Summer 1987

Site characterization of Riverfront Park, Kansas City, Missouri, for the purpose of hazardous waste site remediation

Helen Hudson Scannell

SITE CHARACTERIZATION OF RIVERFRONT PARK,

KANSAS CITY, MISSOURI,

FOR THE PURPOSE OF HAZARDOUS WASTE SITE REMEDIATION

BY

HELEN HUDSON SCANNELL, 1963-

A THESIS

Presented to the Faculty of the Graduate School of the

UNIVERSITY OF MISSOURI-ROLLA

In Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE IN GEOLOGICAL ENGINEERING

1987

Approved by

Allen W. Hatheway (Advisor) _______________

____

ABSTRACT

Riverfront Park, Kansas City, Missouri is located on a point bar along the Missouri River. Portions of the site have historically been used (1950 - 1973) as a municipal landfill receiving residential, commercial and industrial wastes. Relatively high concentrations of elemental lead have been found in small areas of the surface soil within the limits of the Park. Chemicals that may be present in the landfill wastes create a potential for groundwater contamination. A Remedial Investigation, including a series of groundwater monitoring wells is necessary to characterize groundwater geochemistry and flood-induced changes in groundwater flow direction, and to assess any potential environmental problems. During monitoring well installation and groundwater sampling, measures should be taken to obtain parameters for calibration of a computer program that could be used to simulate rates and magnitude of contaminant transport in site groundwater, if such is found to be present. Historical information gathered and data evaluation should be of applied value in determining future sampling or possible remedial action to be utilized at Riverfront Park.

ACKNOWLEDGEMENTS

The author wishes to express her gratitude to all the understanding and supportive individuals who have surrounded her during her studies.

The assistance of Dr. Allen W. Hatheway, Dr. C. Dale Eli frits and Dr. Bobby G. Wixson, all members of the author's committee is greatly appreciated. Funding for this research was made possible through a grant from the City of Kansas City for which the author would like to express her gratitude. Thanks also goes Dr. Cary L. McConnell (UMR) and to Mr. Jeffery Imes, of the US Geological Survey, Roll a, for their help and support.

I would like to thank my parents whose continual support and encouragement throughout my education were invaluable.

Finally, I want to extend my greatest thanks to my fiance, Brett Mongino, for his endearing love and patience which was a major factor in the completion of this work.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

This thesis characterizes Riverfront Park, Kansas City, Missouri as a municipal and industrial landfill representing possible environmental hazards. Information from previous site investigations and reports on another nearby uncontrolled waste disposal site was used to preliminarily characterize the geology, hydrology, wastes, and potential environmental hazards at the site. This report includes suggestions for future Remedial Investigation activities that could be carried out in order to complete the site and waste characterization. The combination of the environmental characterization and the hazard assessment which this thesis presents should provide a useful basis from which a Work Plan (United States Environmental Protection Agency (USEPA) standard procedure) for a Remedial Investigation and Feasibility Study could be developed.

Wastes deposited over the 23-year (1950-1973) history of Riverfront Landfill are believed to contain isolated caches of chemicals which, if they remain unburned, may be potentially hazardous to human health. The goal of remediation of uncontrolled hazardous waste sites (UHWS) is to protect the populace from associated environmental threats. The ultimate, post-remediation use of this land is still undetermined. Presently, the Kansas City Parks and Recreation Department is contemplating redevelopment into a recreational park and nature preserve. This thesis has been compiled with that general goal in mind.

II. METHOD OF INVESTIGATION

Formulation of this thesis involved three phases of research. The first phase required collection of existing information, data or technical reports regarding the Riverfront Park site area. The second phase was an initial chemical characterization of the potentially hazardous wastes that may be present at the site. The third phase was to determine what information was lacking from the first two phases and to suggest how these data needs could be fulfilled by a proper Remedial Investigation.

The First-Phase literature search began at the files of the City of Kansas City, Missouri. This information was supplemented by files on Riverfront Park found at the Kansas City office of USEPA Region VII (EPA), Missouri Department of Natural Resourses (MDNR), US Army Corps of Engineers (COE; Kansas City District) and at the Water Resources Center of the US Geological Survey, Roll a (USGS). Other sources include University of Missouri- Roll a Geological Engineering, Civil Engineering, and Chemistry Departments, the Missouri State Highway and Transportation Department and consulting engineering firms in Kansas City, Missouri. Documents which include personal accounts of historic landfill operations, sequential historic aerial photography, and data acquired through an engineering geologic field investigation were utilized to complete this thesis. The information was used to develop a general site history and to characterize the site in terms of geology, hydrology and potential waste-related hazards present at the site.

The second phase of study was an initial characterization of the wastes determined from sampling information discovered during first-phase research. Chemical properties, pathways of contaminant transport and environmental impact were researched with respect to the uncontrolled disposal of hazardous chemicals. Sources for this research included chemistry texts, EPA Technical Research Documents (TRD's), handbooks on industrial chemicals, and reference books on groundwater contamination and waste management. The results of this study may influence the choice of exploration and sampling techniques employed during the Remedial Investigation.

Finally, the third phase of this study has evaluated the information gathered during the first two phases of the investigation and suggested possible studies that would provide necessary supplementary information. As information is presented throughout the thesis, possible future investigations are suggested, along with general specifications as to the type and level of information that would be beneficial. Important information determined during previous investigations is summerized in the conclusion. Suggested additional investigations are summarized in the recommendation section of this thesis.

III. SITE DESCRIPTION

A. LOCATION AND LAYOUT

Riverfront Park is located along the southern bank of the Missouri River floodplain, in northeastern Kansas City, Missouri (Figure 1). The Park occupies approximately 180 ha (450 acres) of largely underdeveloped land, about 5.6 km (3.5 miles) in length, in Sections 15, 16, 17, and 18, T50N, R32W (Figure 2). From 1950 until 1973, this area was operated by the City of Kansas City Public Works Department (PWD), as an unregulated landfill for disposal of municipal and industrial wastes, in a variety of forms.

Topographically, the Park is relatively flat, supporting vegetation and animal life typical of a floodplain ecosystem. For convenience in site description, the area has been subdivided (Rudy, 1984) into three parts. Figure 2 shows the boundries of the designated areas and the on-site versus off-site limits. Area 1 is west of the Chouteau Bridge; Area 2 lies between the Chouteau Bridge and 1-435; leaving Area 3 east of 1-435.

B. CHRONOLOGIC SITE HISTORY

Table I lists the historic events which have occurred during the operational and post-operational periods at the landfill. The 1857 flood is described in further detail in Section IV. A description of landfill operations appears in the following section. Much of the information concerning the site history was extracted from an unpublished 1983 report to the City of Kansas City; Preliminary Characterization of Historic Landuse at Riverfront Site by Dale K.

Figure 1 - Riverfront Park Site Location Map (from Burns and McDonnell Engineering Co. et al., 1984)

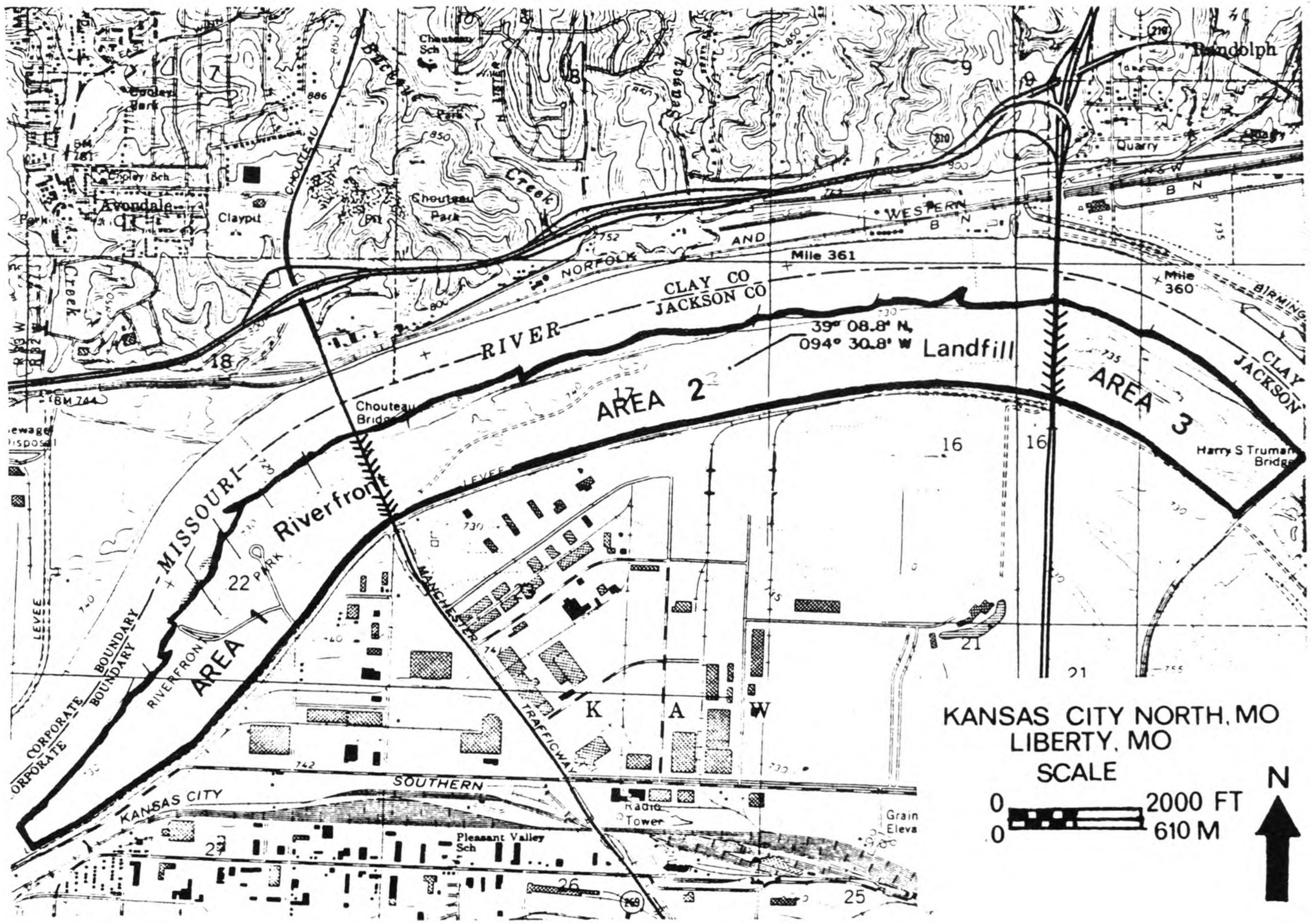


Figure 2 - USGS 7.5 minute Topographic Map (North Kansas City, MO - Kans./ Liberty, MO Quads) showing Site Location and Areas designated by USEPA Region VII

TABLE I

SITE CHRONOLOGIC HISTORY

1857	Flood erosion and redeposition changes the location of the Missouri River channel in the vicinity of the site, resulting in a general shift of the channel to the northeast, into its present location.
1950	Landfill operations begin.
1968	Kansas City passes a no-burning ordinance. Approximately 150,000 fifty-five gallon steel drums, previously used as residential backyard incinerators, are buried at Riverfront Landfill.
1973	Landfill closed.
1981	Baseball diamonds and boat ramp constructed.
1982	EPA becomes aware of possible environmental threats at Riverfront Park.
1983	EPA completes a preliminary site assessment. Nine observation wells installed by Terracon Consultants. Soil and groundwater samples collected and analayzed by EPA Region VII/FIT (Rudy, 1984).
1984	Geophysical study completed by EPA/FIT (contractor Ecology and Environment, Inc.; Rudy, 1984).
1985	Riverfront Park closed by Kansas City Parks and Recreation Department, as a result of high lead concentrations found in surface soil samples.
1986	Consent decree signed for conduct of RI/FS, by the City of Kansas City.

Wilson and C. Dale Elifrits of the University of Missouri-Rolla. In this report, a series of historic panchromatic aerial photographs of the site, dating from 1952 to 1982, were interpreted.

In 1973, the last active area of the landfill was closed and a final cover was completed. A number of years passed before the area was used for recreational purposes. Wilson and Elifrits (1983), noticed in a 1975 photograph that the site had been naturally reworked by flooding and had become partially revegetated, but that evidence of human activity was not apparent. It is likely that recreational use of the area began in the mid to late 70's. In 1981, Area 1 was partially covered with a loess from an offsite location, on which baseball diamonds were constructed. At the same time a boat ramp was constructed as an emergency access for municipal fire truck water supply and as a public river access for boats. Personal communication (1986) with Steve Wendlen, a resident of Kansas City, indicates that Area 1 also was used at least once (perhaps 8 or 10 years ago) as a location for July 4th fireworks displays.

In October, 1985, during a visit to the site, the author noticed that the park was being utilized by individuals as a place to "party" and to ride small motorized vehicles of a wide variety. Areas 1 and 2 have an abundance of "dirt bike" trails near the edge of the landfill.

It wasn't until 1982 that USEPA Region VII became aware of the possible threats associated with the unregulated disposal of wastes at Riverfront Landfill. EPA Region VII officials authorized a Site Investigation Analysis (SIA) by their Field Investigation Team (FIT) contractor (Ecology and Environment, Inc.) to include surface and near-surface soil sampling. Terracon Consultants were also sub-contracted, at that time, to install nine monitoring wells in order to evaluate groundwater quality. The Park was closed in 1985 by the Kansas City Parks and Recreation Department as a result of EPA laboratory analyses indicating excess quanitities of lead in some of the surficial soil samples. EPA Region VII officials were concerned that these high lead concentrations could pose a threat to humans who might inhale/ingest dust or have dermal contact with surface soils.

C. HISTORY OF LANDFILL OPERATIONS

1. Site Operations

Information on site operations was taken from a June 1982 Preliminary Assessment of the Riverfront Landfill (Chouteau Landfill) prepared by the EPA Region VII/FIT contractor, Ecology and Environment, Inc. (Kwoka and Krohn, 1982) and the "Full Field Investigation" (actually a Site Investigation Analysis) of Riverfront Landfill (Rudy,1984) completed by the same organization. The information is supplemented by the 1983 report of Wilson and Eli frits.

The landfill superintendant for the Kansas City, Missouri Department of Public Works (DPW) from 1963 to 1972 was Mr. Willard Winsor. Mr. Winsor has provided EPA with a great deal of information relating to landfill operations during these years (Kwoka and Krohn, 1982). The types of wastes that were deposited included municipal, construction and industrial wastes. Most of these materials were subjected to uncontrolled burning until the City prohibited open burning in 1968. At this time approximately 150,000 208-liter (fifty-five gallon) steel drums, previously used as residential backyard incinerators, were collected at residential curbsides and buried, by the City, in Area 3 of the site.

Site disposal operations were conducted without engineered design; that is, no liners, leachate collection systems, or multi-layer final covers, were established. Liquid and solid wastes were dumped into trenches, excavated close to the depth of the groundwater surface (approximately 4.5 m; 15 feet) and burned or covered with reworked soil local to the area. It was suggested by Mr. Winsor that some wastes had been dumped directly into the river and that midnight dumping and burning was common due to the lack of physical security at the site (Kwoka and Krohn, 1982).

According to Mr. Alfred Beck, DPW Operations Engineer, the landfill operations began west of Chouteau Bridge, in the early 1950's, and were extended eastward into the other available areas of the site (Kwoka and Krohn, 1982). About 75 percent of the available area was used for landfilling. Study of historic aerial photographs by Wilson and Eli frits (1983) confirmed this statement. Figures 3 through 7, from their 1983 report, show the progression of activities across the site from, 1952 to 1975.

2. Potential Waste Origins

Due to the unregulated nature of the historic landfilling operation, precise identification of chemistry or disposal locations of any wastes that may have been disposed at Riverfront Landfill site is impossible. The initial responsibility of site remediation has been directed to the City of Kansas City, which is regarded by USEPA Region VII as the nominal owner of the property. Sources of hazardous waste are identified in the EPA Technical Research Document Hazardous Waste Land Treatment (Brown, K.W. and Assoc., Inc., 1980).

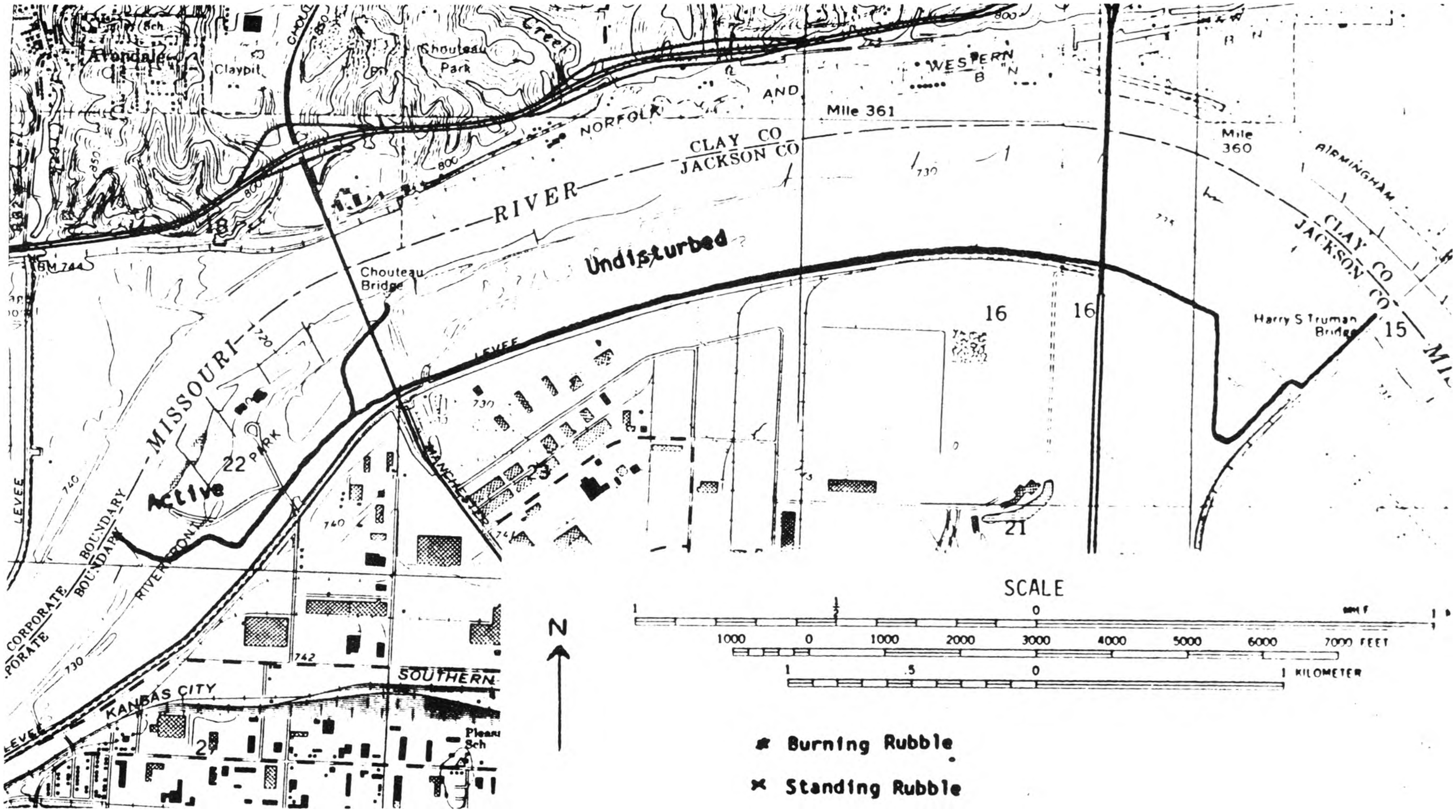


Figure 3 - Extent of 1952 Landfill Activity (from Wilson and Eli frits, 1983)

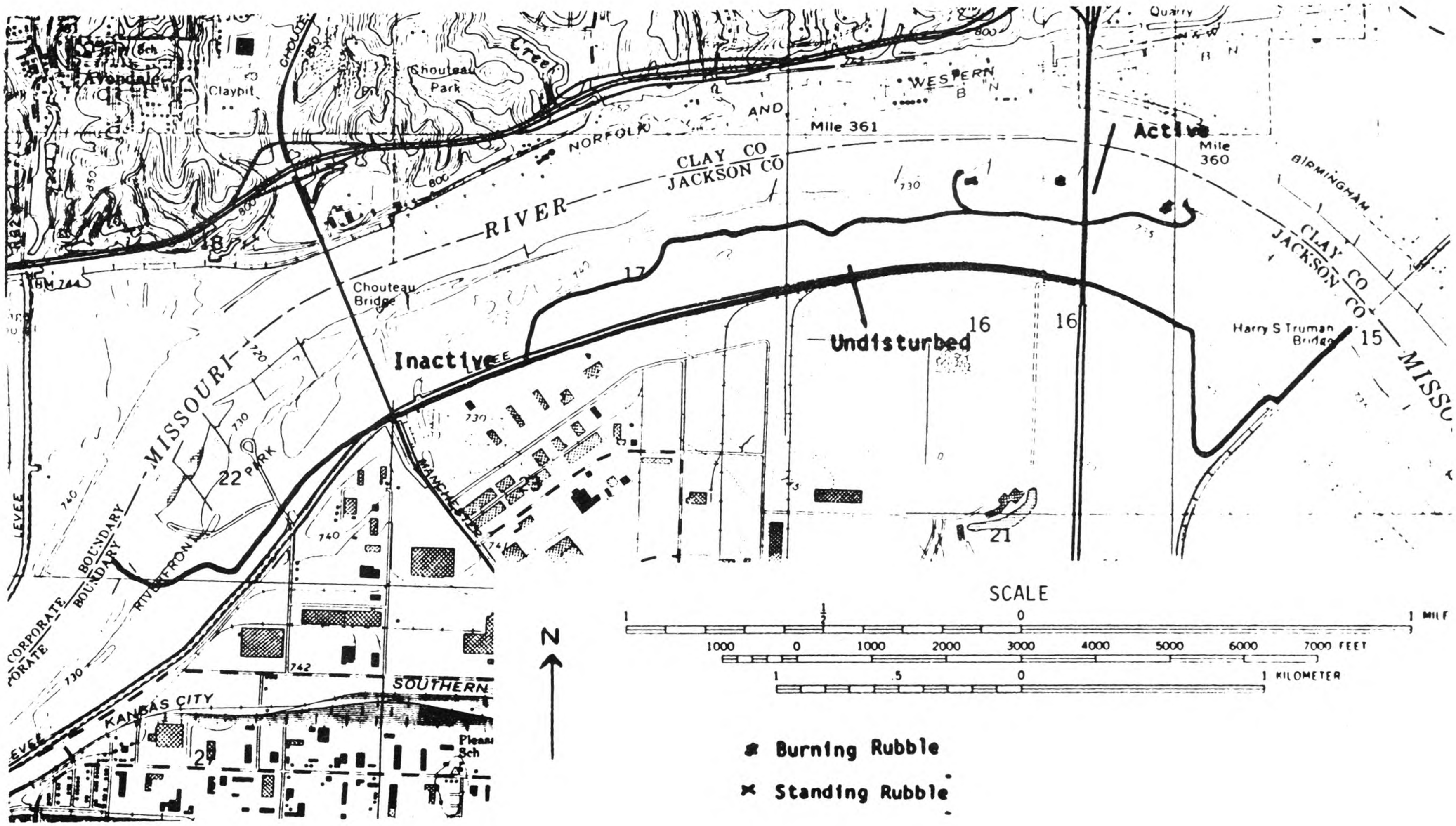


Figure 4 - Extent of 1964 Landfill Activity (from Wilson and Elifrits, 1983)

