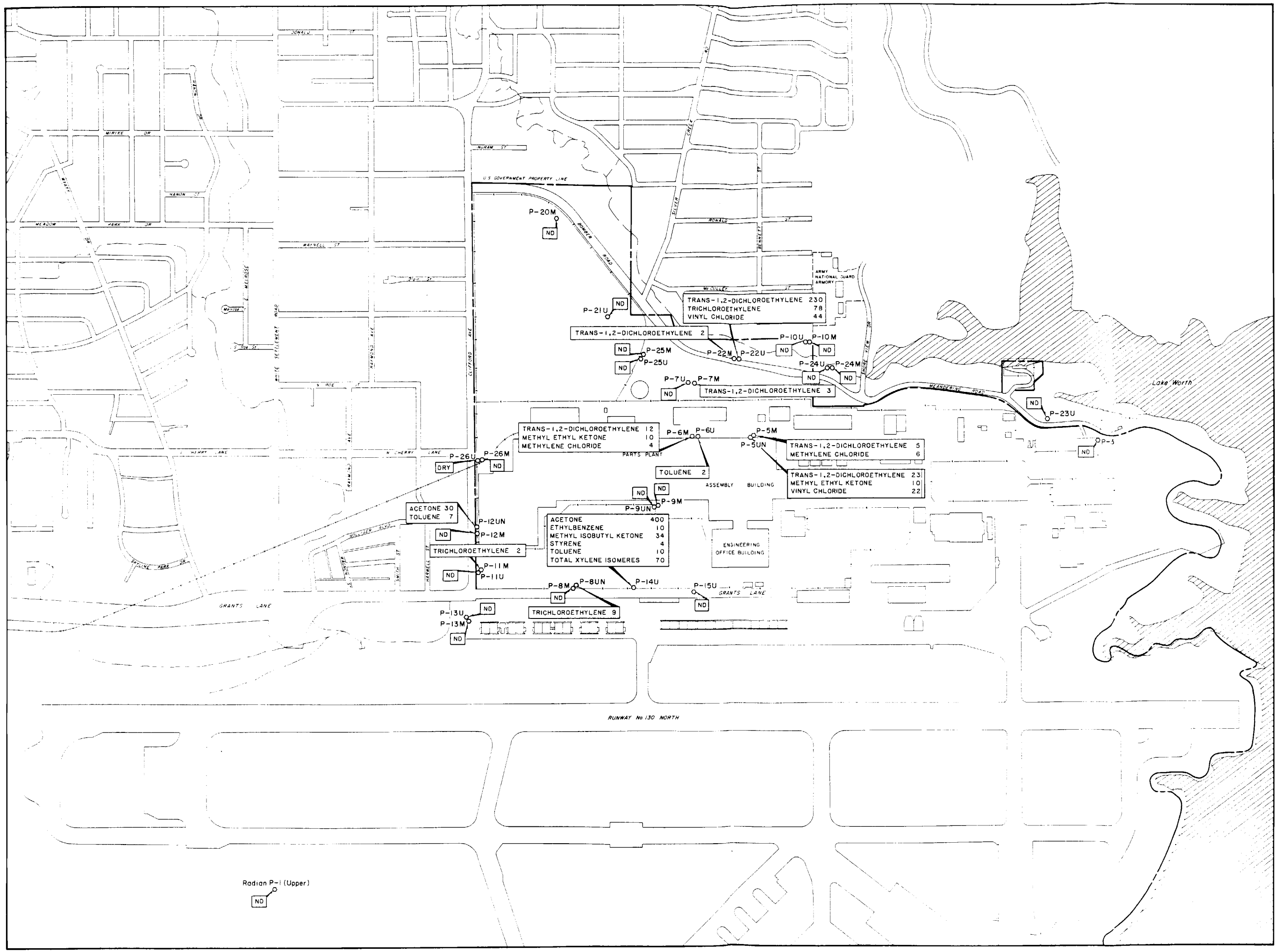
3.4.4 Glen Rose Aquitard

Below the Paluxy Aquifer are the fine-grained limestone, shale, marl, and sandstone beds of the Glen Rose Formation. The thickness of the formation in the vicinity of Carswell AFB reportedly ranges from 250 to 450 feet. Although the sands in the Glen Rose Formation yield small amounts of water to wells in Fort Worth and western Tarrant County, the relatively impermeable limestone is an aquitard restricting water movement between the Paluxy Aquifer above and the Twin Mountains aquifer below.

3.4.5 Twin Mountains Aquifer

The Twin Mountains Formation is, geologically, the oldest formation used for water supply in the Carswell AFB area. The formation occurs approximately 600 feet below Carswell AFB. The thickness of the formation ranges from 250 to 430 feet.

Recharge to the Twin Mountains Aquifer occurs west of Carswell AFB, where the formation crops out. Ground-water movement is eastward in the downdip direction. Like the ground water in the Paluxy Aquifer, Twin Mountains ground water occurs under water-table conditions in the recharge area and becomes confined as it moves downdip. Transmissivities in the Twin Mountains Aquifer range from 1,950 to 29,700 gpd/ft and average 8,450 gpd/ft in Tarrant County. Hydraulic conductivities range from 8 to 165 gpd/ft^2 and average 68 gpd/ft^2 in Tarrant County (CH2M Hill, 1984).