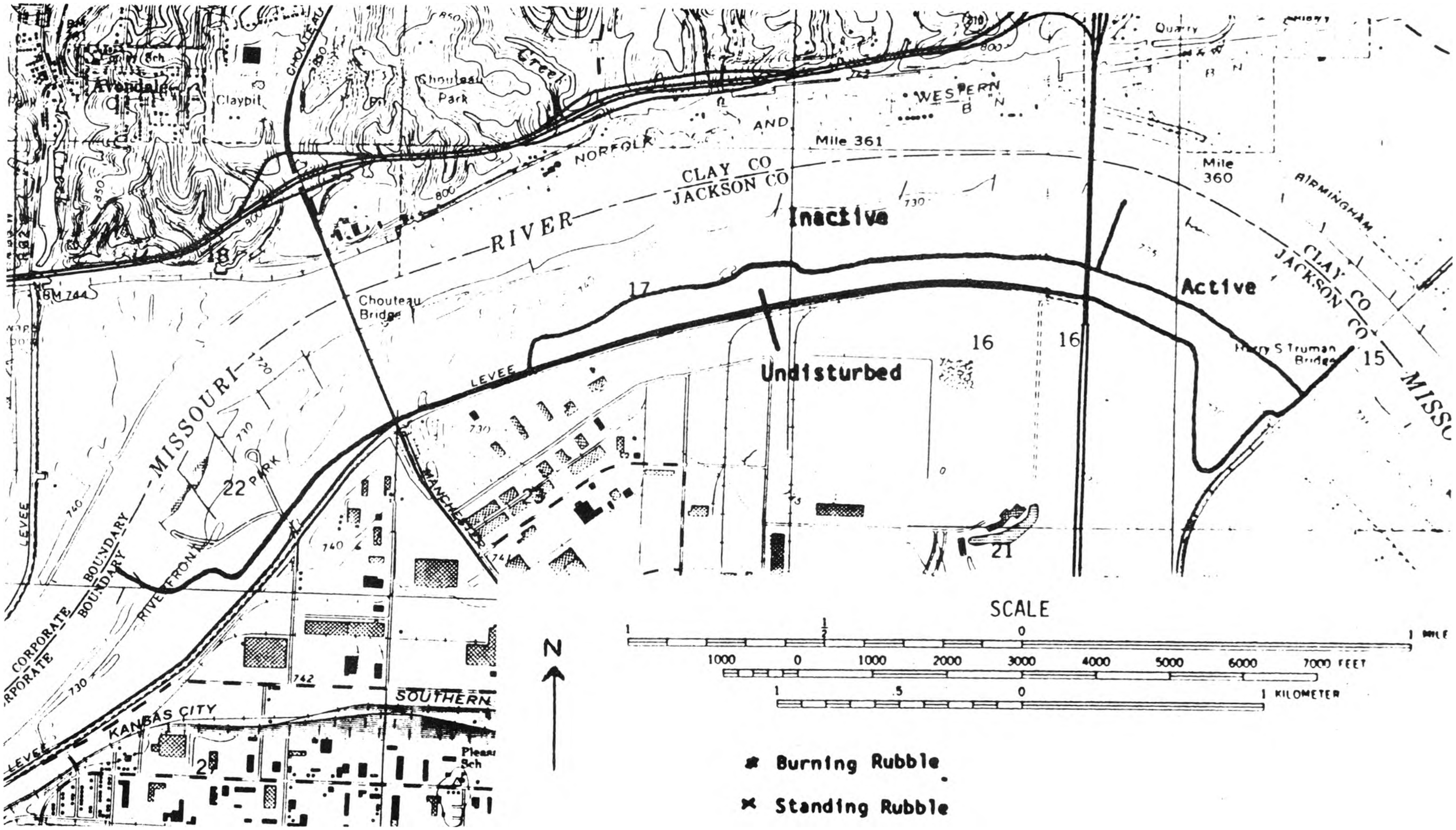


Figure 5 - Extent of 1967 Landfill Activity (from Wilson and Elifrits, 1983)

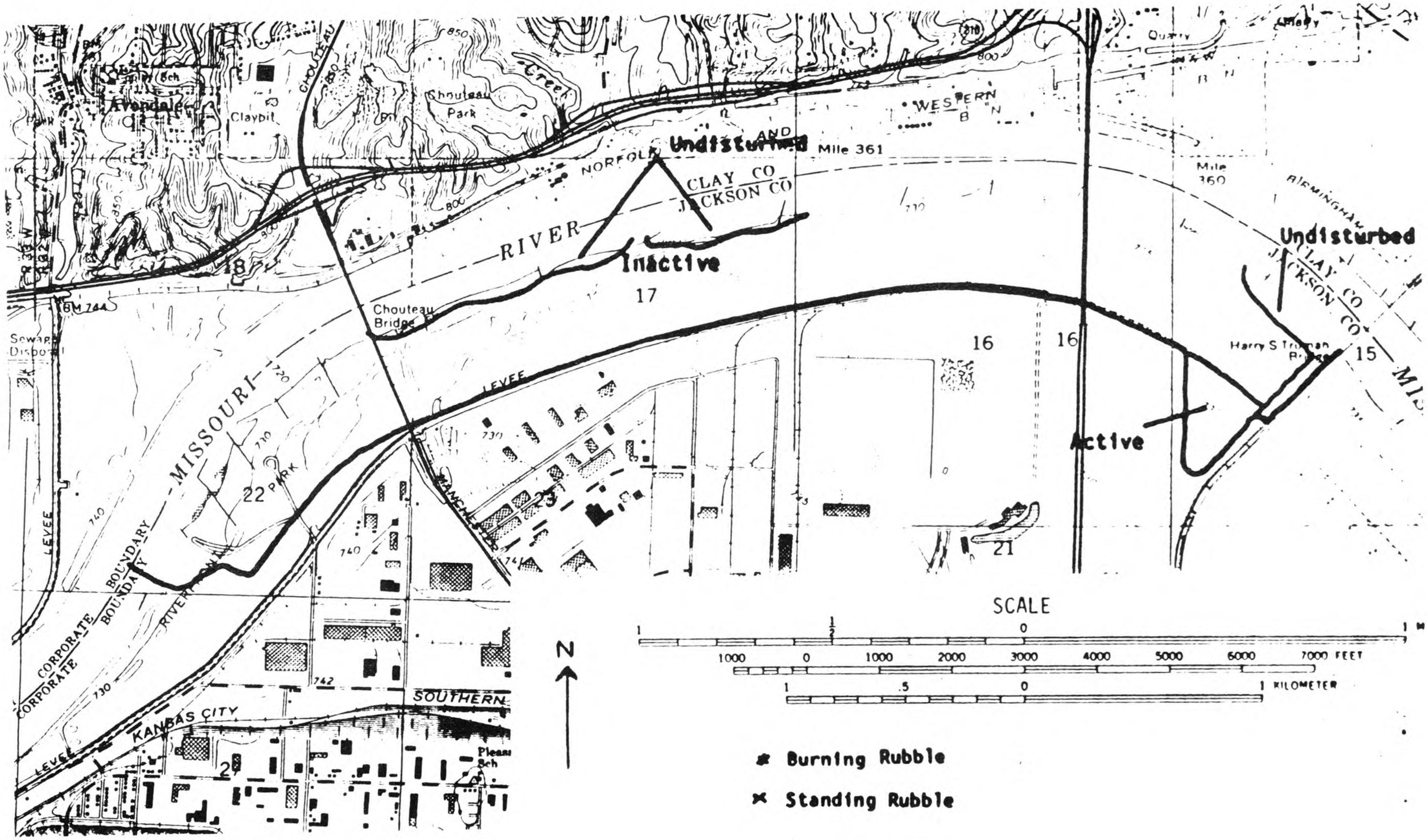


Figure 6 - Extent of 1973 Landfill Activity (from Wilson and Eli frits, 1983)

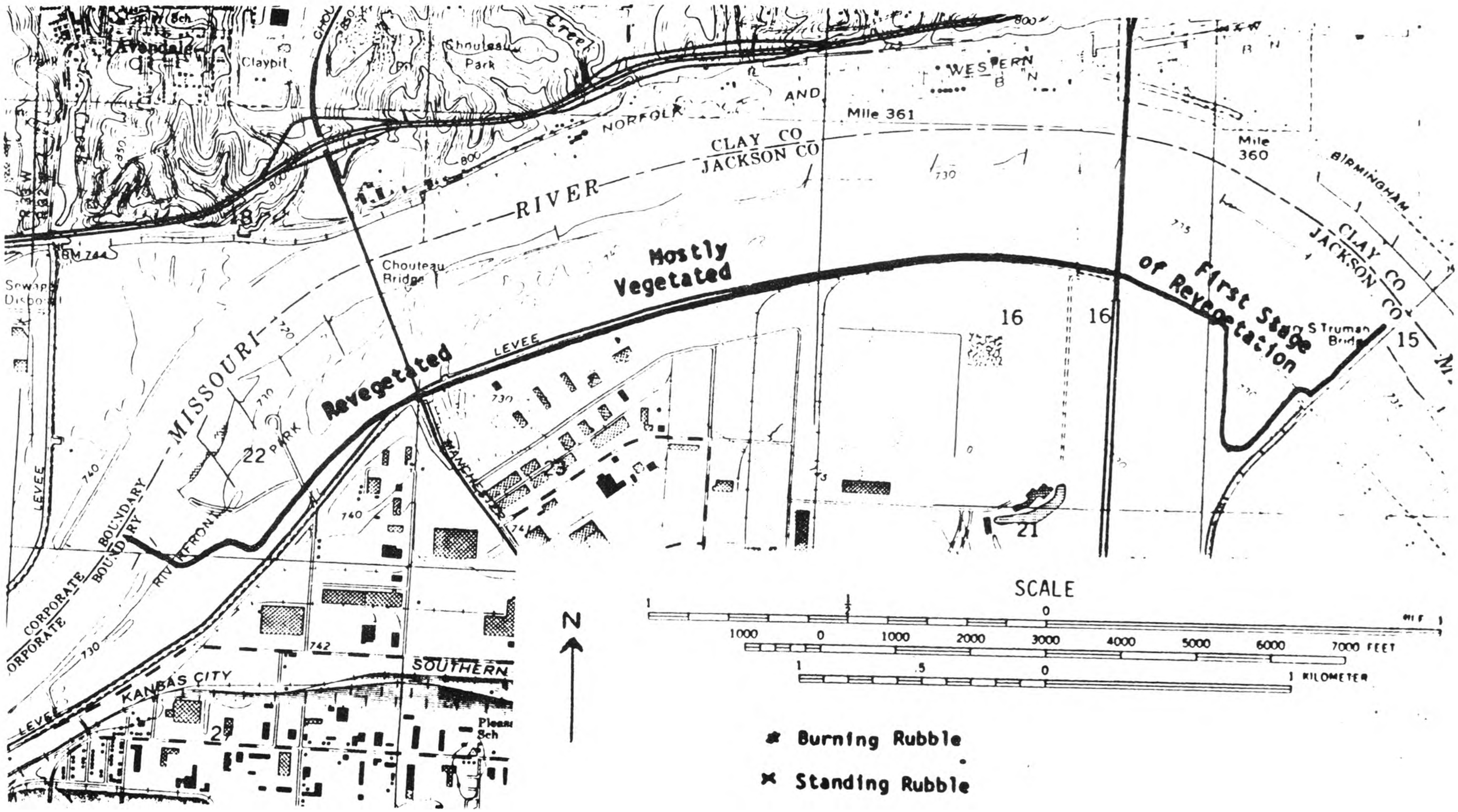


Figure 7 - Final Stage of Landfill 1975 (from Wilson and Elifrits, 1983)

IV. ENVIRONMENTAL CHARACTERIZATION

A. REGIONAL AND LOCAL PHYSIOGRAPHY

Kansas City lies on the border between two physiographic subprovinces, with the Dissected Till Plains to the north and the Osage Plains to the south (Figure 8). The entire area is part of the Central Lowlands Physiographic Province. The Dissected Till Plains are characterized by rolling hills and hummocky topography formed as a result of glaciation. These areas have been highly dissected by periglacial and post-glacial streams. The Osage Plains are small, unglaciated hills and rolling plains. The hills are underlain by limestone and shale, being exposed in broad stream-cut valleys.

The Missouri River lies in a wide floodplain (4,270 m, (14,000 ft); Burns and McDonnell Engineering Co., et al., 1984) bordered by loess terraces. The floodplain shows meander scars representing historic channels of the river. Riverfront Park is located on the inside of one of these meander bends, on a depositional geomorphic feature, known as a point bar. A levee was constructed in about 1951, along with other flood control measures such as groins and drainage channels, by the Kansas City District, US Army Corps of Engineers.

B. GEOLOGY

1. Regional Geology

Bedrock in the Kansas City area consists of Pennsylvanian limestones, sandstones and shales all, of which dip gently to the northeast (Burns and McDonnell Engineering Co., et al ., 1984). Figure 9 is a general stratigraphic section showing the rock types typical of the Kansas City area, that are represented in the Riverfront Park site

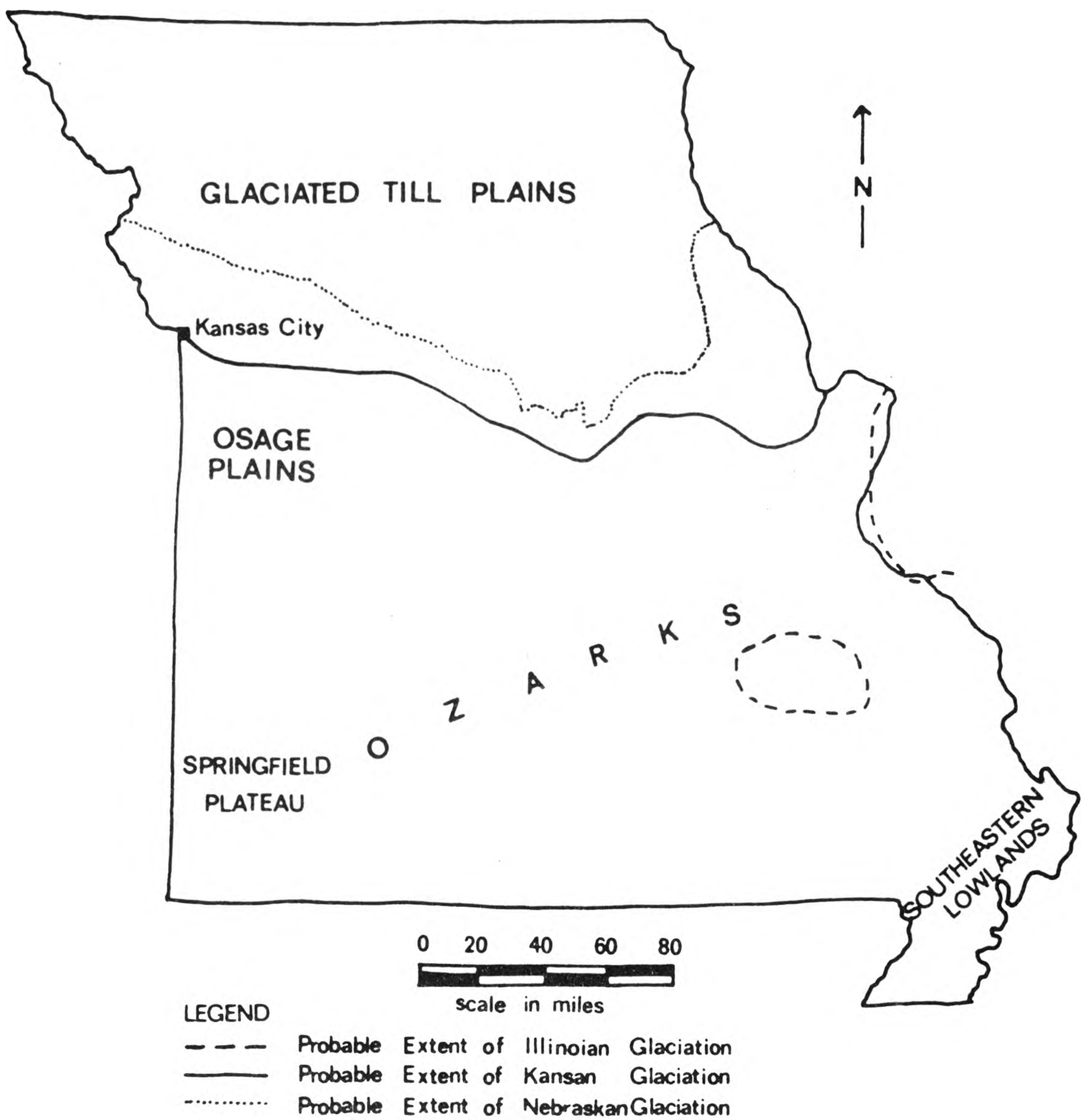


Figure 8 - Physiographic Regions and Limits of Glaciation in Missouri (from Burns and McDonnell Engineering Co. et al., 1984)

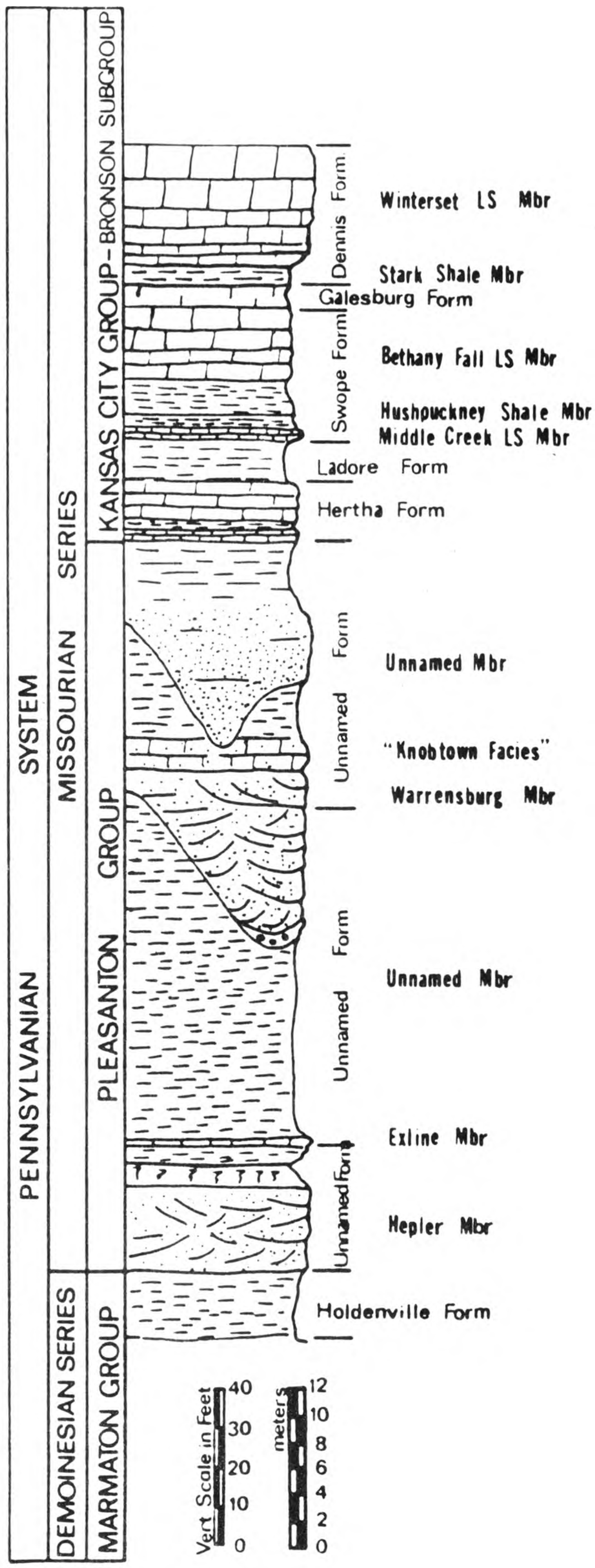


Figure 9 - General Stratigraphic Section of Bedrock in Area of Riverfront Park (from Howe and Koenig, 1961)

area. It is believed that Riverfront Park is underlain directly by shales which are part of the Pleasanton Group and perhaps partially by the lower limestone formations of the Kansas City Group.

The following descriptions of the bedrock illustrated on the stratigraphic section in Figure 9 was derived from The Stratigraphic Succession in Missouri, by W.B. Howe and J.W. Koenig (1961). Figure 10 is a geologic map showing where rocks of the Kansas City Group and the Pleasanton Group outcrop south of the Missouri River.

The Pleasanton Group is approximately 35 m (115 ft) thick in the region of Kansas City, Missouri. It has been described as a "green to buff, argillacious to sandy micaceous shale" by E.J. Parizek, 1965. Howe and Koenig (1961) divided the Pleasanton Group into three unnamed formations. The lower formation is 10 m (32 ft) thick and includes two members. The Hepler Member (7 m; 22 ft) is a thinly-bedded, medium-grained, micaceous sandstone. Above it is an unnamed member composed of underclay, coal and shale. The middle formation is 30 m (95 ft) thick and includes two members. An unnamed, one-foot-thick crinoidal limestone member, is very persistant along the bottom of this formation. Above this is an unnamed, gray, locally silty, micaceous shale member. The upper formation is approximately 20 m (64 ft) thick and contains two members. The basal unit is the Warrensburg Member characterized by typically fine-grained, micaceous and strongly crossbedded, channel-fill sandstone. The thickness of the Warrensburg Member ranges from 3 - 45 m (10 - 150 ft). The top 1.5 m (5 ft of the Warrensburg Member is a thick layer of calcareous, marine sandstone

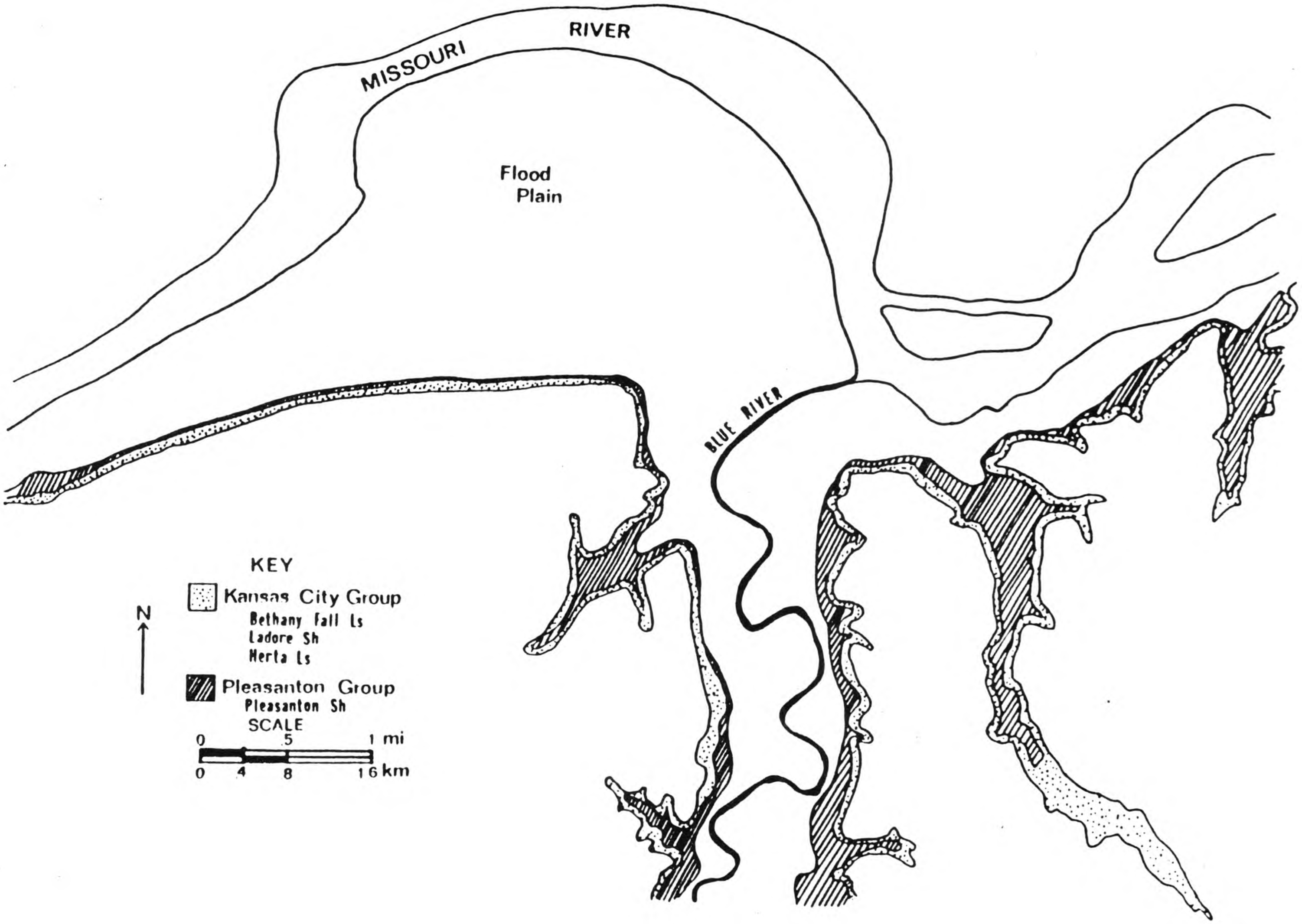


Figure 10 - Geologic Map showing where rocks of the Kansas City Group and the Pleasanton Group outcrop (from McCourt, et al., 1917)

called the Knobtown Facies. The top of the upper formation is an unnamed member containing gray shale and overlying, fine-grained, micaceous sandstone.

Above the Pleasanton Group is the Bronson Subgroup of the Kansas City Group. This Subgroup is separated into the Hertha, Ladore, Swope, Galesburg and Dennis Formations, in ascending order. The Members and rock types are illustrated in Figure 9. Below the Pleasanton Group is the Marmaton Group consisting of shale, limestone, clay and coal beds. The Marmaton Group, part of the Desmoinesian Series is separated from the Pleasanton Group, part of the Missourian Series, by a disconformity distinguished by the absence of typical Desmoinesian fossils.

The Missouri River lies within an ancient fluvial valley that was carved into the bedrock by a peri glacial river during Kansan glaciation. Glacial ablation till and outwash deposits filled the valley as the southern edge of the Kansan glacier receded. The alluvial deposits that fill the valley vary in distinct stratigraphic zones. The lower deposits are mainly coarse-grained sands, gravels and boulders (ablation till). These deposits are overlain by a thick blanket of predominantly medium-grained sand covered by 6 to 12 m (20 to 40 ft) of fine-grained sand, silt and clay characteristic of present alluvial overbank deposits.

2. <u>Site Geology</u>

a. <u>Geomorphology</u>

Figure 11 is an engineering geologic map (Scannell and Eli frits, 1986) of surficial features that were noted while traversing the park on foot. The features were mapped on a 1985 aerial photograph enlarged to 1:4800, scale.

Natural river sediments were observed in layers consisting of clays, silts and sands. Each layer was separated by gradual soil compositional changes ranging from firm clay to coase-grained sand. These deposits appeared along the river edge in an array of ridges and swales, oriented with their long axes parallel to the river. As described by Hickin (1974), <u>The Development of Meanders in Natural River Channels</u>, ridges and swales are a natural part of floodplain morphology and are caused by lateral migration of river channels. Material is eroded from the up-gradient, concave side of a channel and carried downstream where it is deposited as a subtle ridge on the convex side. Riverfront Park lies on the convex side of the Missouri River channel, therefore, acting as a receptor for suspended river sediment. It is conceivable that, during flooding, larger volumes of water, at greater velocities, could carry coarse material which would be released as overbank deposits. There is a lateral change in surficial material at Riverfront Park varying from silty sand in the west to medium and coarse-grained sands in the east. Small patches of distressed vegetation were found in the eastern regions; all are related to sandy soil of poor tilth, rather than to the effects of contaminant migration.

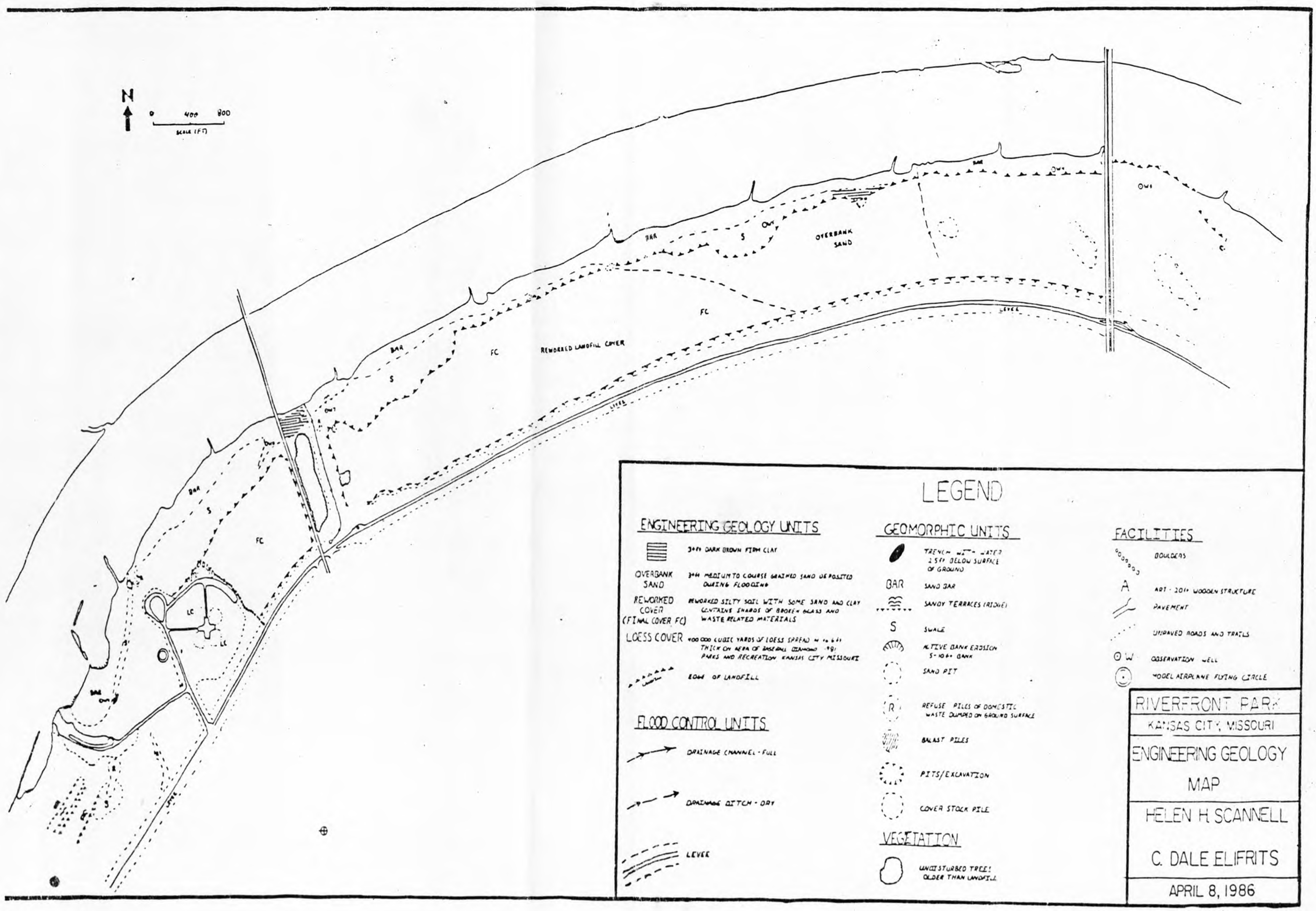


Figure n - Engineering Geolo

An important geomorphologic feature in the site environs appears to be that of an historic river channel. In 1857, a major flood caused the Missouri River channel to shift northward. Figure 12 illustrates this change in the channel pathway, as shown on an 1878 map supplied by the Kansas City District, US Army Corps of Engineers. There is little doubt that such a feature existed and that it was the main river channel at the time. A major concern, in terms of this site remediation, is whether or not the channel remains filled with material that is more permeable, equally permeable or less permeable than the substrate of Riverfront Park. This question is discussed in further sections of this thesis.

b. Subsurface Geology - Engineering Geologic Units

Figure 13 is a geotechnical profile of the geology beneath 1-435, compiled from boring logs acquired from the Missouri State Highway and Transportation Department. This profile shows bedrock overlain by a thick cover of unconsolidated deposits. These deposits are herein separated into generalized Engineering Geologic Units.

Riverfront Park is believed to be underlain primarily by shales of the Pleasanton Group. Boring logs from the Missouri State Highway and Transportation Department described this bedrock as dark, bluish-gray, stiff, non-calcareous, wel 1-statified shale, containing some silt. Figure 14 illustrates stratigraphic sections from two well logs (Missouri Division of Geology and Land Survey) located west of Riverfront Park. Both of these driller's logs confirm that the bedrock in this area is of the Pleasanton Group, possibly overlain by the base of the Kansas City Group. The bedrock is about 25 to 30 m (82 to 98 ft) below the ground surface at Riverfront Park. The

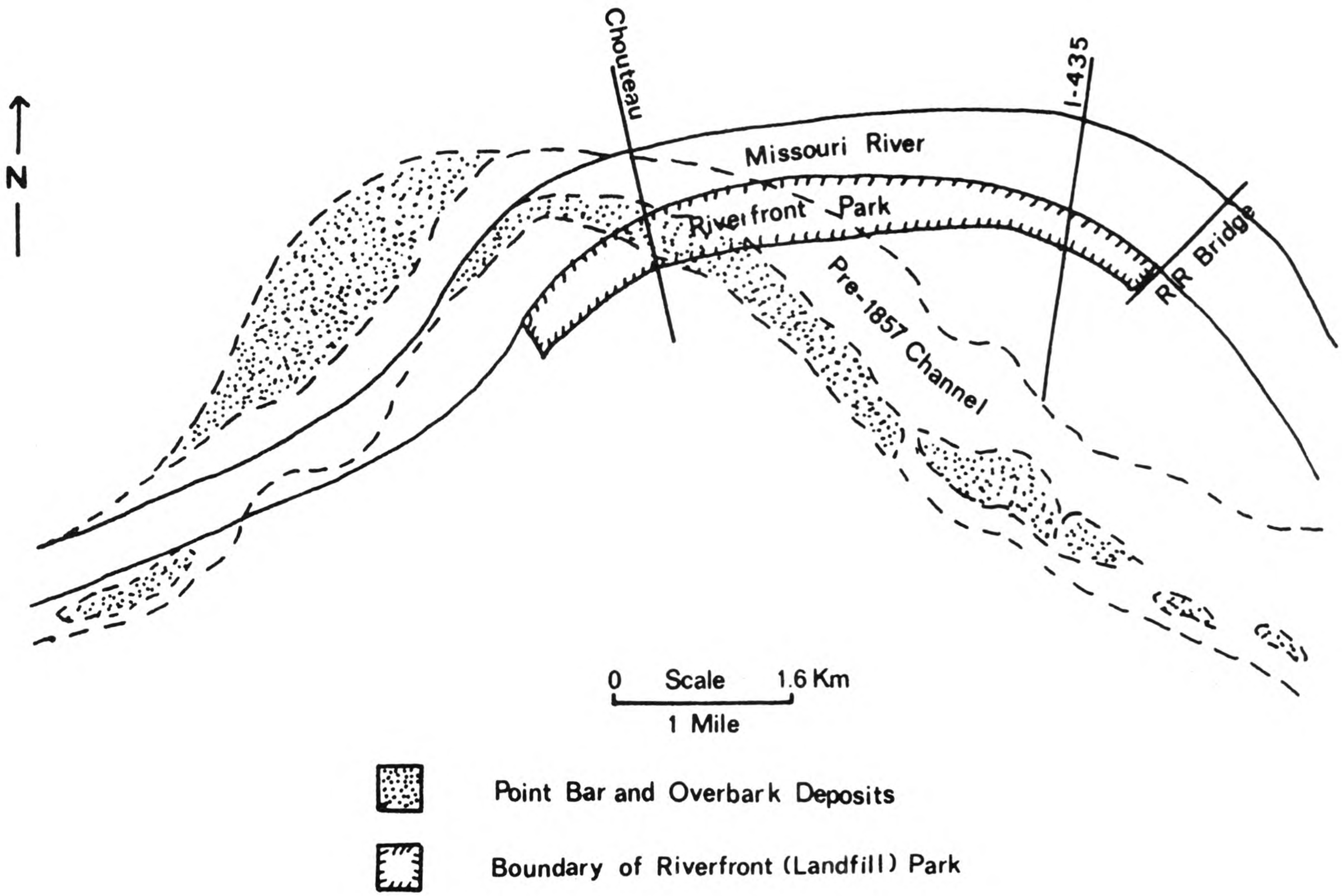


Figure 12 - 1857 Missouri River Channel (US Army Corps of Engineers, 1878)

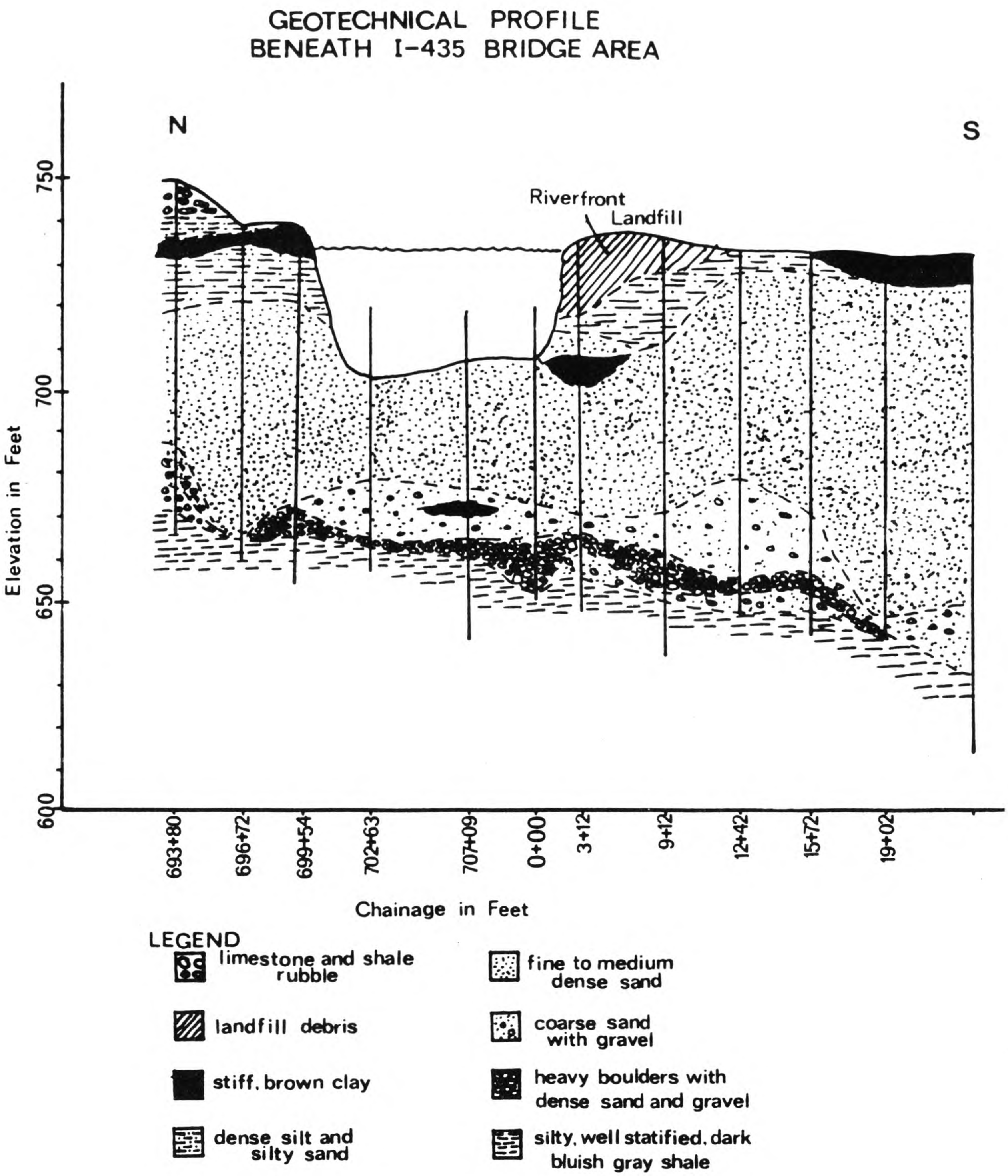
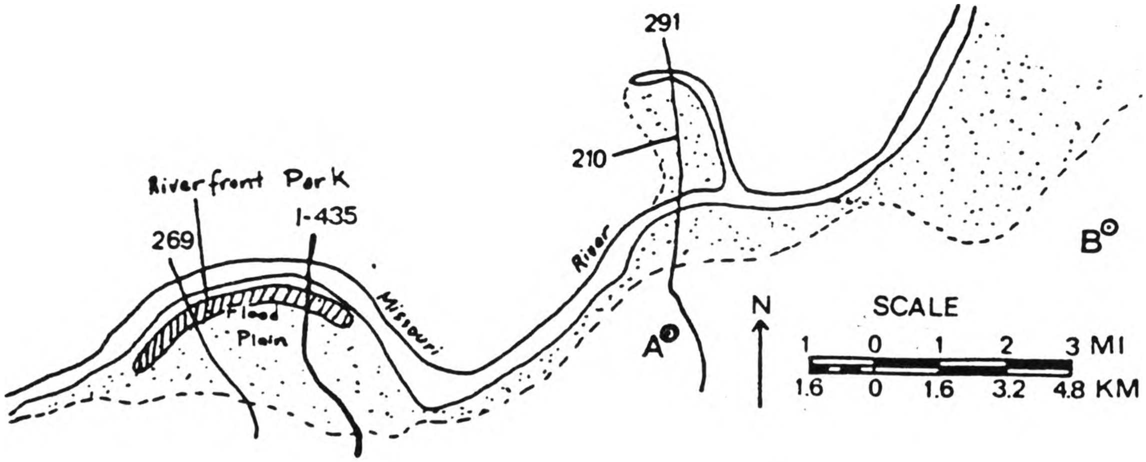


Figure 13 - Geotechnical Profile Beneath 1-435 Bridge



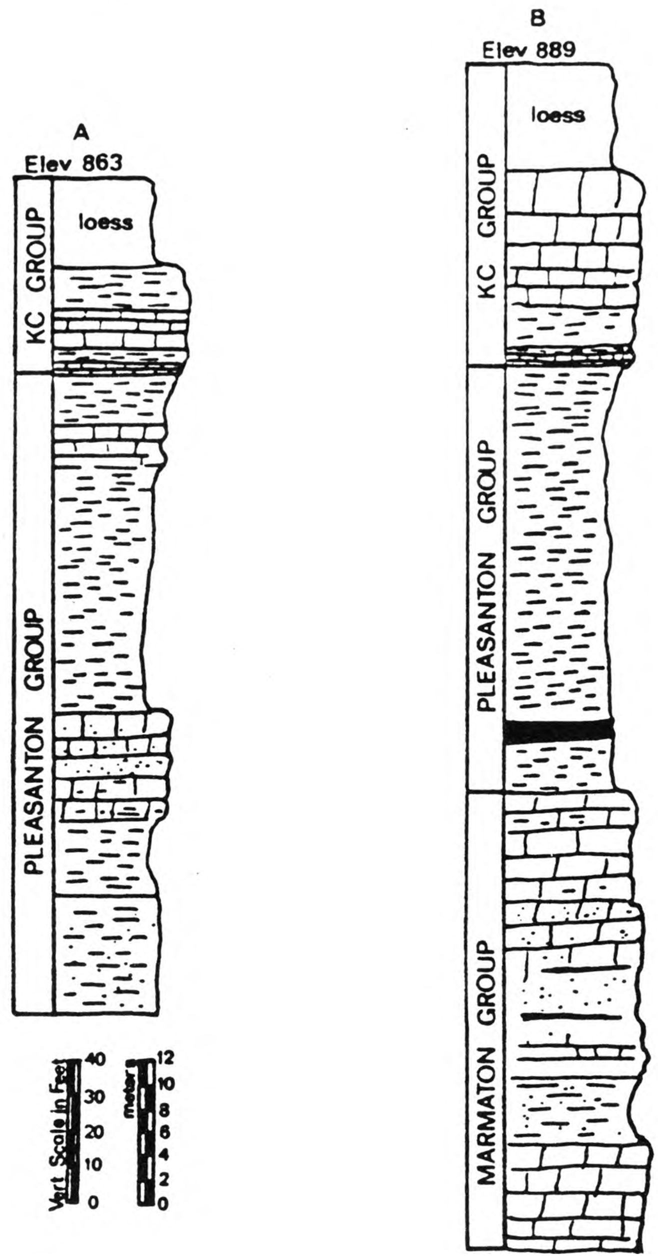


Figure 14 - Stratigraphic Sections from MDNR Boring Logs (1946 and 1960)

erosional surface of the top of bedrock, shown in Figure 15, indicates that the top of bedrock, directly below the Park, slopes to the south-southeast.

The unconsolidated deposits comprising the Missouri River alluvial aquifer can be divided into the following Engineering Geologic Units:

Clay/silt/silty-sand - This unit is 3-6 m (10-20 ft) thick and located directly below ground surface. It consists of mixtures of sand, silt and clay overbank deposits, as well as lenses of stiff, highly-plastic clay, dense silt or medium- to coarse-grained sands. Shallow disposal trenches were excavated into this unit. An average hydraulic conductivity (K) for this unit is herein estimated as 1×10^{-5} cm/s (1 gal/day/ft^2) (Freeze and Cherry, 1979), but due to the variability of the soil types, within the unit, values well above or below this could be encountered.

Fine- to medium-grained, dense sand - This unit is a 20 - 25 m (66 - 82 ft) thick, located directly beneath the clay/silt/silty-sand unit. It is a relatively uniform blanket of fine- to medium-grained dense-sand alluvium with small deposits of coarse-grained sands and gravels. The majority of the Missouri River alluvial water is stored within this unit. These sands are herein estimated to have a hydraulic conductivity of 1×10^{-2} cm/s (1,000 gal/day/ft^2) (Freeze and Cherry, 1979).

Coarse sand and gravel, with heavy boulders - This unit is 6 - 9 m (20 - 30 ft) thick, located below the fine to medium-grained, dense sand unit and directly above the bedrock. It is comprised of coarse sand and gravel coarsening downward to heavy boulders, presumably

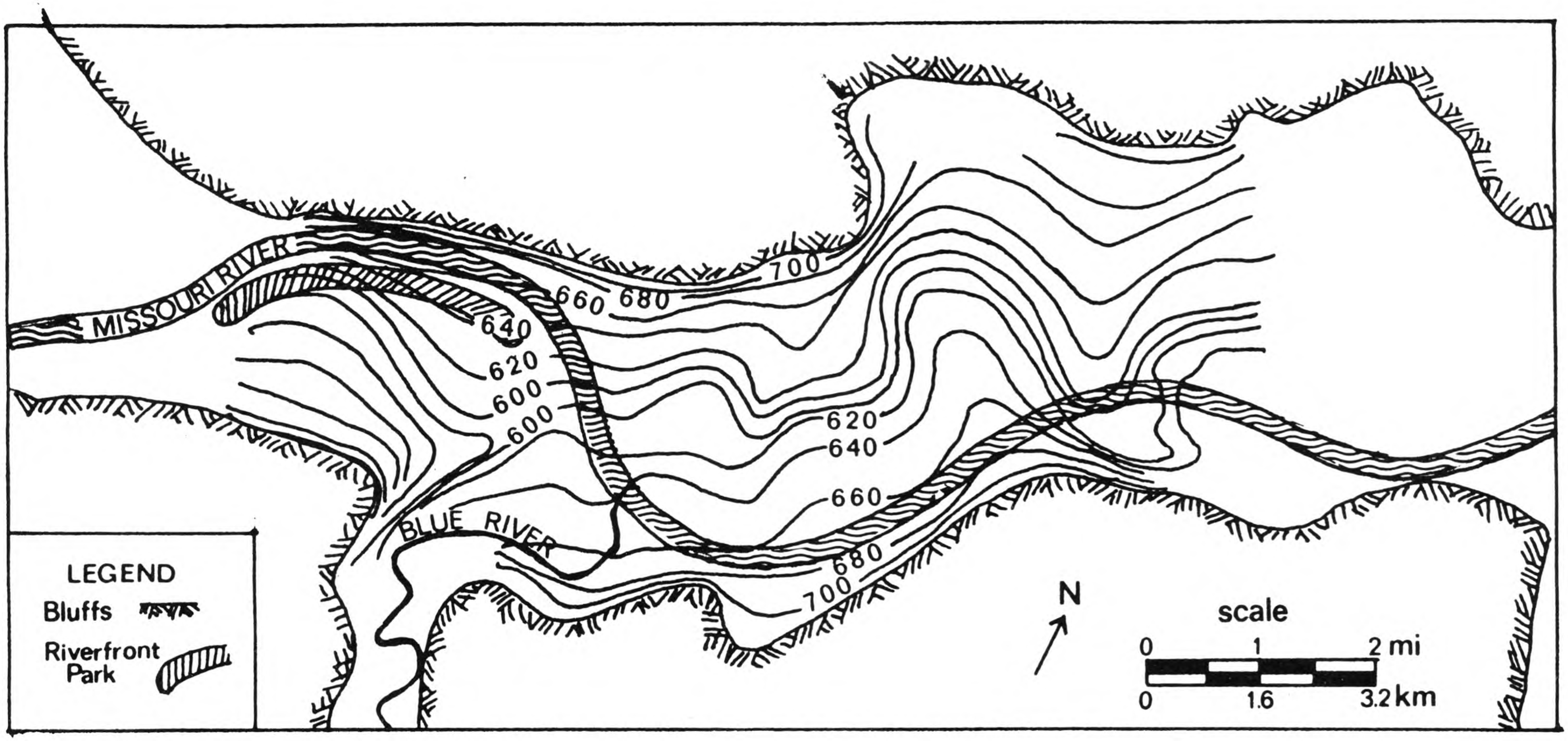


Figure 15 - Erosional Surface of the Top of Bedrock underlying the Missouri River Valley (Highly interpretive; from Simms, 1983)

deposited as a result of glacial melting. The hydraulic conductivity value for this unit depends on the origin of the deposits. If the deposits are alluvial gravel and boulders then their value may be very high 1 cm/s (1×10^{7} gal/day/ft^{2}). Alternately, if the unit is mainly composed of glacial lodgement till the hydraulic conductivity may be as low as 1×10^{-11} cm/s (1×10^{-4} gal/day/ft^{2}) (Freeze and Cherry, 1979).

There is some question about the type of soil deposits that might be found in the historic, 1857, river channel. Either coarse fluvial sediments or dense silts and clays may constitute this fill beneath the site. The problem is further discussed in section IV.

C. <u>LOCAL SURFACE SOIL DISTRIBUTION</u>

1. <u>Engineering Soil Units</u>

The <u>Soil Survey of Jackson County, Missouri</u>,(Preston, 1984) of the US Soil Conservation Service, was used herein to define the surface <u>Engineering Soil Units</u> in the area of Riverfront Park. Figure 16 is a block diagram showing the origin and distribution of the Missouri River Valley soil units in the vicinity of the site.

Most of the soil units are poorly drained and are located on a fairly level topographic surface. Although the soils are protected by the US Army Corps of Engineers levee, they are occasionally subject to flooding. The following list includes the identification and description of the six dominant engineering soil units found in the area of Riverfront Park (modified to USCS descriptors, from Preston, 1984):

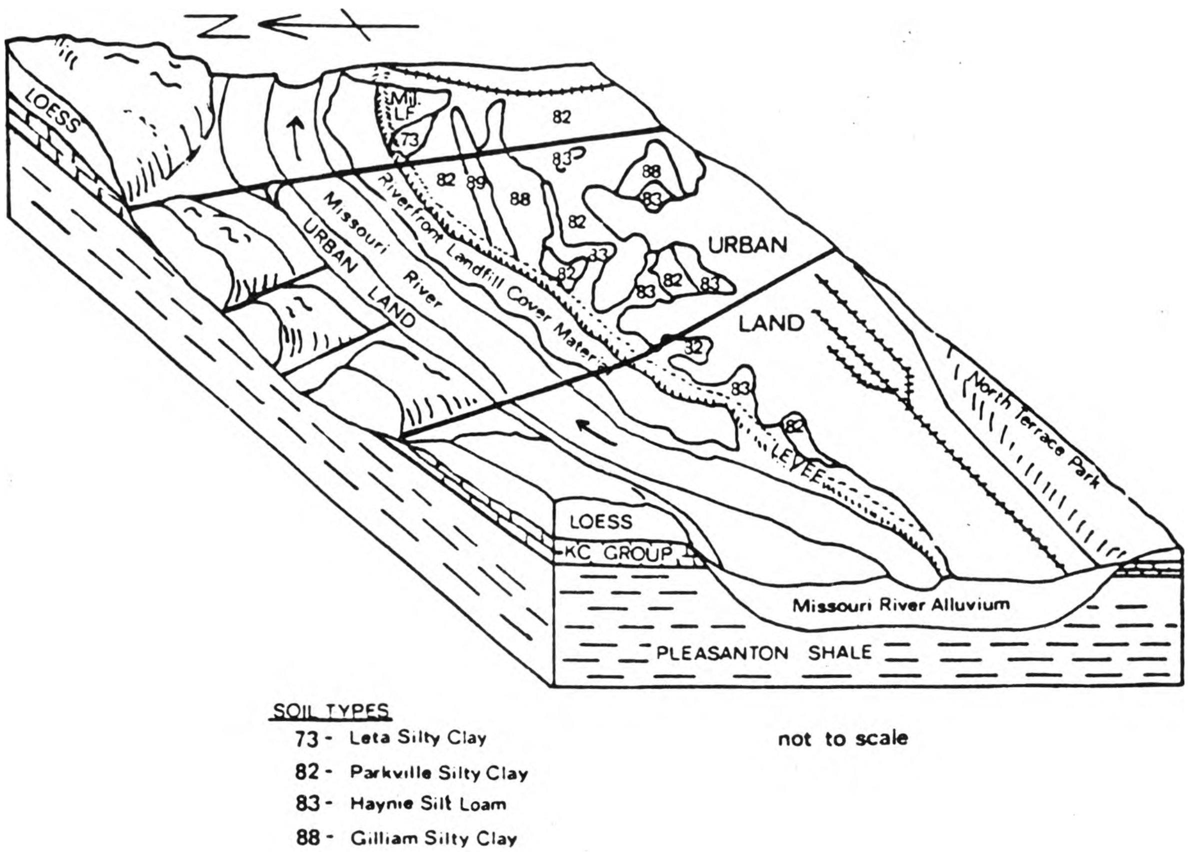


Figure 16 - Origin and Distribution of Missouri River Valley Soil Units in the Vicinity of Riverfront Park

Leta Silty Clay - The surface layer is approximately 15 cm (6 inches) of very dark gray, stiff, silty clay. Below this is about 23 cm (9 inches) of very dark gray, very stiff, silty clay, about 23 cm (9 inches) in thickness. The subsoil is about 15 cm (6 inches) of dark grayish brown very stiff, silty clay. The substratum is stratified silt loam or fine sandy loam.

Parkville silty clay - The surface layer is about 18 cm (7 inches) of black, very stiff, silty clay. Below this is about 25 cm (10 inches) of very dark gray, very stiff, silty clay. The substratum is a grayish brown, mottled, very fine sandy and silty loam, to a depth of about 1.5 m (60 inches).

Haynie silt loam - The surface layer is about 23 cm (9 inches) of very dark grayish brown, soft silt loam. The substratum is stratified silt loam and very fine sandy loam, to a depth of about 1.5 m (60 inches).

Gilliam silty clay loam - The surface layer is about 18 cm (7 inches) of very dark grayish brown, friable silty clay loam. Below this is about 20 cm (8 inches) of soft to friable and stiff silty clay loam. The substatum is dark grayish brown, loose,silty clay loam to a depth of about 1.5 m (60 inches).

Riverfront Landfill Cover Material - The ground cover in these areas are usually composed of manmade material and some silty soil, and they average 0.6 m - 1.2 m (2 to 4 feet) in thickness. They are fill areas on the Missouri floodplain that are used for commercial or landfill purposes. Some of these areas have been covered by silt and sand overbank deposits.

Urban Land (bottom land, zero - 3 percent slopes) - These are areas where at least 85 percent of the ground surface is covered by concrete, asphalt, buildings or other impervious materials.

2. Soil Quality

The small amount of trace elements naturally found in soil should be considered when establishing background concentrations for soil analysis. Table II lists the results of chemical analysis conducted by the EPA on 12 soil samples taken from Area 1. The table also lists the natural concentrations of the trace elements for "typical" soil. The analysis for other compounds indicates that their concentrations did not exceed natural background concentrations.

D. HYDROLOGY

1. Surface Water

a. Surface Water Flow

The only significant channel of surface flow at Riverfront Park is the Missouri River. At Kansas City, the Missouri River drains most of the north-central United States, having a drainage area of 1,297,100 sq km (489,200 sq mi). Records of river discharge and river stage have been kept at the Kansas City gaging station since 1875. The average discharge, 1898-1975, of the Missouri River at Kansas City is 1,550 cubic m/s (54,720 cfsMBurns and McDonnell Engineering Co., et al, 1984). The highest stage recorded was 229.4 m (752.6 ft) above mean sea level, on July 14, 1957.

b. Surface Water Quality

Water passing Riverfront Park through the Missouri River has traversed a huge system of tributaries, picking up a variety of sediment and other materials along the way. Despite this diverse

TABLE II

POLLUTANTS DETECTED IN SOIL SAMPLES AT RIVERFRONT PARK, KANSAS CITY, MISSOURI*

	Range of Conc. (ppm)		No. of times Detected** ***	Natural Conc.*** (ppm)
Inorganic Pollutants	lowest	highest		
Beryllium	2.41	5.68	4	0.01
Copper	644.00	1740.00	6	0.02
Lead	199.00	1560.00	12	0.01
Zinc	725.00	1160.00	4	0.05
Selenium	6.00	10.00	2	0.0005
Mercury	1.13	1.83	5	-
Organic Pollutants				
Vinyl Chloride	0.028	4.100	4	ND
Methylene Chloride	0.084	0.250	10	ND
1,1-Dichlorethane	0.009	0.016	2	ND
(trans 1,2-Dichl oroethane	0.011	1.200	4	ND
Chloroform	0.042	0.042	1	ND
Bromodichloromethane	0.003	0.003	1	ND
Benzene	0.007	0.480	9	ND
Trichloroethylene	0.007	0.180	5	ND
1,1,2-Trichioroethane	0.014	0.014	1	ND
1,1,2,2-Tetrachloroethane	0.013	0.100	4	ND
Chlorobenzene	0.008	0.011	3	ND
Ethyl Benzene	0.038	6.400	8	ND
1,3-Dichlorobenzene	0.014	0.079	2	ND
1,2-Dichlorobenzene	0.020	0.310	4	ND
1,4-Dichlorobenzene	0.020	0.310	4	ND

ND = not detected

* (Rudy, 1984)
** 12 sampling points
*** for "typical" soil. (Brown, K.W. and Assoc., Inc., 1980)

origin, the chemical water quality is rather consistant. Rivers have a buffer system which serves to maintain equilibrium of the aqueous system when chemicals are added. An unusual aspect of the Missouri River is its characteristically high sediment content (Total Suspended Solids; TSS), commonly reaching 5000 ppm (Burns and McDonnell Engineering Co., et al., 1984).

2. <u>Groundwater</u>

a. <u>Regional Aquifer Properties and Groundwater Flow</u>

The Missouri River Valley alluvium provides a large supply of groundwater to the Kansas City Area. It has a high average yield; about 58.7 1/s (930 gal/min; Fishel, et al, 1953). The average specific capacity of the alluvium is 3.8 1/s per meter of drawdown (60 gal/min per foot of drawdown) and at some wells may support pumping capacities which exceed 126.2 1/s (2,000 gal/min) (Geotrans, 1984).

Studies by several investigators (Nuzman, 1972; Foreman, 1977; Granneman, 1976) indicate that hydraulic conductivity increases exponentially with depth, in the Missouri River Valley alluvium (Geotrans, 1984). This correlates with the increasing grain size of the alluvial sediments with depth. Groundwater levels are found around 1.5 to 4.5 m (5 to 15 ft) below ground surface, below which is a saturated thickness of approximately 20 m (70 ft). Using this saturated thickness an average transmissivity was calculated at approximately 0.03 sq m/s (0.324 sq ft/s) (Geotrans, 1984).

Regional groundwater flow in the area of Riverfront Park is difficult to determine due to the lack of historical records. Figure 17 is a map showing the groundwater level contours for the alluvial aquifer in this area on October, 1967 (from Geotrans, 1984). The

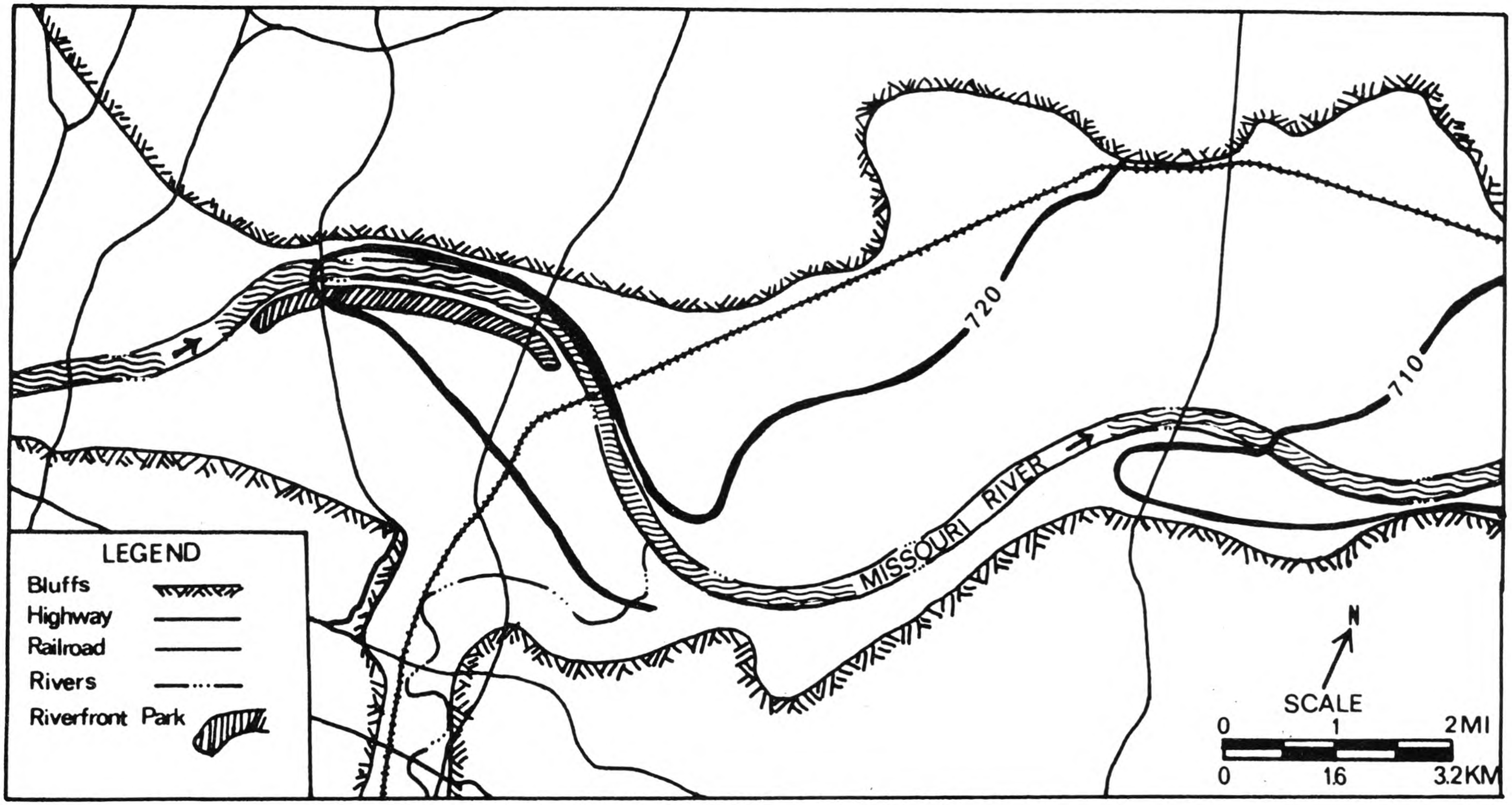


Figure 17 - Groundwater Level Contours for the Alluvial Aquifer in the Vicinity of Riverfront Park, in October, 1967 (from Geotrans, 1984)

water levels were recorded by the US Geological Survey (Emmett and Jeffery, 1970). Although the information on this map is limited, one can assume that the flow direction is perpendicular to the equipotential lines. This would mean that the general direction of flow accross the Riverfront Park Site is from the southwest to the northeast. A more accurate estimation would require more thorough records of water levels in the area at specific times of the year.

The groundwater surface fluctuates according to the height of the river stage. During heavy precipitation, late spring to early summer, the river stage is high and water flows into the alluvium, recharging it through bank storage. During the drier seasons, the river stage is lower and the hydraulic gradient is reversed. This causes the stored water to discharge into the river. Aside from seasonal fluctuations, no other potential, major flow direction has been identified.

b. Local Groundwater Flow

There is presently very little information available to use as a guide for defining the hydraulic parameters of the Missouri River Valley alluvium in the vicinity of Riverfront Park. The historic 1857 river channel may produce a significant change in the average values of hydraulic conductivity and transmissivity but there is no substantial evidence to support whether the presense of an ancient channel would increase or decrease these values. If such a channel were to be infilled with material of an overall greater permeability than that of the Park substrate, then water could be flowing south when the river stage was high. It could flow either along the course of the channel, being diverted back into the Missouri River, or out of the channel toward the south. Alternately, if the channel, having become abandoned, became a low-energy trough of silt and clay deposition, then it would act as a barrier to southward groundwater flow. The channel, therefore, could be a prime factor in limiting contamination transport in the southern direction.

A series of well tests must be conducted at the site in order to obtain the data needed to define the basic flow system. The groundwater monitoring plan described in the following section has been designed to provide a preliminary basis for obtaining confirmatory results.

c. Groundwater Quality

Beginning on February 7, 1983, the EPA FIT contractor, Ecology and Environment, installed 8 permanent, on-site groundwater monitoring wells and 3 permanent, off-site wells. One temporary off-site well was also installed. The locations of these wells are shown in Figure 18. These wells were designed for determining groundwater levels and groundwater quality (Figure 19). Table III gives limited physical data for these wells. The present condition of the wells is poor, with at least one (# 4) having had the upper part of its casing broken and torn out of the ground. The location of several of the wells is now unknown.

Approximately one week after well installation, groundwater samples were selected from each of the wells and analysed for substances including volatile organics, total metals, acids, base/neutrals, and pesticides (Rudy, 1984). Samples were processed according to EPA protocol and analysed at the Region VII Laboratory. The results of the tests are listed in Table IV.

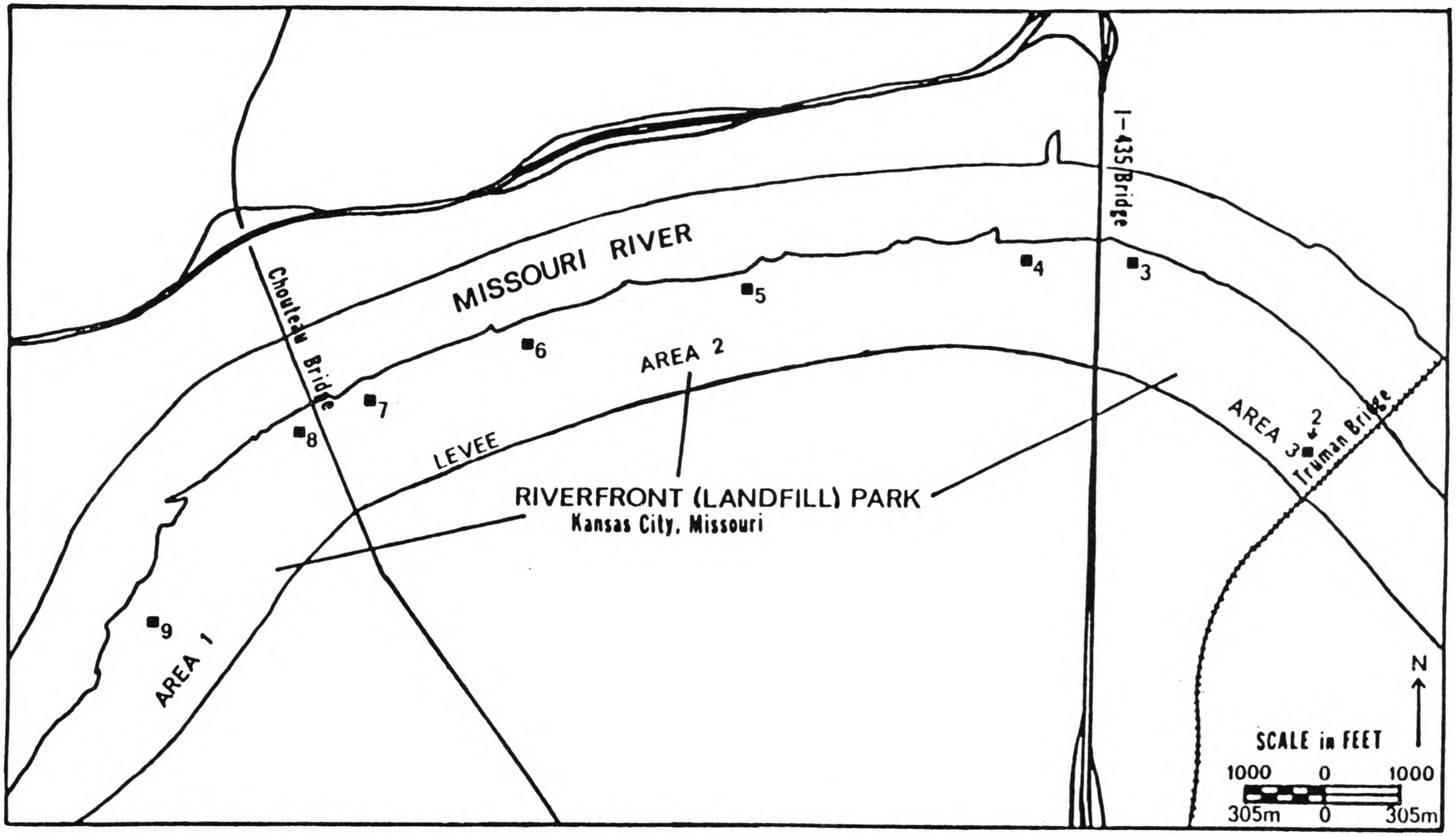


Figure 18 - Location of USEPA installed Onsite Monitoring Wells (Rudy, 1984)

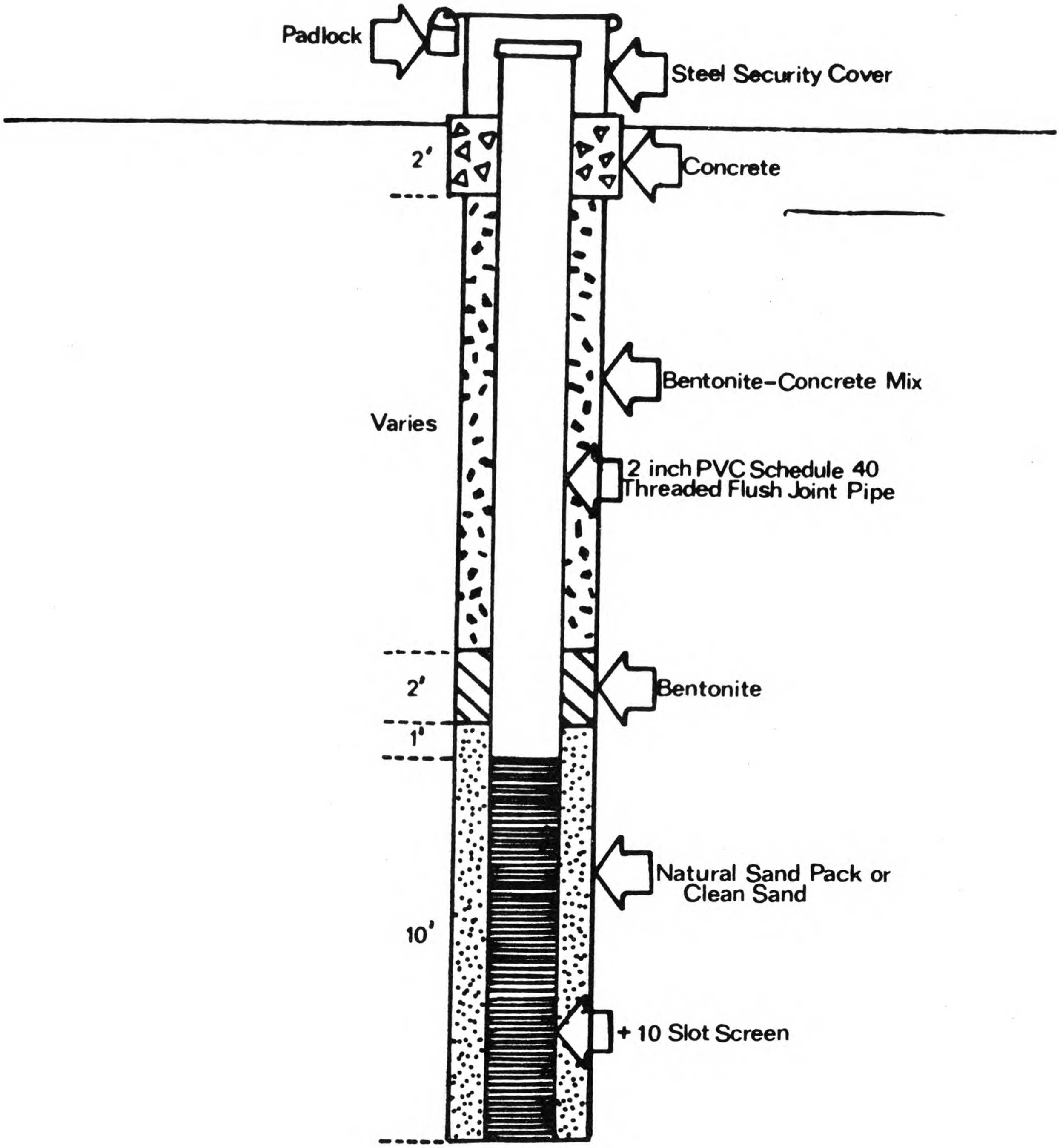


Figure 19 - Typical Design of Existing Groundwater Monitoring Wells (Rudy, 1984)

TABLE III

1983 GROUNDWATER QUALITY PARAMETER DATA, RIVERFRONT PARK, KANSAS CITY, MISSOURI*

Well Number	pH	Temperature (C)	Conductivity (micromhos)
1A	7.5	15.0	950
2A	6.3	-	-
3A	6.5	-	-
4A	6.4	-	-
2	8.0	16.0	1900
3	8.0	16.0	1740
4	7.0	17.0	2690
5	7.0	17.0	2220
6	7.0	15.0	2850
7	7.0	14.0	1740
8	7.0	15.0	2530
9	7.0	15.0	2530
PZ4	6.3	-	-

*from Rudy, 1984

TABLE IV

POLLUTANTS DETECTED IN 1983 GROUNDWATER SAMPLING AT RIVERFRONT PARK, KANSAS CITY, MISSOURI*

Inorganic Pollutants	Range of Cone.(ppm) lowest	highest	No. of times detected**
Aluminum	2.690	160.000	13
Arsenic	0.010	0.350	10
Barium	0.242	3.000	13
Boron	0.100	2.100	12
Cadmium	0.002	0.018	12
Chromium	0.013	0.190	10
Cobalt	0.100	0.100	3
Copper	0.050	0.650	7
Iron	5.800	308.000	13
Lead	0.005	1.000	13
Manganese	0.408	0.600	13
Mercury	0.0002	0.0006	5
Nickel	0.043	0.200	7
Selenium	0.002	0.006	4
Silver	0.020	0.020	1
Vanadium	0.400	0.400	3
Zinc	0.036	115.000	13
Organic Pollutants			
Methylene Chloride	0.0050	0.0664	4
Benzene	0.0073	0.0085	2
Ethyl benzene	0.0055	0.0087	2
Bis(2-ethylhexyl)phthalate	0.0230	0.0540	4
Toluene	0.0290	0.0290	1

* from Rudy, 1984
** 13 Wells sampled

3. Groundwater Monitoring Plan

The objective for the proposed groundwater monitoring is to provide a basis for determining the degree of contamination present at the landfill and the distance/depth and rate at which such may have been transported from individual source areas or caches.

A two-phase plan for groundwater monitoring has been proposed by the Kansas City Department of Health. The first phase of this plan includes groundwater monitoring within the bounds of Riverfront park. On-site well construction, water level measurements and chemical analyses of groundwater will provide a means of estimating the level and spatial distribution of contamination presently at the site and the potential of the site as a source for contaminants which might be transported offsite. The need for installing off-site wells will be determined on the basis of Phase-One findings. A summary of the Groundwater Monitoring Plan can be found in the University of Missouri-Rolla report to the City of Kansas City entitled "Proposed Ground Water Monitoring Plan and Park Area Monitoring Plan for Riverfront Park, Kansas City, Missouri", 1986.

a. Groundwater Monitoring Well Location

Figure 20 shows the proposed general locations for the 17 groundwater monitoring wells to be used for phase- one on-site studies. These locations were adopted from those recommended wells specified in the 1985 report to EPA Region VII by Jeffery Imes of the US Geological Survey, Roll a, Missouri.

Locations 2 though 9 are the wells EPA installed for prelimi nary site assessment. These wells were constructed using PVC casing, a material that can interfere with chemical analyses of groundwater for

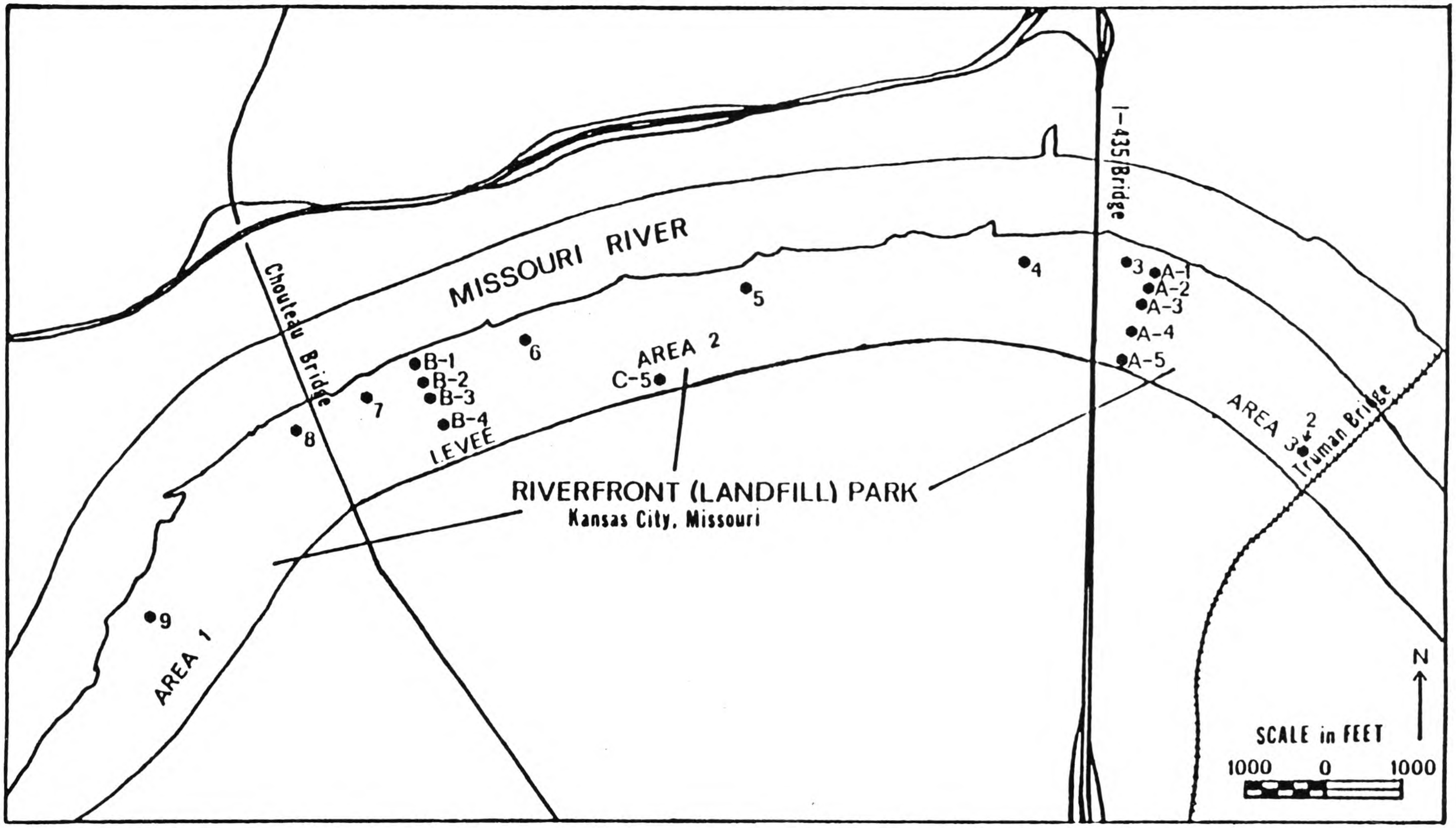


Figure 20 - Location of Proposed Monitoring Wells

some organic substances. It would therefore be impractical to use these wells for further chemical groundwater sampling. Well 5 has been destroyed and wells 2 and 6 are no longer locatable. Wells 3, #4, #7, #8 and #9 may be in suitable condition to be used for well level measurements. A new stainless steel well should be installed in the near vicinity of each location.

Wells 2 through 9 are spaced across the site in a line nearly parallel to the river. These monitoring wells would provide chemical data across the site but would not provide data needed to identify the hydraulic gradient (and any seasonal variations) perpendicular to the Missouri River. Well series A-l though A-5 and B-l through B-4 are designed to provide this information.

The A- and B-well series are located in two specific areas which showed an anomolously high electrical conductivity during the 1983 EPA geophysical survey. The methods and results of the geophysical survey will be discussed in the following section. The geometry of the transects makes these wells useful for several purposes. They can be used to measure groundwater fluctuations with respect to the river stage, and to investigate the possibility of contaminants in the areas of high conductivity. Pump testing for permeability data could be conducted on the center wells with the outer wells used as observation wel 1s.

b. Monitoring Well Construction Design

Wells 2 through 9, as proposed in the Groundwater Monitoring Plan submitted by Kansas City (1986), will be constructed in the following manner. Single wells will be installed to a depth of about 15 m (50 ft), with 3 to 6 m (10 to 20 ft) intake screens placed at various depths below the groundwater surface. Well casings, screens, and dedicated sample-retrieval bailers are to be constructed of stainless steel (type 316). Although there is a significant cost differential between stainless steel and PVC, the latter material has been chosen so as to provide unambiguous water quality data. The inner diameter of the casing will be 5 cm (2 inches) and the screening will be factory slotted at 0.0254 cm (0.01 inches). Continuous- flight augers will be used for drilling, and the auger flights will be decontaminated between borings in order to avoid the contaminant transport. Telescoping casing installation techniques should also be used to insure sample quality. Construction design is illustrated in Figure 21.

Two of the wells in the A-series will have a modified design in order to obtain various aquifer properties. Well A-3 will be designed for in-situ permeability testing, as either a pumping (drawdown) well or an injection (slug-test) well. The well screen placement and length should be modified to minimize the loss of specific capacity while it increases the drawdown. One well location in the series should be designated for a cluster of piezometers to be used in determining vertical conductivity/vertical flow gradients. Figure 22 illustrates an approximate design for this cluster. The piezometers should be installed approximately 3 m (10 ft) apart and at varying depths. Vertical hydraulic conductivity of the alluvial aquifer can be determined using the change in head measured in the piezometers or by way of a dye tracer test. Due to the relatively small distance between the piezometers, the change in head between them may be very small and difficult to detect accurately. A non-toxic tracer test may

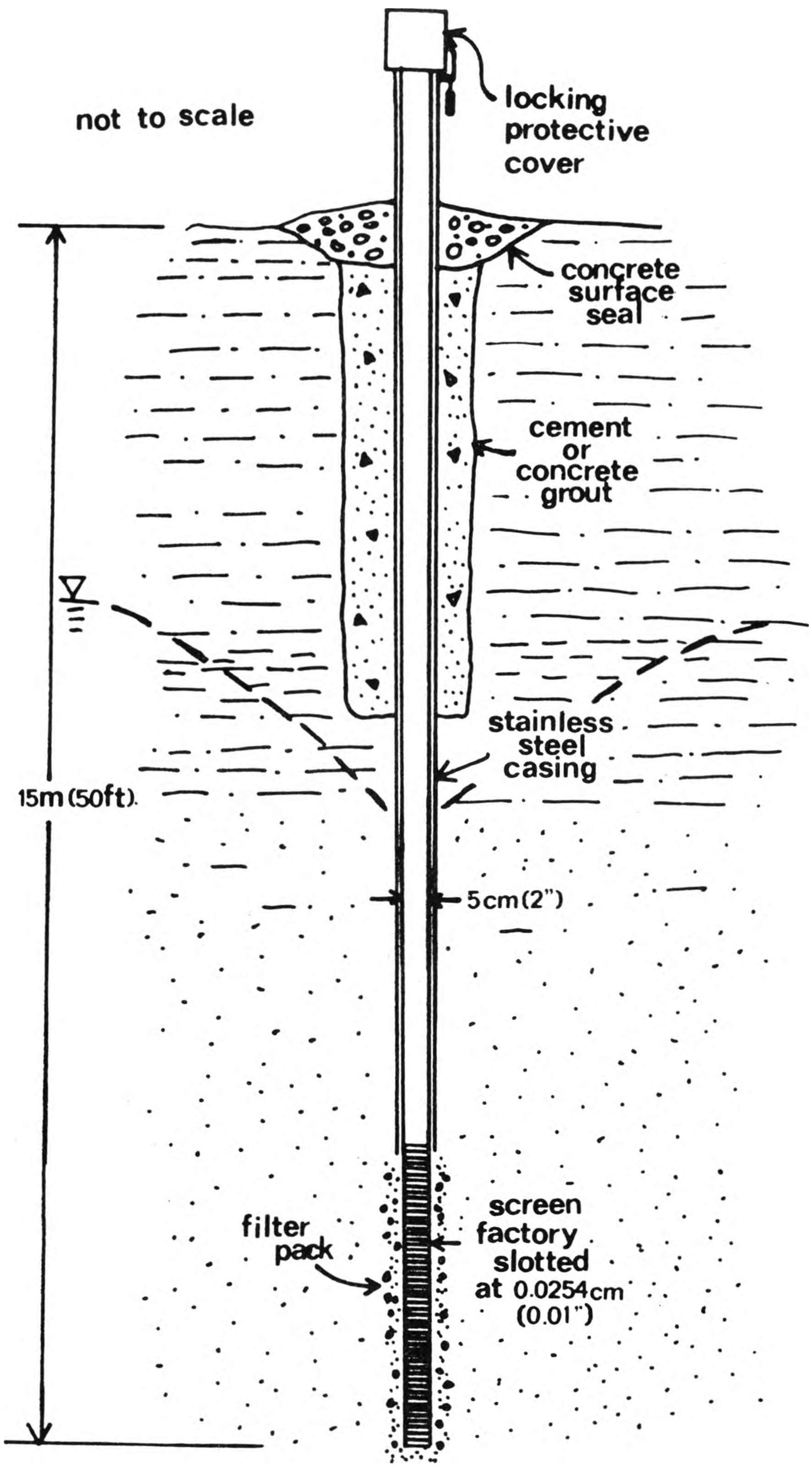


Figure *21* - Proposed (1987) Groundwater Monitoring Well Construction Design

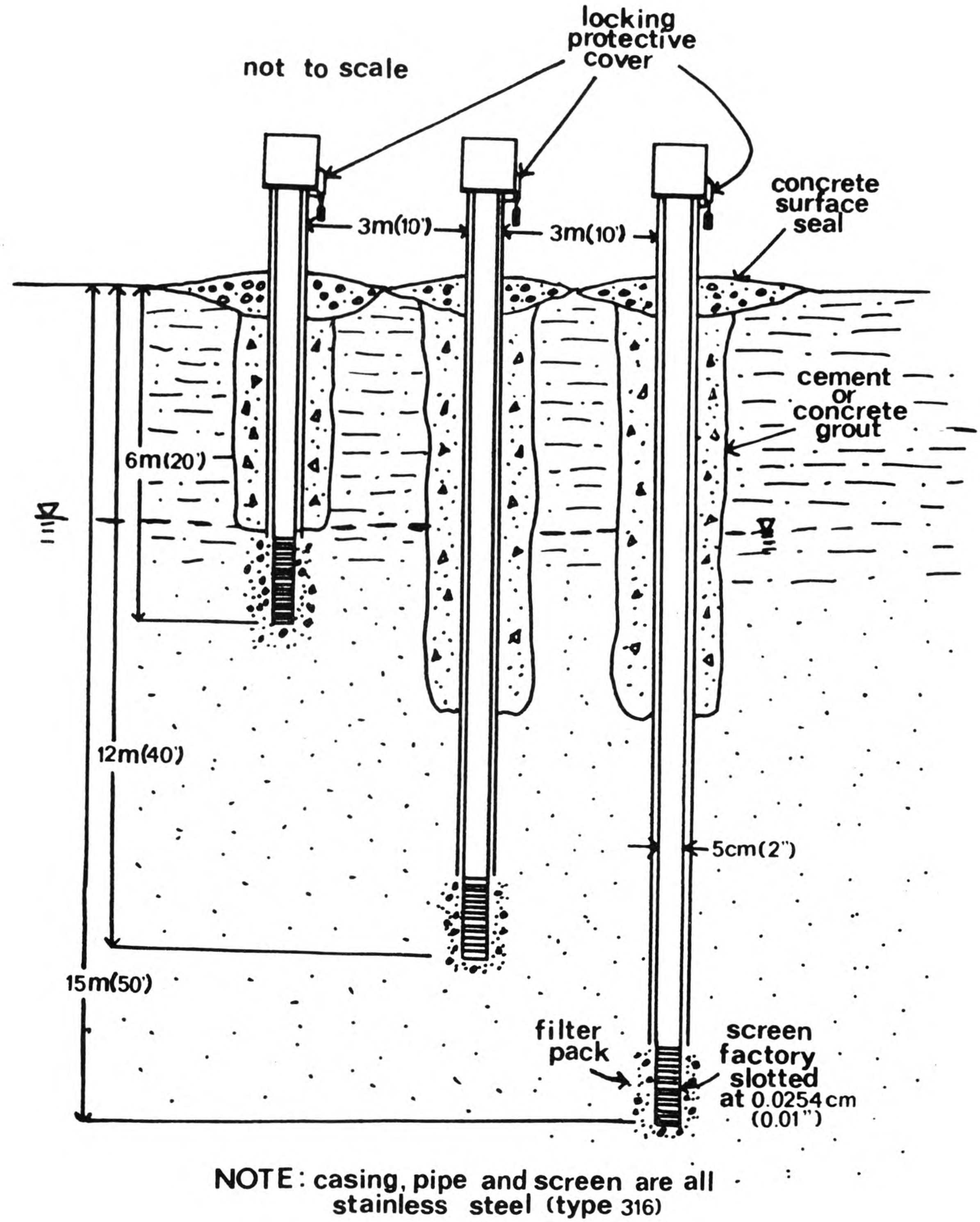


Figure 22 - Proposed (1987) Piezometer Cluster Construction Design for Measuring Vertical Hydraulic Conductivity

represent a more accurate way to find vertical hydraulic conductivity because the travel time of a tracer and the distance of travel are easier measurements to obtain. This test involves placing a dye in the piezometer of highest head and measuring the rate at which it reaches the other piezometers. Well A-2 would be an appropriate location for the piezometer cluster because it is fairly close to the river where change in river stage may have a greater affect on vertical flow. The other wells of the series should be constructed in a manner similar to that of wells 2 through 9.

The B-series wells should also be constructed in a similar manner to those of the A-series , with B-3 constructed for pumping and B-2 designated as the piezometer cluster. The other B-wells, and well C-5, should also be constructed similar to wells 2 through 9.

c. Groundwater Monitoring

Once monitoring wells have been installed, groundwater levels will be manually measured at weekly or less frequent intervals. Missouri River stage measurements will be taken coincident to groundwater levels. This will allow detection of small changes in groundwater level with respect to season, climate and river stage.

Groundwater quality samples will be taken according to EPA protocol and requirements. Sampling will occur, at monthly intervals, and, initially, at more frequent intervals. If contaminant-indicator species can be established, laboratory analyses will be so structured as to determine levels of contamination in specific engineering geologic units.

d. Proposed Computer Modeling

When properly calibrated and thoroughly understood, applicable computer-based groundwater flow models can be used in the analysis of specific hydrogeologic settings. By using the USGS finite element program SUTRA, for example, water pressures, flow velocities and spatial distribution of solute concentations can be predicted. The program performs a two dimensional (employed in a quasi-three dimensional manner), saturated-unsaturated flow and contaminant transport analysis. Profiles across the site and across the Missouri River can be introduced into the model and calibrated with actual site data. The following boundary conditions and hydraulic parameters would need to be established, requiring special field and laboratory analyses.

The first consideration is that of establishing model boundary conditions. The geologic conditions at this site suggest that there is a constant boundary head located an infinite distance to the south of the river. Near the river, the head will change as a function of river stage and will therefore be time-dependant.

The geometry of the model should be as precise as the geology can be described by RI field data. Bedrock geometry, soil layering or other geologic heterogenieties can be accounted for in this model. This information can be obtained from boring logs of the new RI groundwater monitoring wells, as well as foundation boring logs from the State Highway and Transportation Department, and the well driller logs from the Missouri Department of Natural Resources and from local residences. Identification of flow-retarding clay soil layers or highly porous, sandy layers would lead to a more accurate picture of the complex hydrologic system in the Missouri River valley aquifer.

Hydraulic parameters must be determined in the saturated and unsaturated zones of the aquifer. Information on flow through the unsaturated zone, requires knowledge of relative permeability, unsaturated flow and transport parameters. These data can be calculated using capillary pressure-saturation curves (Figure 23), constructed from laboratory measurements of volumetric water content (θ), porosity (n), and pressure head (P) at a variety of depths. Three curves should be developed for each major engineering geologic unit.

Different tests need to be conducted to determine saturated zone parameters. Laboratory test samples should be collected during drilling of at least five widely-spaced monitoring wells (such as 2, 3, 5, 7, and 9). These samples should be tested for horizontal and vertical permeability. Splits should also be made so that the distribution coefficient (K^) can be determined for the most mobile contaminants. Values for and porosity should be determined for each major engineering geologic unit. Porosity can be calculated on the basis of measured grain density (ASTM method D854).

Wells A-3 and B-3 should be considered for use for pump tests. The other wells in these transects can be used as observation wells, for they should be close enough to discern drawdown measurements. This well can also be used for tracer tests. The average dispersion

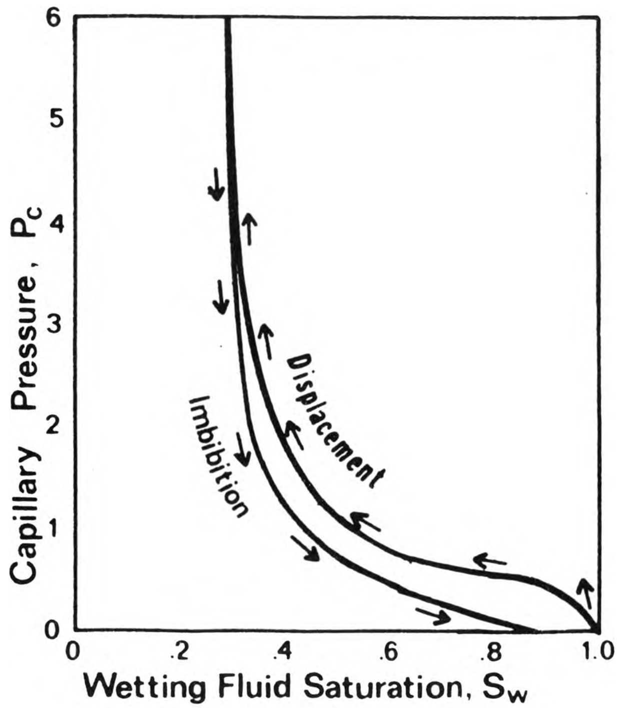


Figure 23 - Typical Capillary Pressure-Wetting Fluid Saturation Relationship for Porous Rock, showing Hysteresis

coefficient (D) at the injection velocity (v) and the dispersivity (**) of the aquifer can be calculated using data collected during tracer analysis. The equation to use when calculating D is:

D = °< v + D*

where D* is the coefficient of diffusion

Slug tests should be performed on several other widely-spaced wells (such as 2, 3, 5, 7, and 9).

E. <u>GEOPHYSICAL INVESTIGATIONS</u>

1. <u>Introduction</u>

On January 13 and 14, 1983 an electrical resistivity survey was conducted under contract to the USEPA, Region VII FIT Contractor, E & E. The specific concern of this study was to detect possible variations in the bulk geophysical characteristics of subsurface soils in the location of the pre-1857 historic river channel.

On October 31, 1983 Ecology and Environment, Inc. was authorized, under USEPA contract number TDD R-07-8309-05, to conduct a geophysical survey at Riverfront Park. The field part of this study was conducted on November 29 to December 14, 1983 by Geo-physi-con, Inc. of Lakewood, Colorado. The results of this study are detailed in Appendix C of the USEPA Full Field Investigation of Riverfront Landfill (Rudy, 1984).

The objectives of this geophysical study were to identify and delimit by signatures which might be interpreted to represent contaminant plumes in or emminating from Riverfront Landfill, and to locate major concentrations of buried metal. The geophysical methods choosen to accomplish these objectivies were <u>conductivity profiling</u> and <u>magnetometer surveys</u>. Conductivity profiling was used to delimit the boundries of the landfill and the extent of possible contaminants. Total field and gradient-type magnetometer surveys were conducted to locate caches of metallic wastes.

2. Operative Principles

Electrical Resistivity

The resistivity of a soil or rock is the measured reluctance to conduct induced current flow between two electrodes of opposite polarity. A Bison Model 2350B resistivity meter was used for this study. Soundings were conducted at eight locations (Figure 24) using the modified Wenner array. This array consists of four col inear surface electrodes, with the two outer electrodes (current electrodes) introducing a current into the earth and the two inner electrodes (potential electrodes) detecting the voltage caused by this current. To increase depth of sounding, the current electrodes were spaced at 91.5 m (300 ft) and the potential electrodes increased in separation in 1.5 m (5 ft) intervals until a separation of 45.7 m (150 ft) was reached. The configuration is illustrated in Figure 25. The equation used to calculate the apparent resistivity is:

$$\text{Apparent Resistivity} = (2\pi R)\frac{1}{\frac{1}{R_1}-\frac{1}{R_2}-\frac{1}{R_3}-\frac{1}{R_4}}$$

where R = instrument reading in ohms

Factors which influence earth material resistivity are parameters such as water content, soil composition, texture and pore water chemisty.

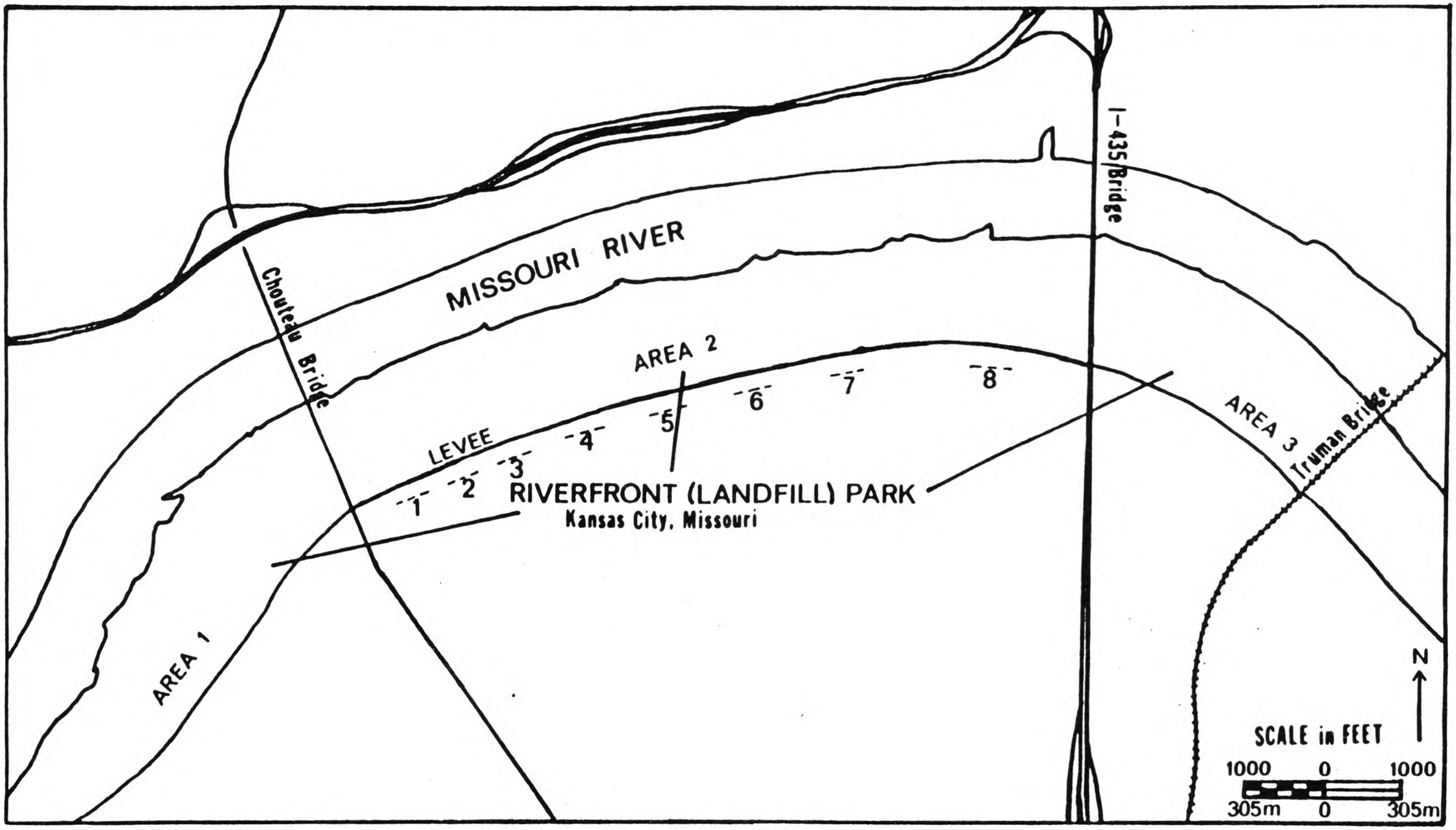


Figure 24 - 1984 Electrical Resistivity Sounding Locations

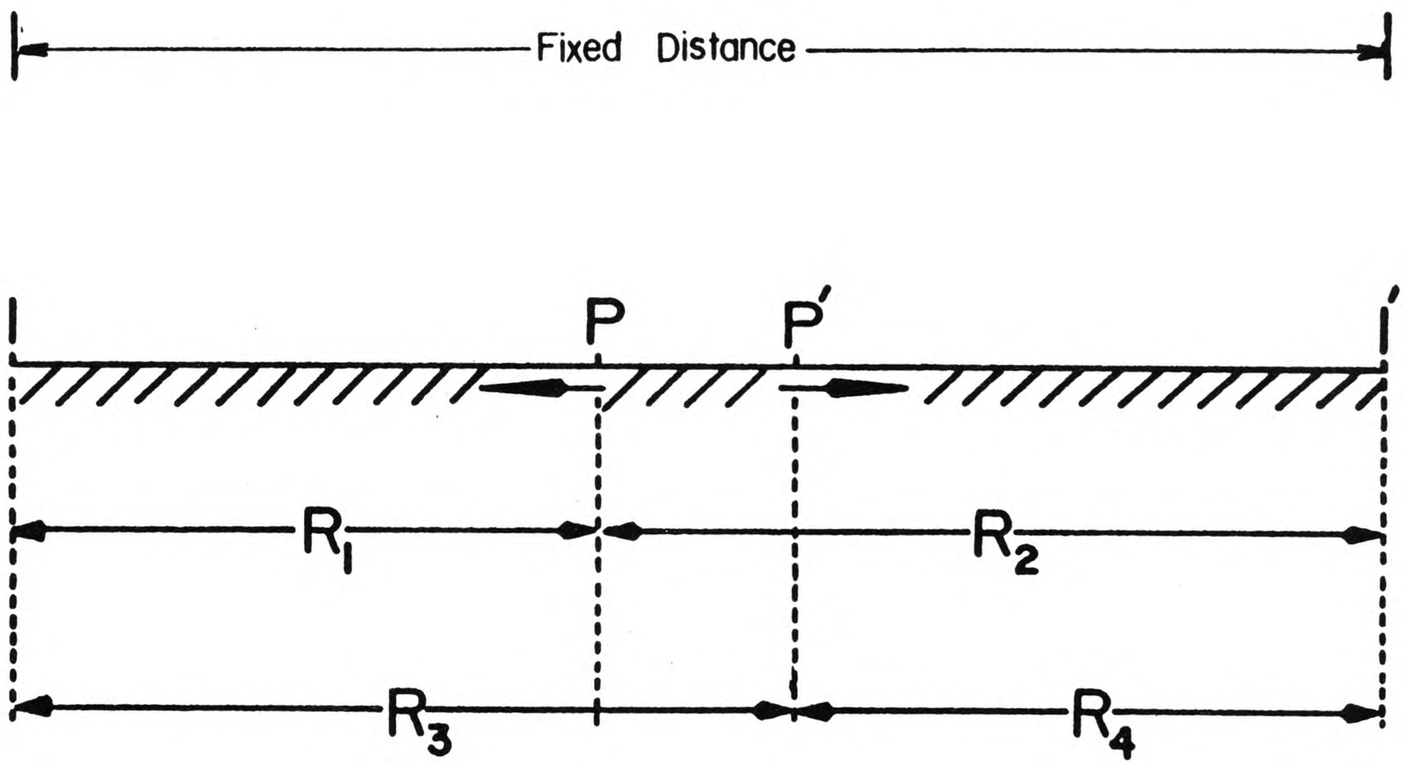


Figure 25 - Modified Wenner Array

Fixed-Frequency Magnetic Induction

Two electromagnetic conductivity (EM) surveys were conducted using Geonics EM-31 and EM-34-3 transmitter- receiver apparati. The transmitter induces eddy-currents which cause a magnetic field in the ground. The magnetic field produces an electromagnetic force which is sensed by the receiver dipole. Figure 26 illustrates the transmitter-receiver configuration for the fixed frequency method. The effective exploration depth is related to the separation between the transmitter and receiver. The EM-31 (3.7 m /12 ft intercoil spacing) provided approximately a 1.8 m (6 ft) exploration depth and the EM-34, at a 6 m (20 ft) separation provided a 3 m (10 ft) maximum exploration depth. All EM-34 readings were taken in the vertical coplanar mode (horizontal dipole).

Factors which influence ground conductivity include soil type, hydrogeologic conditions and buried soil contaminants. Figure 27 gives the relative conductivity values for various unconsolidated materials. Charged ions in pore water or in matrix material will normally increase conductivity of these materials. There must be a significant amount of groundwater contamination in order to use conductivity profiling to delimit a leachate plume.

Magnetometer Survey

Magnetometer surveying is based on magnetic fluctuations in the earth's total magnetic field. Fluctuations can be caused by ferrous materials such as the cache(s) of recovered, inert, residential incinerator drums. These fluctuations appear as anomalies relative to characteristic measurements for the earth's magnetic field at that 1ocation.

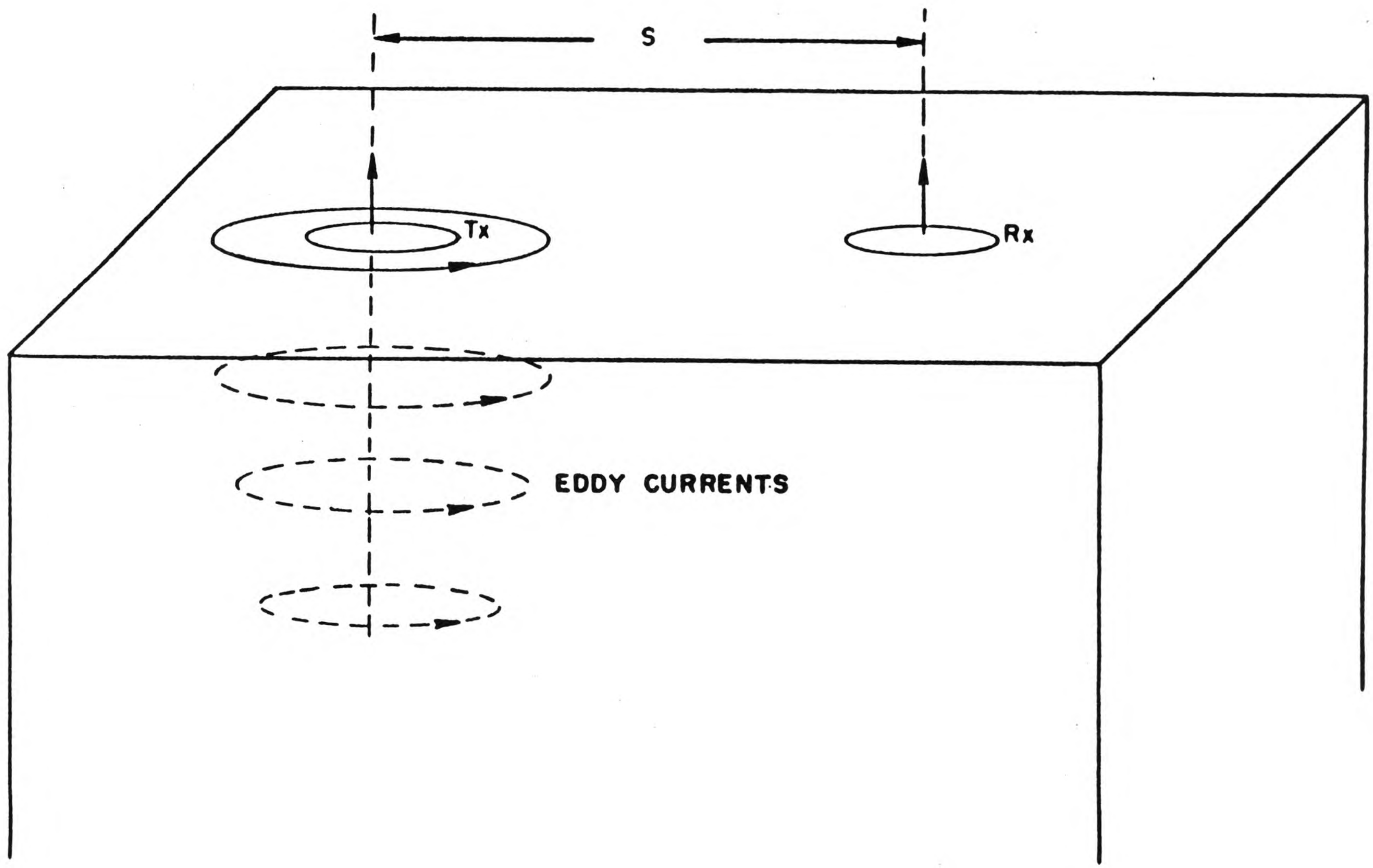


Figure 26 - Transmitter-Receiver Configuration for Fixed Frequency EM (Rudy, 1984)

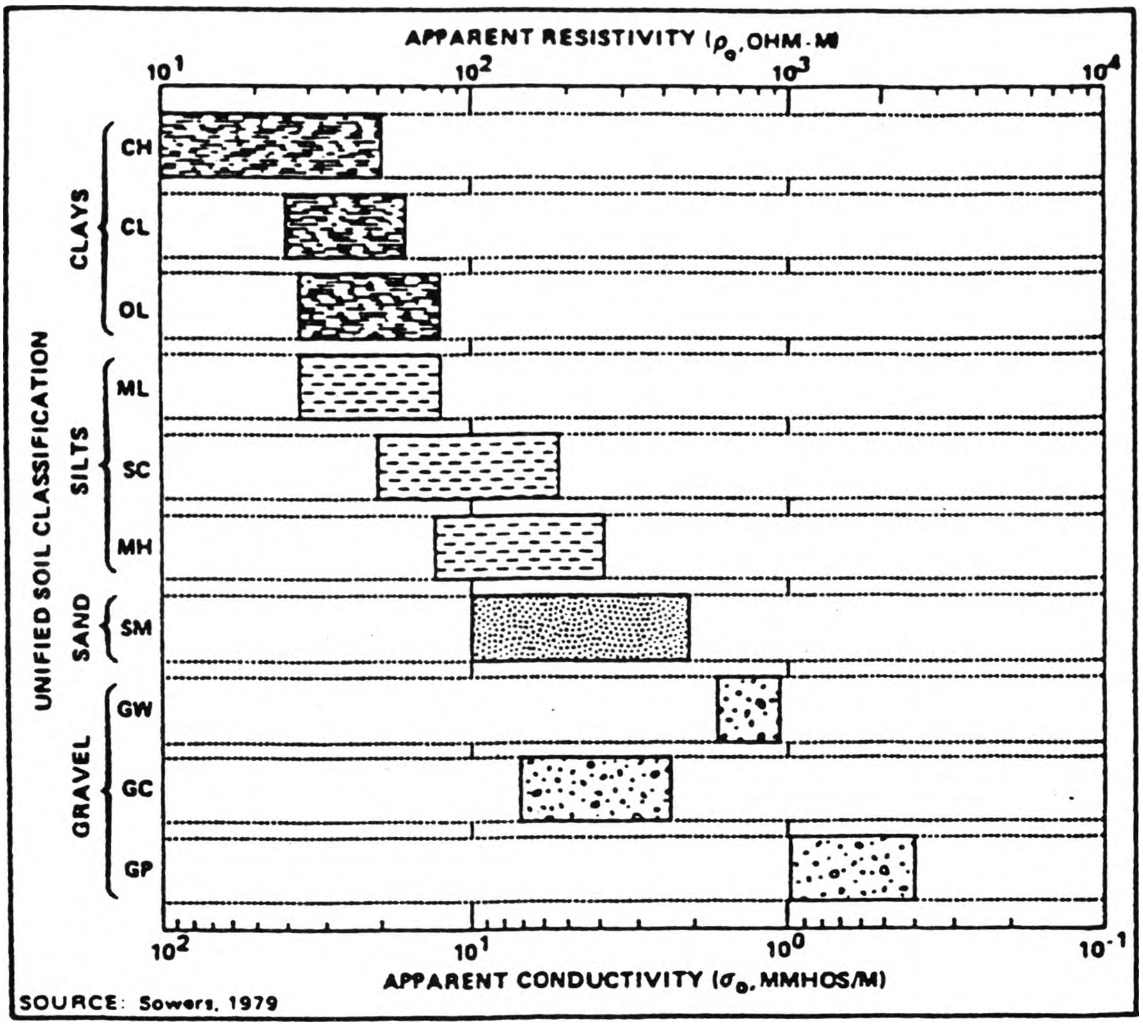


Figure 27 - Conductivity versus Soil Type

Two EDA PPM-500 Model Proton Precission Magnetometers were used in the 1983 EPA sponsered site survey, to locate possible magnetic anomalies. Five reconnaissance survey lines (Figure 28) were established 30 m (100 ft) apart, parallel to the Missouri River and readings were taken at 15 m (50 ft) intervals along these lines. From the results of these measurements, detailed magnetic grids were established in areas where magnetic anomalies were detected. Eight grids (2 in Area 1,4 in Area 2, and 2 in Area 3) were chosen for evaluation of individual target anomalies.

3. <u>Data Collection and Interpretation</u>

The results of the resistivity survey were plotted and generally show an area of lower resistivity below sounding locations 4, 5 and 6. This is in the presumed vicinity of the 1857 channel but these anomolies could also be attributed to several other factors, such as, coarse-grained, silty-sand, rapidly deposited in the river channel or it could possibly represent dense clay deposited on the bank of the river. A water well log supplied by Layne-Western Drilling Company near this area supports the case of loose, rapidly deposited sand (Rudy, 1984).

A fifty-foot grid was established across each of the three Areas of Riverfront Park from which stations were located for the electromagnetic survey. EM-31 and EM-34 measurements were taken at each station and recorded in a notebook.

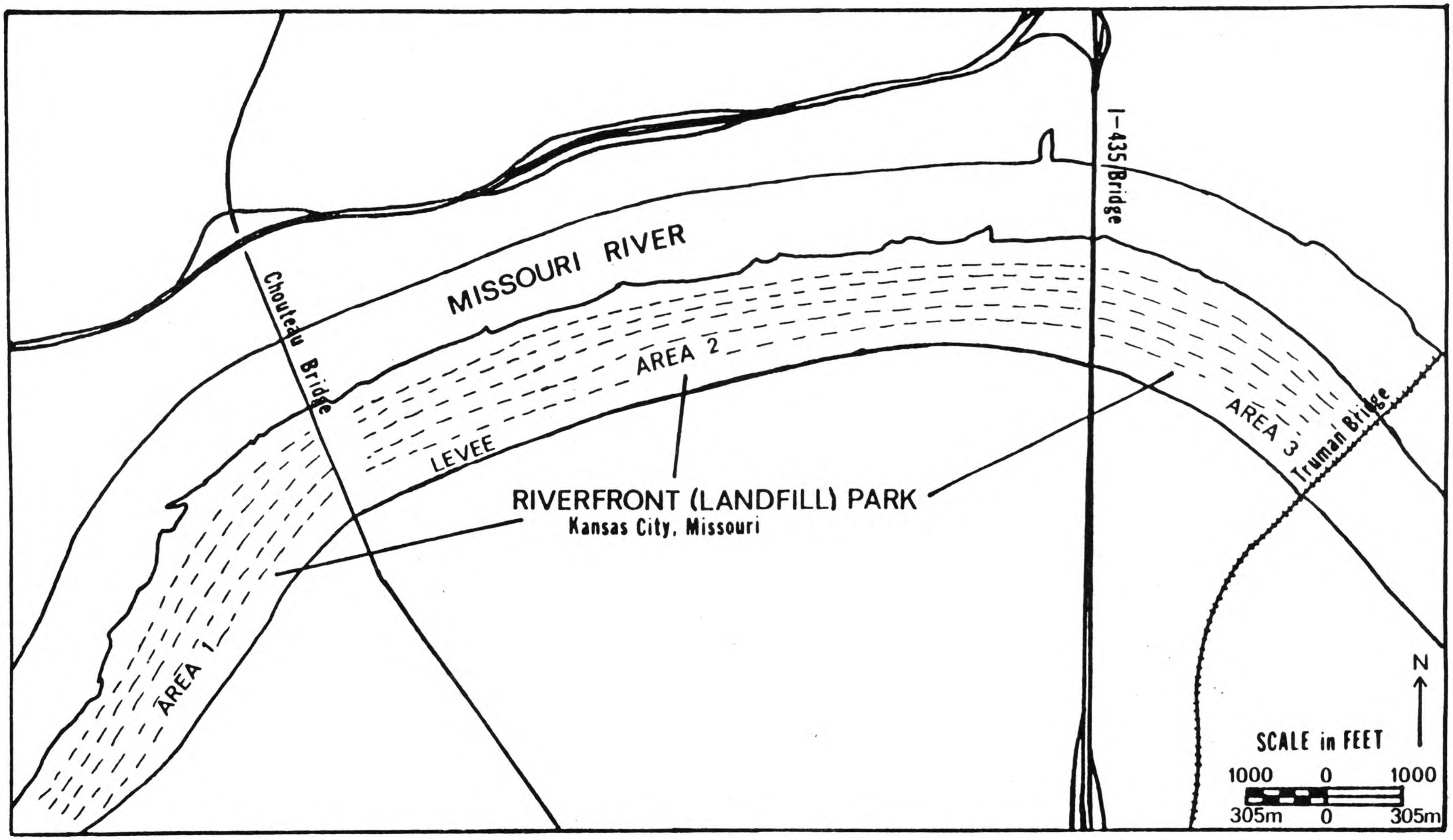


Figure 28 - 1984 EM Traverse Lines (Rudy, 1984)

The following information was interpreted by E & E, (Rudy, 1984) from profiles and graphs produced from the survey data:

Area 1	zones of high conductivity
Area 2	small anomaly in western half, zone of high conductivity in eastern one third
Area 3	predominantly high conductivity

The EM-31 to EM-34 surveys revealed basically similar information. Results of the EM-34 survey are contoured on Figure 29. There are two zones of higher conductivity which appear to extend south, to the levee. One is in the southwestern corner of Area 2 and the other is in the southwestern corner of Area 3.

The 1983 magnetometer survey consisted of the reconnaissance readings and the readings included on the eight grids of specifically-anomalous sites. All the grids, except one in Area 2, contained what have been interpreted as significant concentrations of metal, especially in the eastern side of Area 2 and all of Area 3. The Site Activity Map in Figure 3.6 shows that in 1967 Area 3 was the primary location for waste disposal. This suggests that Area 3 would be the logical location of the back-yard incinerator drums, collected and buried in 1968.

4. <u>Conclusions</u>

When analysing geophysical data one must always remember the fundamental ambiguity of the data. Results and conclusions should always be compared with soil borings or well logs before interpretations are assumed to be accurate. Due to the lack of absolute subsurface information presented at the Riverfront Landfill

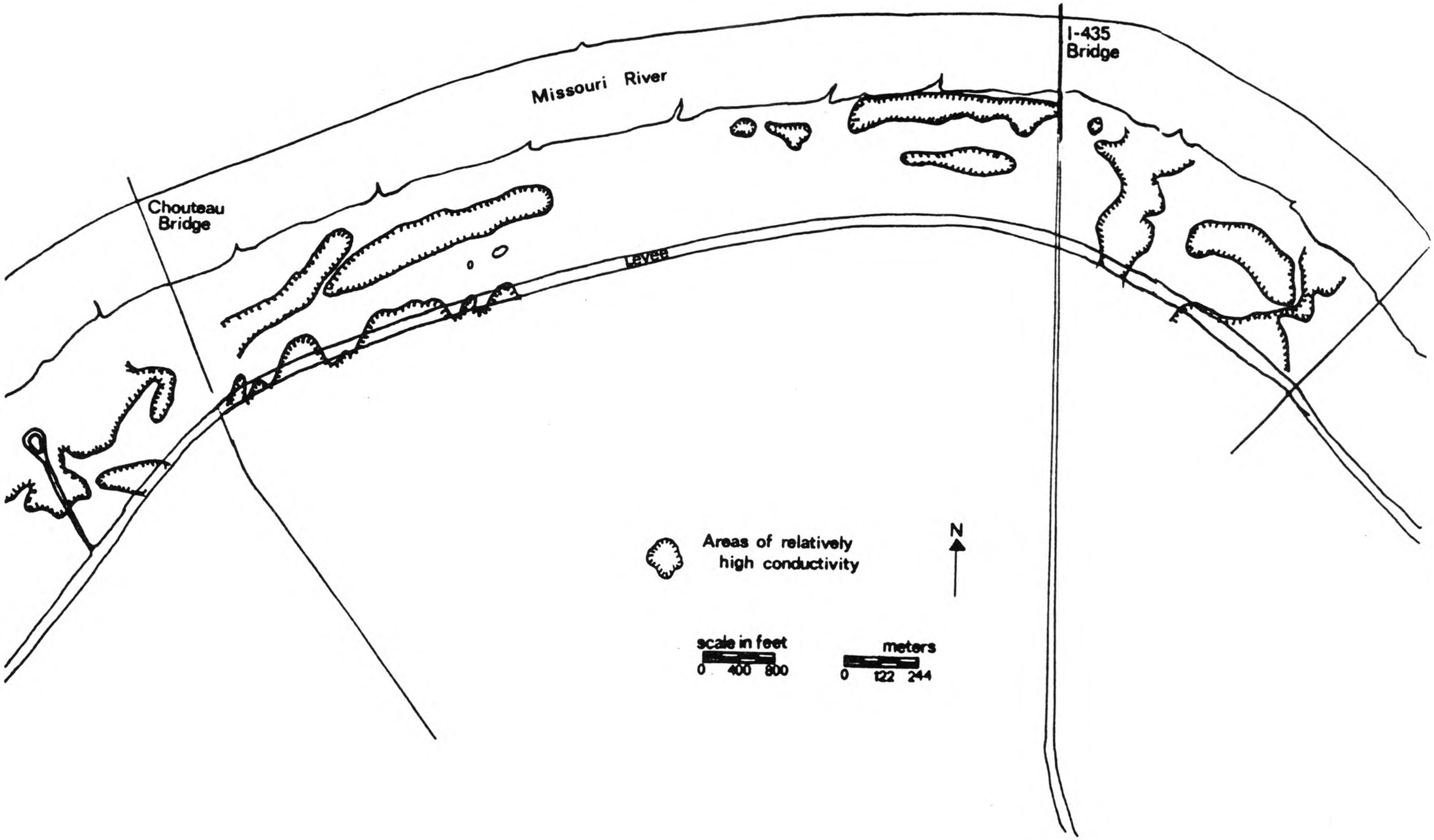


Figure 29 - Contour Map of the 1984 EM-34 Survey (Rudy, 1984)

site, interpretations must remain tentative. However, these results can be used for the purpose of determining the best locations for more direct subsurface exploration such as soil borings or monitoring wells. Execution of the proposed 1987 groundwater monitoring well plan will be a valuable compliment to this geophysical investigation.

Area 1

Significant indications of concentrations of metals were detected near the center of the Area, continuing to the eastern boundary. No significant zones of higher conductivity were identifiable.

Area 2

At the western end of the area, indications of isolated concentrations of metallic masses were detected, and a high-conductivity zone was detected beneath the levee. On the eastern end, indications of larger metallic masses were detected with metal objects appearing to be concentrated near the ground surface in the northwest part of this area. Conductivty was also high in these areas. The center of the Area was rather clear of geophysical anamolies.

Area 3

Almost all of this area shows evidence of a high metal content. A high-conductivity zone is present to the southeast, possibly also lying beneath the levee.

Well series B-l through B-4, along with well series A-l though A-5, will reveal valuable data toward confirmation or refutation of the preceding conclusions. Metal objects are expected to be encountered in the course of drilling most of the wells. Water sampled in wells B-4 and A-5 should give some indication of the quality and type of material in the potential plume locations. Well C-5 will also help to locate the controversial pre-1857 historic Missouri River channel.

V. CHARACTERIZATION OF WASTES

A. CHEMICAL CHARACTERIZATION/ENDANGERMENT ASSESSMENT

Riverfront Landfill was operated as a disposal site for municipal and industrial wastes from 1950 to 1972. To give an indication of the volume and weight of the wastes collected at the landfill, an average amount of wastes deposited each year from 1962 to 1964 was calculated at 501,767 cubic yards and 75,265 tons (Kwoka, B., and Krohn, R., 1982).

Results for the 1983 sampling by EPA Region VII are listed in Tables III and IV. Some chemicals occur in higher concentrations than others but concentration is not the only definative hazard concerning toxic chemicals. Potential reactions with other chemicals, hazardous decomposition products and exposure limits should be considered when determining the degree of hazard associated with a particular chemical. The concentration of the chemicals could also be found to vary in different areas of the site.

A list of the chemicals detected at concentrations of concern to USEPA Region VII during its 1983 soil and water sampling is contained in an appendix at the end of this thesis. Each chemical is described in terms of its toxic affects on humans, decomposition products and other associated hazards. It should be noted that these descriptions represent the characteristics of the chemical in its purest concentrated form and that at Riverfront Landfill, burning of wastes before burial as well as reactions which occured to the wastes after disposal could have considerably changed the nature of the chemicals which composed the wastes.

B. POTENTIAL IMPACTS OF WASTES DISPOSED AT THE SITE

Chemical waste materials have the potential to migrate essentially via air, surface water and groundwater. The ease of movement though these media depends on factors such as adsorption capacity, viscosity and solubility of the chemicals and the porosity, permeability and clay mineral content of the material through which the migration is occuring. At Riverfront Park most gases have probably escaped via vol ital ization. Particulate matter may be carried into the Missouri River by surface runoff during heavy precipatation or after flooding, and contaminants could be transported through the Missouri River aquifer by means of groundwater flow. As a result of offsite migration, wastes could potentially be transported to receptors. The following is a description of the possible pathways of migration, the potential receptors and the impact of wastes transported out of Riverfront Landfill.

1. Pathways

a. Ai r

Gas may have been generated within the landfill in several ways. Gas can be produced as a result of aerobic and anaerobic breakdown in a soil commonly in the form of methane or sulfurous gases. Also, some Priority Pollutants will have undergone volitalization. Due to the great amount of time which has past since landfill wastes have been deposited, and the fact that they were not placed in a contained cell, it is likely that the gas- generation potential at Riverfront Landfill is exhausted. The EPA FIT contactors sampled the near surface air quality during the 1983 Full Field Investigation. It was determined that the contaminant level in the air was small and that such vapors tended to disperse quickly into the surrounding ambient air. However, during remedial well installation or excavation, gas may be released inadvertantly. The prevailing wind direction in the area is from the south with a mean velocity of close to 17.2 km/hr (10.3 miles per hour; Burns & McDonnell Engineering Co., et al., 1984). This wind will be the primary control of gas after emanation from the landfill and should be considered when developing a health and safety program for well installation.

Air can also carry contaminated particulate matter. Relatively high concentrations of some of the chemicals (mostly metals) have been found in the ground surface and near-surface soil samples. Lead is the most prominent of these metals and such is of prime concern to EPA Region VII because of unauthorized recreational use of the Park. Pollutants found in surface soil could lead to dermal contact or inhalation during recreational uses such as motorcycle riding or playing baseball. The lead exposure to humans is presently questionable under these conditions. Dr. Bobby G. Wixson and a graduate assistant (University of Missouri-Rol1 a) executed a systematic soil sampling plan during the summer of 1986 and are utilizing the results for a computer analysis to characterize the distribution of lead in Area 1 of Riverfront Park.

b. Surface Water

There are no permanent ponds or surface water impoundments on this site. Several ephemeral puddles approximately 0.15 - 0.3 m (0.5 - 1.0 ft) have formed in ruts and at low spots. This is not unusual because the surface soil contains clay soil lenses which would impede the rate of surface water infiltation. Rain water easily filtrates into most of the silty or sandy surface soils. Water that does not infiltrate into the soil moves directly, as runoff, into the Missouri River. It can be assumed that water infiltrating pockets of wastes or contaminated soil could itself become contaminated. It is therefore rational to anticipate that the Missouri River may be receiving some quantity of potentially contaminated runoff, however small, as released from the landfill residuum. Materials in this water could be carried to potential receptors along the Missouri River. Rate of migration in surface water is controlled by rate of flow, rate of sedimentation and the solubility and sorption qualities of the chemicals. River water and riverbed sediments should be sampled upstream and downstream of the site in order to determine the general effect of any leachate migration into the river.

c. Groundwater

The hydrogeologic setting at Riverfront Park is relatively conducive to contaminant transport in groundwater. There are areas of highly permeable soils within the landfill, above and below the groundwater surface. There are wastes believed to be in direct contact with groundwater and wastes consist partially of uncontainerized materials which have a higher density and lower viscosity than water. Factors which control the rate of migration within the vadose and the saturated zones of the Missouri River Valley alluvial aquifer include groundwater flow rate, dilution, dispersion, filtration, sorption and degradation.

The flow rate in the saturated zone can be calculated using the following equation known as Darcy's Law:

$$q = -KAh/Al = -Ki$$

where q is the specific discharge of the porous media and Ah/Al or i is the gradient of groundwater flow. The gradient will be negative so the specific discharge will be positive, since head decreases in the direction of flow.

Calculation of groundwater flow and contaminant migration rate in the vadose zone involves more complicated factors. Through field and laboratory analysis, certain soil and water parameters should be determined, including water content, porosity, capillarity and saturation. These factors can be used to calculate adsorption capacity, cation exchange capacity (CEC) and dispersion. These parameters are then incorporated in the suggested computer program discussed in section IV—3. A groundwater flow and contaminant transport model is an efficient way to compile all of this data and systematically analyse it.

Mobility in both the vadose and saturated zone will be effected by physical and chemical processes. Filtration occurs when the pore space between soil particles is too small to allow the passage of contaminant ions or particles on which ions are attached. Acid-base reactions as well as oxidation-reduction reactions involve the mobilization of constituents as pH decreases.

Precipitation-dissolution can occur if concentrations of anions or cations are high enough.

2. <u>Potential Receptors</u>

a. <u>Air</u>

Measures have been taken to keep the public from trespassing within the boundaries of Riverfront Park. The area surrounding the Park is generally industrial meaning no residential area would be in jeopardy of receiving wind carried sediments. There is only a small likelyhood that particulate matter would be carried from the site in the air, and even these small quantities would be distributed widely. Toxic gases encountered during drilling should only be of concern to those present at the drill site because gases diffuse so quickly in the atmosphere. The Health and Safety officer of the RI team site should be prepared for an occurance of this sort. Air quality monitoring devices should be used during all stages of drilling and well developing. Air quality monitoring should also be considered during periodic sampling, depending on findings during well installation.

b. <u>Water</u>

There are a number of wells in the vicinity of Riverfront Park, though none are used for drinking water. Kansas City Power and Light Company (KCP&L) has a high- capacity well approximately 15 m (50 ft) deep, maintained as a source of cooling water for the Hawthorn generating station (Kwoka and Krohn, 1982). This plant is located down gradient approximately 1.6 km (1 mi) southeast of the east end of the landfill. There were also wells used (although not currently) for KCP&L cooling water about 0.8 km (0.5 mile) east of the Paseo Bridge, and a production well owned by Chem-Tech, Inc., on the north side of the river (Kwoka and Krohn, 1982).

There is a well in front of The Inn, part of the Executive Park Development, used for filling the impoundment on the grounds of the hotel (Kwoka and Krohn, 1982). Other wells include Corps of Engineers pressure- relief wells along the landward toe of the levee and a well drilled approximately at the north end of Universal Avenue. This well, installed at the base of the levee, is to be used as part of a runoff pump station, which has not been built (Kwoka and Krohn, 1982). Unless significant contaminant plumes are migrating toward these industrial wells, or drinking wells are installed in this area, groundwater contamination does not appear to be a significant problem. Implementation of the groundwater monitoring plan will determine the existance of leachate plumes and thus suggest the significance of the probl em.

Discharge into the Missouri River could be a potential problem to receptors down river of the site, but the nearest receptor that withdraws water directly from the river is located approximately 67 km (40 miles) downstream (Burns & McDonnell Engineering Co., et al., 1984). Any site-discharged contaminants would likely be well mixed, diluted, volitalized and degraded after traveling that distance (Burns & McDonnell Engineering Co., et al., 1984).

Flood waters could conceivably carry contaminants off the site but the impact of this event would be relatively insignificant. The point bar is a depositional feature and would be more likely to receive sediments than to have such carried away. Only the surface sediment would be available for transport (most of which contains only metals of low solubility in water) and the large amount of water flowing a short period of time would contribute to a large amount of dilution.

VI. CONCLUSIONS

1. Between 1950 an 1973 portions of Riverfront Park, Kansas City, Missouri were used for municipal and industrial landfill activities. A variety of solid wastes were deposited at the site and subject to unregulated burning and burial. Landfill debris were not contained in formally-designed cells or restrained by impermeable barriers. Open burning occured until 1968, at which time Kansas City passed a no-burning ordinance. At this time approximately 150,000, 210-liter (55 gal) steel drums, previously used as residential backyard incinerators, were buried at Riverfront Landfill.

2. Riverfront Park is located on the Missouri River floodplain, within a geomorphic feature called a point bar. Disposal activity involved the excavation of trenches to a depth of 3-4.5 m (10-15 ft), which is believed to have been close to the groundwater surface. Groundwater is stored within the Missouri River Valley alluvium and is seasonally discharged or recharged, into or out of the alluvium, as influenced by the stage of the river. This indicates that seasonally-fluctuating groundwater levels could possibly subject soils containing wastes to periodic immersion. Such a condition must be evaluated during the proposed Remedial Investigation (RI).

3. Site geology consists of approximately 20-30 m (82-98 ft) of unconsolidated material, grading vertically downward from fine- to coarse-grained soils. This material is underlain by Pleasanton Formation shales or is possibly separated from the shale by remnant stata of lower limestone formations of the Kansas City Group. Regional

bedrock dip is gently to the northeast but, due to the erosional surface below the Missouri River, the bedrock surface directly below the site slopes to the south-southeast.

4. Regional groundwater flow is to the north-northeast, but the on-site flow gradient and direction remains to be determined during the RI. Flow direction at the site is believed to change from north to south seasonally, as influenced by the Missouri River stage. In any case, the gradient differential is probably slight, with a pronounced vertical component during rapid fluctuations in river stage.

5. Limited soil and water quality tests were conducted by USEPA Region VII in 1982. Six heavy metals and fifteen organic chemical species were detected in soil samples from Area 1, at concentrations of concern to EPA. Small amounts (generally more than 1000 ppm) of lead in near- surface soils created the greatest concern due to possible dermal contact with individuals who recreate on the site. Thirteen wells were installed in 1983 by USEPA Region VII; eight on site. Seventeen trace elements and five organic pollutants (generally less than 0.02 ppm) were detected in water samples from these wells. Not all chemicals were detected in every well.

6. Geophysical magnetometer and electromagnetic studies were conducted in 1983, under contract to USEPA Region VII. Results from this study were highly generalized, with questionable reliability. Indications of "metal" concentrations were detected near the center of

Area 1, continuing to the eastern boundary. As in other site areas, there are no absolute verifications of these alleged "metallic" anomalies. In Area 2 indications were detected of isolated "metallic" mass concentrations at the western end and indications of larger "metallic" masses, as well as areas of high conductivity, were detected at the eastern end. Almost all of Area 3 shows evidence of high "metal" content. A high conductivity zone is present to the southeast of Area 3, possibly also lying beneath the levee.

7. The potentially hazardous chemicals that were detected during soil and groundwater sampling by USEPA Region VII are listed in Appendix A, with descriptions of their effect on humans and the environment. Due to burning and further chemical and biological processes which have occurred during environmental exposure, these wastes may have been altered to some degree. It is unlikely that these wastes all still occur today in their as-disposed or purest form.

8. The most likely paths of contaminant transport are from dermal contact with surface soils and through groundwater contamination. Direction and rate of contaminant transport cannot be determined until actual groundwater flow direction and soil properties are defined.

VII. RECOMMENDATIONS

1. The site at Riverfront Park should be adequately characterized to determine the degree of groundwater contamination apparent on site. The proposed Remedial Investigation and its associated groundwater monitoring plan should be implemented with the installation of monitoring wells and groundwater sampling. If data indicates that groundwater contamination is indeed a problem then more effort should be directed toward determining direction of groundwater flow and to define the source of contamination.

2. A more complete soil sampling survey should be completed on all three Areas, if all areas are intended for public use in the future. Surface samples should be analysed to determine whether remediation is necessary.

3. If potentially hazardous chemicals are found in water or soil samples at high enough concentrations to be considered a problem, these chemicals should be characterized in relation to properties and processes which would effect migration. These processes would include dilution, dispersion, adsorption, precipitation, and biological activity.

4. If the previous information is collected then a computer model may be used to assess the convection and attenuation of the wastes within the landfill. Predictions could be made using such a model, of where and what concentrations of chemicals could be flowing within or off the site.

5. Finally, the results of the computer model should be compared with the field data collected at the site. A good correlation of these studies will result in a thorough remedial investigation.

REFERENCES

American Conference of Governmental Industrial Hygienists, 1986, Threshold Limit Values and Biological Exposure Indices for 1986-1987 : American Conference of Governmental Industrial Hygienists, 111 p.

Black & Veatch Consulting Engineers, 1974, Water Quality Management Plan, Phase II Report for Kansas City, Metropolitan Region, submitted to Mid-America Regional Council, (Selected Sections).

Boutwell, S., Brown, S., Roberts, B., and Atwood Anderson- Nichols & Co., Inc., 1985, Modeling Remedial Action at Uncontrolled Hazardous Waste Sites, USEPA Technical Research Document #540/2-8/001

Brown, K.W. and Associates, Inc., 1980, Hazardous Waste Land Treatment, Technical Research Document #63-03- 2940, USEPA.

Brown, K.W. and Associates, Inc., 1980, Hazardous Waste Land Treatment, HWERL, Cincinnati, Technical Research Document #63-03-2940, USEPA.

Burns & McDonnell Engineering Company, 1975, Kansas City Urban Study, Water Supply Management Study, Current Baseline Condition, Water US Projections, Needs Identification and Analysis. Submitted to Kansas City District Corps of Engineers.

Burns & McDonnell Engineering Company, Fred C. Hart Associates, Inc., S.S. Papadopulos & Associates, Inc, and Woodward-Clyde Consultants, 1984, Remedial Investigation Report on the Conservation Chemical Company Site, Kansas City, Missouri, performed for the Responsible Parties to site remediation.

Caoile, J., and Rudy, R., 1983, Work Plan for Additional Geophysical Work at Riverfront Landfill, Kansas City, Missouri: Ecology and Environment, Inc., Kansas City, Missouri, Report No. R-7-8301-llb and 11c; submitted to USEPA Region VII, 17p.

City of Kansas City (Missouri),1986, Proposed Ground Water Monitoring Plan and Park Area Monitoring Plan for Riverfront Park, Kansas City, Missouri: Department of Health, Kansas City, submitted to USEPA, Region VII. 8 p.

Crabtree, J., and Older, K., 1985, Impacts of Waste Disposal at the Conservation Chemical Company, Kansas City, Missouri, on the Regional Hydrolic Regime: Geotechnical Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, MS. Final Report prepared for USEPA Region VII.

Crabtree, J., and Malone, P., 1984, Hydrogeologic Characterization Conservation Chemical Company Site, Kansas City, MO: Geotechnical Laboratory, US Army Engineer Waterways Experiment Station. Final Report prepared for USEPA Region VII.

Ecology and Environment, Inc., 1983, Draft Form of Proposed Work Plan for Further Environmental Characterization of Area 1, Riverfront Landfill, Kansas City, Missouri: FIT Project Task Report submitted to USEPA Region VII.

Ellis, G.M., 1983, Standard Operating Procedures No. IV-1 Screening Studies at Hazardous Waste Sites, NUS Corp. FIT Region IV, Report No. F4-8212-166; submitted to USEPA Region VII, 21p.

Emmett, L.F., and Jeffery, H.G., 1970, Reconnaissance of the Groundwater Resources of the Missouri: US Geological Survey, Hydrologic Investigations Atlas HA-344, 9 sheets.

Engineering Foundation Conference, 1976, Land Application of Residual Materials; selected papers.

Everett, L.G., and Schmidt, D., 1979, Establishment of Water Quality Monitoring Programs: American Water Resources Association.

Everett, L.G., Wilson, L.G., and Hoylman, E.W., 1984, Vadose Zone Monitoring for Hazardous Waste Sites: Noyes Data Corporation, NJ.

Fishel, V.C., 1948, Ground-water Resources of the Kansas City, Kansas Area: The University of Kansas/ State Geological Survey of Kansas, Division of Groundwater, 107p.

Fishel, V.C., Searcy, J.K., and Rainwater, F.H., 1953, Water Resources of the Kansas City Area Missouri and Kansas: US Geological Survey, Circular 273, 52 p.

Foreman, T.F., 1977, Determination of hydrogeologic properties of Missouri River alluvium using numerical modeling techniques, Master's Thesis, University of Missouri-Columbia, Missouri. 124 P-

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Prentice Hall, Inc., Englewood Cliffs, NJ. pg 29.

Fuller, W.H., 1978, Premonitoring Waste Disposal Sites, in Establishments of Water Quality Monitoring Programs: L.G. Everett and K.D. Schmitt, American Water Resources Association, p 85-95.

Geological Survey and Water Resources, Rept. Inv. 31, 62, pp, i11 us.

GeoTrans, Inc., 1985, Hydrogeologic Analysis of the Conservation Chemical Company Site, Kansas City, Missouri, Volume I, Report contracted by USEPA Region VII.

GeoTrans, Inc., 1985, Hydrologic Analysis of the Conservation Chemical Company Site, Kansas City, Missouri, Volume II, Attachments contracted by USEPA Region VII.

Granneman, Norman, 1976, Hydrogeology of the Missouri River Flood Plain Near Glasgow, Missouri, Master's Thesis, University of Missouri-Columbia, Missouri. 98p.

Hatheway, A.W., 1985, Geological and Geotechnical Aspects of Hazardous Waste Management and Cleanup, Course Notes for Geological Engineering 337/401, University of Missouri-Rolla, 420 p.

Hatheway, A.W., Eli frits, C.D., and Wixson, B.G., 1985, Feasibility Study of Groundwater Monitoring and Remedial Options, Area 1, Riverfront Park Kansas City, Missouri, Rept to City of Kansas City; University of Missouri-Rolla, lip.

Hicken, E.J., 1974, The Development of Meanders in Natural River-channels: American Journal of Science, vol. 274, pg 414-442.

Howe, W.B., and Koenig, J.W., 1961, The Stratigraphic Sucession in Missouri; State of Missouri Division of Geological Survey and Water Resources, Roll a, Missouri,pg 90-99.

Imes, J.L., 1985, Review of Previous Investigations and Assessment of Data Requirements to Evaluate that Potential for, and Impact, of the release of Hazardous substances from Riverfront Landfill, Kansas City, Missouri: Report to USEPA, Region VII, US Geological Survey, Water Resources Branch, Roll a, Missouri, 12 p.

Krohn, R., 1983, Summary of Riverfront Landfill Sample Results-Aql4: Ecology and Environment, Inc., FIT Project Task Report submitted to USEPA Region VII.

Kwoka, W., and Krohn, R., 1982, Preliminary Assessment of the Riverfront Landfill (Chouteau Landfill): E & E, FIT Project Task Report submitted to USEPA Region VII.

Long, F.A., and Schweitzer, G.E., 1982, Risk Assessment at Hazardous Waste Sites: American Chemical Society, Washington, D.C.

McCourt W.E., Bennett, J.W. and Albertson, M., 1917, The Geology of Jackson County, MO: Missouri Bureau of Geology and Mines, Rolla, MO. Vol. XIV, second series, map in pocket.

Mid-America Regional Council, 1978, Water Quality Management, 208 Final Plan, Kansas City Metropolitan Region.

Miller, D.W., 1980, Waste Disposal Effects on Groundwater: Premier Press, Berkeley, California.

Morby, R., 1983, Letter to Mr. T.E. Mysl inski, Public Health Engineer, Health Department/Environmental Health Services, Kansas City, Missouri: Air Waste Management Division, USEPA Region VII, 3p.

National Institute for Occupational Safety and Health/ Occupational Safety and Health Administration (NIOSH/OSHA), 1981, Occupational Health Guidelines for Chemical Hazards: US Dept of Health and Human Services/ US Dept of Labor.

Nuzman, C.E., 1972,"Jackson County Hydrology Study", Layne-Western Co. Inc., submitted to Missouri Water Company.

Parizek, E.J., and Gentile, R.J., 1965, Guidebook, field trip, annual meeting, 1965, Geological Society of America, The geology of the Kansas City Group at Kansas City; Missouri

Preston, G.D., 1984, Soil Survey of Jackson County, Missouri, Soil Conservation Service, US Department of Agriculture in cooperation with the Missouri Agricultural Experiment Station, pg 40-45 and sheets 5 & 6.

Rudy, R., 1984, Full Field Investigation of Riverfront Landfill, Kansas City Missouri: Ecology and Environment/FIT, Kansas City, KS, Contracts TDD#R-07-8301-ll, 11A. and 11D with six appendices.

Rudy, R., and Blackman, N., 1984, EPIC (Environmental Protection Inspection Consulting) Field Sampling Report Riverfront Park - Area 1: Ecology and Environment, Inc., Kansas City, Missouri; USEPA Region VII Representatives, 17p. plus appendices.

Sax, N.I., 1975, <u>Dangerous Properties of Industrial Materials</u>: Van Nostrand Reinhold Company, NY. 1258 p.

Scannel1 , H.H. and Eli frits, C.D., 1986, Engineering Geology Map of Riverfront Park, Kansas City, MO, Department of Geological Engineering, UMR. Scale 1:4800.

Sowers, G.F., 1979, Introductory Soil Mechanics and Foundations: Geotechnical Engineering: Macmillan, New York, 621 p.

Stohr, C.J., St. Ivany, G. and Williams, J.H., 1981, Geologic Aspects of Hazardous-Waste Isolation in Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey.

Tan, K.T.,1976, <u>Principles of Soil Chemistry</u>: Marcel Dekker, Inc., NY.

U.S. Army Corps of Engineers, Kansas City District, 1973, An Urban Study, Metropolitan Region of Kansas City, Missouri and Kansas, Plan of Study.

U.S. Army Corps of Engineers, Kansas City District, 1977, An Urban Study, Metropolitan Region of Kansas City, Missouri and Kansas, Background Information Report.

U.S. Army Corps of Engineers, Kansas City District, 1879- 1954, Operation and Maintenance Manuel, Kansas Citys Flood Control Project, Missouri and Kansas Rivers, East Bottoms Unit; Comparison of Conditions Missouri River, Rulo Nebraska to mouth: Kansas City, MO, Volume One.

U.S. Army Corps of Engineers, Kansas City District, 1981, A Report on Flood Damage Reduction, Brush Creek and Tributaries, Missouri and Kansas, Supplemental Draft, Technical Support Appendix.

Wendland, S., 1986, Undergraduate Geological Engineering student, UMR - Personal Comment.

Wilson, D.K., and Eli frits, C.D., 1983, Preliminary Characterization of Historic Landuse at Riverfront Site: University of Missouri-Rolla. 13 p.

Wixson, R.G., 1985, Preliminary Evaluation of Metals at Riverfront Park Landfill, Kansas City, Missouri, 22p.

VITA

Helen Hudson Scannell was born on July 26, 1963 in Albany, New York. She received her primary and secondary education in Castleton, New York. She has received a Bachelor of Arts degree in Geology from the State University of New York at Potsdam, New York, in May 1985. Also, in December 1985, she completed a USEPA sponsored Health and Safety Course.

Miss Scannell's work experience includes one summer as a staff geologist at Dunn Geoscience Corporation, Latham, New York and one summer as a field assistant during a Remedial Investigation for SCS Engineers Inc. of Reston, Virginia.

She has been enrolled in the Graduate School of the University of Missouri-Rolla since August 1985 during which time she has held positions as Graduate Research Assistant (1985-86) and Graduate Teaching Assistant (1986- 87).

APPENDIX

CHEMICAL CHARACTERIZATION

The following information was obtained from various published references including the Occupational Health Guidelines for Chemical Hazards (NIOSH/OSHA; 1981), Threshold Limit Values and Biological Exposure Indices for 1986-1987 (American Conference of Governmental Industrial Hygienists) and Dangerous Properties of Industrial Materials (Irving N. Sax; 1957). Each chemical that was detected at a concentration of concern to EPA Region VII is listed and described. Threshold Limit Values (TLV = Threshold Limit Value for Time Weighted Average over a 40 hour per week, 8 hour per day work week) are given for each along with a description of toxic affects on humans, decomposition products and other potential associated hazards.

A1uminum

Aluminum is a silvery ductile metal with a TLV (aluminum oxide) of 10 Mg/m3. It is the third most abundant element in the earth's crust. Groundwater typically contains not more that 0.5 ppm of aluminum except where pH is below 4. The amounts detected during sampling ranged from 2.7 to 160 ppm. Ranges of pH in the wells was 6.3 to 8.0.

Arsenic

Arsenic is a silvery, brittle, crystalline metal with a TLV of 0.2 mg/m3. The routes by which it can enter the body is by inhalation, ingestion or by dermal contact. Swallowing or inhaling the substance can cause irritation of the stomach and intestines along with nausea, vomiting and diarrhea. Chronic arsenic poisoning can result in liver damage, blood, kidney and nervous disorders, and may cause skin abnormalities.

Barium

Barium is a silver, white, slightly lustrous, somewhat maluable metal with a TLV of 0.5 mg/m3. It can affect the body though all routes of exposure. Soluble boron compounds may cause irritation of eyes, nose, throat, bronchial tubes and skin. Also, it may cause severe stomach pains, irregular heart beat, convulsions and possible death. Contact of barium oxide with water, carbon dioxide or hydrogen sulfide .he 45 may cause fire or explosions. Barium carbonate reacts with acids to form carbon dioxide gases. Barium nitrate, when combined with organic matter or combustible materials may cause fire or explosions.

Boron

Boron is an odorless trace element occurring in the form of colorless, glassy granules or flakes. The TLV assigned to Boron is 10 mg/m3. Boron oxide can affect the body through all routes of exposure causing eye, nose or skin irritation. It is a fairly stable chemical.

Cadmium

Cadmium is a silver-white malleable metal with a TLV of 0.05 mg/m3. It is insoluble in water but soluble in acid. It affects the body if inhaled or swallowed (especially in the form of cadmium dust). Inhalation can cause chest pain, coughing, chills, shortness of breath or possible death. Ingestion can cause nausea, vomiting, diarrhea and abdominal cramps. Long term effects of cadmium exposure includes loss of sense of smell, kidney damage or cancer of the prostate in men. Cadmium compounds will emit highly toxic fumes when heated and will react vigorously with oxidizing materials.

Chromium

Chromium can occur as a metal or as an insoluble chromium salt. It has a TLV of 0.5 mg/m3 and will effect the body if inhaled or swallowed. The toxic effects of chromium vary with its valence state possibly causing respiration system, liver or kidney damage. It is also known as a human carcinogen . Chromium is incompatible with strong oxidizers and may be a fire or explosive hazard.

Cobalt

Cobalt is a silver-gray metal with a TLV of 0.1 mg/m3. It is insoluble in water but soluble in acid. It can affect the body though all routes of exposure. Fumes and dust can be irritating to the nose and throat, causing cough and shortness of breath or to the extreme, disability and death. It is incompatible with strong oxidizers.

Copper

Copper is a reddish metal which is insoluble in water and has a TLV of 1 mg/m3. In the form of dust it can affect the body through all routes of exposure. Copper compounds may cause skin, eye and upper respiratory tract irritation.

Lead

Lead is a silvery metal with a TLV of 0.15 mg/m3. Lead poisoning can occur through all routes of exposure. It is cumulative in the body, producing brittleness of red blood cells. Lead can cause abdominal pain, vomiting, diarrhea, central nervous system damage among other symptoms.

Manganese

Manganese is a reddish-gray metal with a TLV of 5 mg/m3. It decomposes in water and dissolves in acid. As fumes or dust it can affect the body through all routes of exposure. It causes only minor irritations to the respiratory tract. Long term affects occur as a result of accumulation in major organs.

Nickel

Nickel occurs in the form of silver, metallic crystals and has a TLV of 1 mg/m3. Nickel is insoluble in water but soluble in acid. It affects most humans through inhalation or ingestion. Nickel fumes are respiratory irritants and have been known to cause cancer in the lungs and sinuses. Soluble salts of nickel can cause nausea, vomiting and shortness of breath. Contact of nickel with strong acids may form flammable and explosive hydrogen gas. Decomposition produces toxic vapors and gases such as nickel carbonyl, and oxides of nitrogen.

Selenium

Selenium has a TLV of 0.2 mg/m3 and can affect the body through all routes of exposure. Various compounds of selenium can cause such problems as severe breathing difficulties, skin burns and eye irritations. Long term exposure can cause damage to liver and spleen. Decomposes to toxic vapors and gases.

Silver

Silver is a metal with a TLV of 0.1 mg/m3. It affects the body through all routes of exposure. Exposure to silver can cause discoloration or blue-gray darkening of eyes, nose , throat and skin. Silver nitrate is strongly corrosive and can cause skin burns or eye damage. Decomposition forms toxic gases and vapors.

Vanadium

Vanadium has a TLV of 0.05 mg/m3. It can affect the body through inhalation and ingestion. It can be an irritant to the respiratory tract, can cause gastrointestinal disorders, discoloration of the tongue and pain in the chest.

Zinc

Zinc has a TLV of 5 mg/m3. It is toxic when heated, producing high concentration of zinc fumes.

Vinyl Chloride

Vinyl chloride is a colorless liquid or gas with a faintly sweet odor. It has a TLV of 5 ppm. It is used to form polyvinyl chloride which is widely used in the production of plastics. The chemical can affect the body through all routes of exposure possibly causing local irritation or frostbite on skin due to rapid evaporation. It may cause central nervous system damage, heptic disorders, respiratory irritation and is known as a carcinogen in humans. Vinyl chloride is highly flammable and explosive, and emits highly toxic fumes when heated to decomposition.

Methylene Chloride

Methylene chloride is a colorless, volatile liquid with a TLV of 100 ppm. It is used in the manufacture of paint and varnish removers, insecticides and solvents. It can affect the body through all routes of exposure. Fumes may cause mental confusion, light headedness, nausea, vomiting and possibly unconsciousness or death. Long term exposure may cause irritation of the skin. It is unstable in heat or moisture and incompatible with strong oxidizers, strong caustics and chemically active metals. Decomposition produces toxic substances such as hydrogen chloride, phosgene and carbon monoxide.

1.1- Dichloroethane

1.1- Dichloroethane is a colorless liquid with an aromatic, etherial odor. It has a TLV of 200 ppm. It is used as a solvent and cleaning agent and can affect the body through all routes of exposure. Short term exposure through inhalation may cause drowsiness or unconsciousness and can cause liver, kidney or lung damage. Long term skin contact can cause a burn. This chemical can be a fire hazard when exposed to heat or flame and it is also a moderate explosive hazard. When heated to decomposition it forms toxic fumes of phosgene, vinyl chloride, hydrogen chloride and carbon monoxide. It can react vigorously with oxidizing materials and strong caustics.

trans 1,2-Dichloroethylene

Trans 1,2-dichloroethylene is a colorless liquid with a strong, distinctive odor. It has a TLV of 200 ppm and is similar to 1,1-dichioroethane in chemistry and toxic effects on humans. May cause dizziness or have an irritating effect to eyes and upper respiratory tract. Chronic poisoning may cause nausea, vomiting, low blood sugar and possibly dermatitis. It is a moderate fire and explosive hazard when exposed to heat or flame.

Chloroform

Chloroform is a colorless liquid with a heavy sweet odor. It has a TLV of 10 ppm and is known widely as an anesthetic. It can affect the body through all forms of exposure. Inhalation can cause irritation of mucus membrane and skin, headache, drowsiness, vomiting, dizziness, unconsciousness, irregular heart beat and possibly death. Chronic symptoms of prolonged exposure may be liver, heart or kidney damage. In the presence of light, chloroform slowly reacts to form toxic gases such as phosgene and hydrogen chloride. It is incompatible with strong caustics and chemically active metals such as aluminum, magnesium powder, sodium or potassium.

Benzene

Benzene is a colorless liquid with a TLV of 10 ppm. Poisoning commonly occurs through inhalation but can also occur through the skin. It can affect the respiratory tract, blood cells and bone marrow. It has a cumulative affect on the body making long term exposure more serious.

Trichl oroethane

Trichloroethane (1,1,1-Trichioroethane) is a colorless liquid known as methyl chloroform, with a TLV of 50 ppm. It is used as an industrial cleaner and degreaser of metals, and can affect the body through all routes of exposure. It is dangerous when heated to decomposition due to the highly toxic fumes of chloride produced.

1.1.2- Trichioroethane

1.1.2- Trichioroethane is a colorless liquid which has a TLV of 10 ppm. It can affect the body through all routes of exposure. Breathing high concentrations can cause the heart to beat irregularly and stop. Prolonged contact with skin can cause irritation. It reacts with active metals and decomposes to form hydrogen chloride, hydrogen flouride, phosgene and carbon monoxide.

<u>1.1.2.2- Tetrachloroethane</u>

1.1.2.2- Tetrachloroethane (Acetylene tetrachlorite) is a heavy, colorless liquid with a detectable odor at 3 ppm. It is generally considered the most toxic of the chlorinated hydrocarbons. It can affect the body through all routes of exposure. It is a strong irritant to the mucus membranes of the eyes and upper respiratory tract. Can cause liver damage as well as fatty degeneration of kidneys, heart, lungs and brain. When heated to decomposition, it emmits highly toxic fumes.

<u>Chlorobenzene</u>

Chlorobenzene is a colorless, liquid with a TLV of 75 ppm. It can affect the body through all routes of exposure. Short term exposure may cause drowsiness, incoordination or unconsciousness as well as some eye, nose and skin irritation. Prolonged exposure can cause kidney and liver damage. Contact with strong oxidizers may cause fines or explosions. Decomposition produces toxic chlorine compounds along with phosgene and carbon monoxide.

<u>Ethyl Benzene</u>

Ethyl benzene is a colorless, aromatic liquid with a TLV of 100 ppm. It can affect the body through all routes of exposure. Short term exposure causes eye, nose, throat and skin irritation. Exposure to high concentrations can cause dizziness, unconsciousness or a sense of constriction of the chest. Long term exposure may cause a skin rash. It is a moderate fire hazard when exposed to heat or flame and is incompatible with strong oxidizing agents. It decomposes to form toxic gases and vapors.

1.2- Dichlorobenzene

1.2- Dichlorobenzene is a colorless to pale yellow liquid with a pleasant, aromatic odor. It has a TLV of 50 ppm and can affect the body through all routes of exposure. As a vapor, it may cause irritation of the upper respiratory tract and eyes. In high concentrations it may cause drowsiness, unconsciousness and death. As a liquid, it may burn the skin or eyes. It is incompatible with strong oxidizers and decomposes to toxic chlorine compounds.

1.4- Dichlorobenzene

1.4- Dichlorobenzene is a colorless solid with a moth-ball-like odor and is used as an insecticide. It has a TLV of 75 ppm and can affect the body through all routes of exposure. It can be an eye, nose or throat irritant and may cause a headache, loss of appetite, nausea, vomiting, liver damage or death. Decomposition products are hydrogen chloride and carbon monoxide.