EXPLANATION

○ PALUXY AQUIFER MONITOR WELL

- U Completed in upper Paluxy aquifer
- UN Reconstructed in upper Paluxy aquifer
- M Completed in middle Paluxy aquifer
- P-3 Completed in multiple Paluxy aquifers

P-6U IDENTIFIER

TOLUENE 2

- CONCENTRATION, IN MICROGRAMS PER LITER
- VOLATILE ORGANIC COMPOUND

ND = NONE DETECTED

NOTE: BASED ON SAMPLES COLLECTED APRIL 1989 OR MOST RECENT DATA

0 400 800 FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

VOLATILE ORGANIC COMPOUNDS UPPER AND MIDDLE PALUXY AQUIFERS

HARGIS - ASSOCIATES, INC.
Consultants in Hydrogeology
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FIGURE 3

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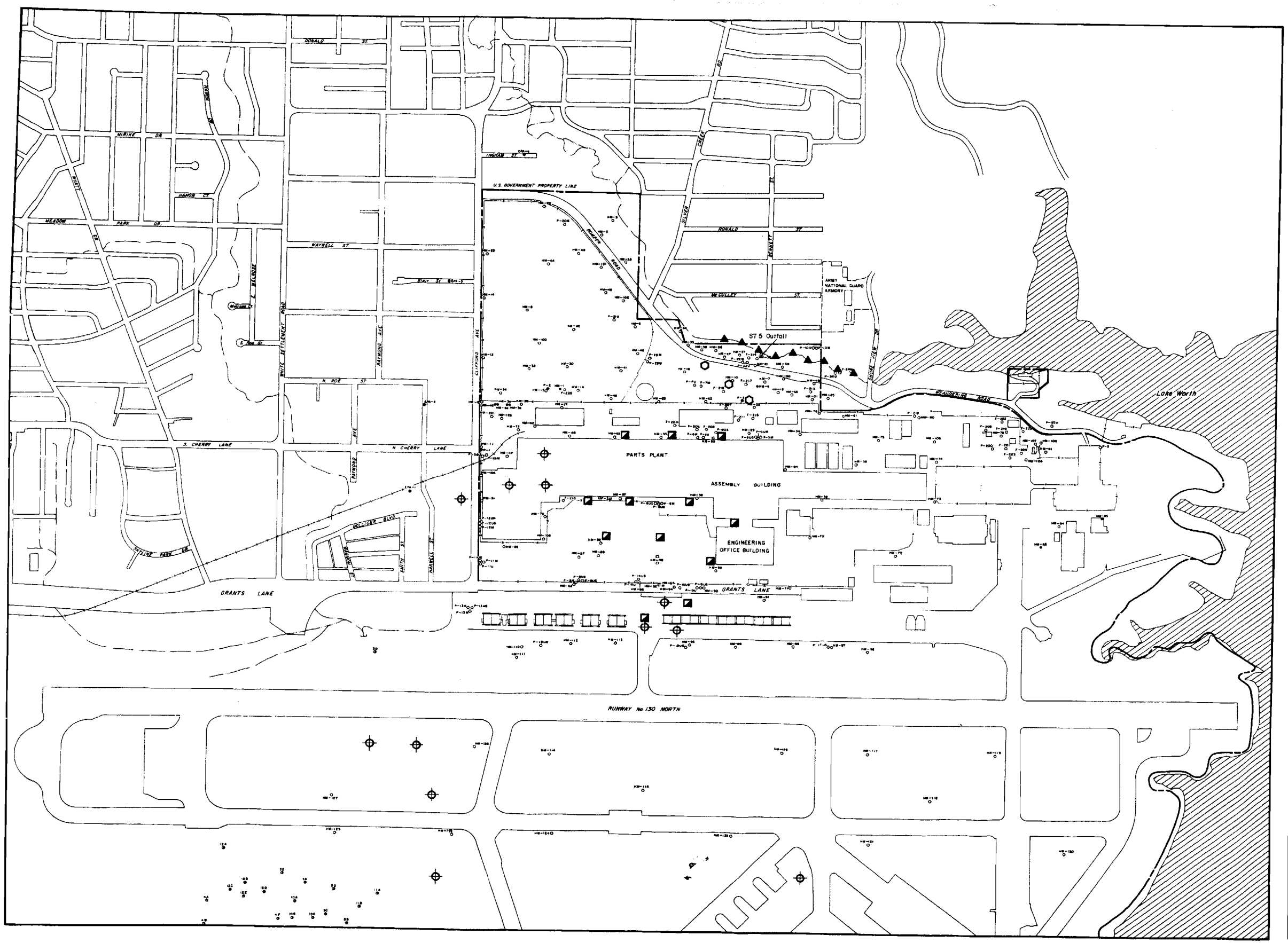

EXPLANATION

- UPPER ZONE MONITOR WELL
- ABANDONED UPPER ZONE MONITOR WELL
- UPPER ZONE MONITOR WELL CONSTRUCTED BY RADIAN CORPORATION
- PALUXY AQUIFER MONITOR WELL
  - US Completed in upper sand unit
  - U Completed in upper Paluxy aquifer
  - UN Reconstructed in upper Paluxy aquifer
  - M Completed in middle Paluxy aquifer
  - P-3 Completed in multiple Paluxy aquifers
- ABANDONED PALUXY AQUIFER MONITOR WELL
- APPROXIMATE LOCATION OF PROPOSED UPPER ZONE MONITOR WELL
- APPROXIMATE LOCATION OF PROPOSED EXPLORATORY BORING IN MEANDERING ROAD CREEK BED
- APPROXIMATE LOCATION OF PROPOSED UPPER SAND EXPLORATORY BORING AND POTENTIAL UPPER SAND MONITOR WELL
- APPROXIMATE LOCATION OF PROPOSED UPPER AND MIDDLE PALUXY MONITOR WELLS

0 400 800
FEET

GENERAL DYNAMICS CORPORATION
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

RECOMMENDED
ADDITIONAL INVESTIGATIONS

HARGIS + ASSOCIATES, INC.
Consultants in Hydrogeology
San Diego, California

7/69

FIGURE 20

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FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE