M-32

West Valley Demonstration Project

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SAFETY ANALYSIS REPORT FOR

PROJECT OVERVIEW AND GENERAL INFORMATION

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8-22-00
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WVNS RECORD OF REVISION

Rev. No.	Description of Changes	Revision On Page(s)	Dated
6	Per ECN #12783 Annual Revision - All chapters were updated to reflect current site practices, procedures, and configurations. In addition, each chapter was updated to reflect changes in DOE guidance. Chapter 10 was revised to reflect recent WVNS corporate changes as well as WVDP organizational changes. The section on Emergency Management was substantially revised to reflect the current program.	All	08/30/00

WVNS RECORD OF REVISION CONTINUATION FORM

Rev. No.	Description of Changes	Revision On Page(s)	Dated

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LIST OF TECHNICAL SUPPORT DOCUMENTS

NOTE: ALL TECHNICAL SUPPORT DOCUMENTS (TSDs) ARE CONTAINED IN A SEPARATE BINDER WVNS-SAR-001 (REV. 2) TECHNICAL SUPPORT DOCUMENTS.

LIST OF ACRONYMS AND ABBREVIATIONS

A/E	Architect/Engineer
Å	Angstrom (10^{-8} centimeter)
A&PC	Analytical and Process Chemistry
AA	Atomic Absorption
AAC	Assembly Area Coordinator
AADT	Average Annual Daily Traffic
ABA	Authorization Basis Addendum
ACC	Ashford Community Center
ACFM	Absolute Cubic Feet Per Minute
ACGIH	American Conference of Governmental Industrial Hygienists
ACI	American Concrete Institute
A/E	Architect/Engineer
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AED	Assistant Emergency Director
AEDE	Annual Effective Dose Equivalent
AEOC	Alternate Emergency Operations Center
AES	Atomic Emission Spectrophotometer
AIHA	American Industrial Hygiene Association
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ALARA	As Low As Reasonably Achievable
ALI	Annual Limit of Intake
ALS	Advanced Life Saving
AMCA	Air Movement and Control Association
AMS	Aerial Measurement System
AMS	Alarm Monitoring Station
ANC	Analytical Cell
ANL	Argonne National Laboratory
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOC	Ashford Office Complex
APOC	Abnormal Pump Operating Condition
AR-OG	Acid Recovery - Off-Gas
ARC	Acid Recovery Cell
ARF	Airborne Release Fraction
ARI	Air-Conditioning and Refrigeration Institute
ARM	Area Radiation Monitor
ARPR	Acid Recovery Pump Room
ARR	Airborne Release Rate
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AU	Alfred University
AWS	American Welding Society

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

B&P	Buffalo & Pittsburgh
BDAT	Best Demonstrated Available Technology
BDB	Beyond Design Basis
BDBE	Beyond Design Basis Earthquake
BNFL	British Nuclear Fuels Limited
BNL	Brookhaven National Laboratory
Bq	Becquerel
BRP	Big Rock Point
BSW	Bulk Storage Warehouse
BWR	Boiling Water Reactor
c	Centi, prefix for 10^{-2}
C	Coulomb
CAM	Continuous Air Monitor
CAS	Criticality Alarm System
cc	Cubic Centimeter
CC	Communications Coordinator
CCB	Cold Chemical Building
CCDS	Cold Chemical Delivery System
CCR	Chemical Crane Room
CCS	Chilled Water System
CCSR	Cold Chemical Scale Room
CCSS	Cold Chemical Sump Station
CCTV	Closed-Circuit Television
CDDS	Computer Data Display System
CDS	Criticality Detection System
CEC	Cation Exchange Capacity
CEDE	Committed Effective Dose Equivalent
cfm	Cubic feet per minute
CFMT	Concentrator Feed Make-up Tank
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CGA	Compressed Gas Association
CHT	Condensate Hold Tank
Ci	Curie
CLCW	Closed-Loop Cooling Water
cm	Centimeter
CMAA	Crane Manufacturers Association of America
CMP	Construction Management Procedure
CMR	Crane Maintenance Room
COA	Chemical Operating Aisle
CPC	Chemical Process Cell
CPC-WSA	Chemical Process Cell Waste Storage Area
cpm	Counts per minute
CPR	Cardiopulmonary Resuscitation
CR	Control Room
CRM	Community Relations Manager
CRT	Cathode Ray Tube
Cs	Cesium

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

CSDM	Cognizant System Design Manager
CSE	Criticality Safety Engineer
CSE	Cognizant System Engineer
CSER	Confined Space Entry Rescue
CSPF	Container Sorting and Packaging Facility
CSR	Confined Space Rescue
CSRF	Contact Size Reduction Facility
CSRT	Confined Space Rescue Team
CSS	Cement Solidification System
cSv	centi-Sievert
CTS	Component Test Stand
CUA	Catholic University of America
CUP	Cask Unloading Pool
Cv	Column Volume
CVA	Chemical Viewing Aisle
CW	Cooling Tower Water
CWTP	Commercial Waste Treatment System
CY	Calendar Year
D&D	Decontamination and Decommissioning
D&M	Dames & Moore
DAC	Derived Air Concentration
DAS	Data Acquisition System
DB	Dry Bulb
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DBT	Design Basis Tornado
DBW	Design Basis Wind
DC	Drum Cell
DCF	Dose Conversion Factor
DCG	Derived Concentration Guide
DCS	Distributed Control System
DEAR	Department of Energy Acquisition Regulation
DF	Decontamination Factor
DGR	Diesel Generator Room
DOE	Department of Energy
DOE-EM	Department of Energy - Environmental Management
DOE-HQ	Department of Energy - Headquarters
DOE-HQ-EOC	Department of Energy - Headquarters - Emergency Operations Center
DOE-ID	Department of Energy - Idaho
DOE-OCRWM	Department of Energy - Office of Civilian Radioactive Waste Management
DOE-OH	Department of Energy - Ohio Field Office
DOE-PD	Department of Energy - Project Director
DOE-WV	Department of Energy - West Valley Area Office
DOE-WVDP	Department of Energy - West Valley Demonstration Project
DOELAP	Department of Energy Laboratory Accreditation Program
DOP	Dioctylphthalate
DOSR	DOE On-Site Representative
DOT	Department of Transportation

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

DP	Differential Pressure
dpm	Disintegrations per minute
DR	Data Recorder
DR	Damage Ratio
DVP	Developmental Procedure
DWPF	Defense Waste Processing Facility
DWS	Demineralized Water System
E-Lab	Environmental Laboratory
E-Spec	Equipment Specification
EA&SRP	Engineering Administration & Safety Review Program
EBA	Evaluation Basis Accident
EBE	Evaluation Basis Earthquake
ECN	Engineering Change Notice
ECO	Environmental Control Officer
ED	Emergency Director
EDE	Effective Dose Equivalent
EDR	Equipment Decontamination Room
EDRVA	Equipment Decontamination Room Viewing Aisle
EDS	Electrical Power Distribution
EG	Evaluation Guideline
EHS	Employee Health Services
EID	Environmental Information Document
EIP	Emergency Implementing Procedure
EIS	Environmental Impact Statement
EMAP	Environmental Management Administrative Procedure
EMC	Emergency Management Coordinator
EMIP	Emergency Management Implementing Procedure
EMOA	East Mechanical Operating Aisle
EMP	Emergency Management Procedure
EMRT	Emergency Medical Response Team
EMT	Emergency Medical Technician
EMT	Environmental Monitoring Team
EMU	Emergency Medical Unit
EOC	Emergency Operation Center
EP	Engineering Procedure
EPA	Environmental Protection Agency
EPD	Elevation Plant Datum
EPI	Emergency Prediction Information
EPIcode	Emergency Protection Information Code
EPRI	Electric Power Research Institute
EPZ	Emergency Protection Zone
ERO	Emergency Response Organization
ERPG	Emergency Response Planning Guideline
ES&H	Environmental, Safety, and Health
ESA	Endangered Species Act
ESH&QA	Environmental, Safety, Health, and Quality Assurance
ESQA&LO	Environmental, Safety, Quality Assurance, and Laboratory Operations

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

FACTS	Functional and Checklist Testing of Systems
FB	Fire Brigade
FBC	Fire Brigade Chief
FBR	Fluidized Bed Reactor
FFCA	Federal Facility Compliance Act
FHA	Fire Hazards Analysis
FM	Factory Mutual
fpm	Feet per minute
fps	Feet per second
FRI	Feed Reduction Index
FRS	Fuel Receiving and Storage
FSAR	Final Safety Analysis Report
FSFCA	Federal and State Facility Compliance Act
FSP	Fuel Storage Pool
ft	Feet
FWCA	Fish and Wildlife Coordination Act
g	Gram
g	Gravitational Acceleration Constant
G	Giga, prefix for 10^9
GAC	Granular Activated Carbon
gal	Gallon
GC	Gas Chromatograph
GCR	General Purpose Cell Crane Room
GCS	Gravelly Clayey Soils
GE	General Electric
GET	General Employee Training
GFE	Government Furnished Equipment
gM	Gravelly mud
GM	Geometric Mean
GM	Geiger-Mueller
GOA	General Purpose Cell Operating Aisle
GOALS	General Office Automated Logging System
GOCO	Government-Owned, Contractor-Operated
GPC	General Purpose Cell
gpd	Gallons per day
GPLI	General Purpose LAN Interface
gpm	Gallons per minute
GRS	General Record Schedule
G_s	Specific gravity
GTAW	Gas Tungsten Arc Welding
h	Hour
ha	Hectare
HAC	Hot Acid Cell
HAF	Hot Acid Feed
HAPR	Hot Acid Pump Room
HAZMAT	Hazardous Materials
HAZWOPER	Hazardous Waste Operations and Emergency Response

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

HDC	High Density Concrete
HEC	Head End Cells
HEME	High Efficiency Mist Eliminator
HEPA	High Efficiency Particulate Air
HEV	Head End Ventilation
HFE	Human Factors Engineering
HIC	High Integrity Container
HLDS	High-Level Drainage System
HLW	High-Level Waste
HLWIS	High-Level Waste Interim Storage
HLWISA	High-Level Waste Interim Storage Area
HLWTS	High-Level Waste Transfer System
hp	Horsepower
HPGe	Hyperpure Germanium
HPLC	High Performance Liquid Chromatography
HPS	High Pressure Sodium
HRA	Human Reliability Analysis
HRM	Human Resources Manager
HV	Heating and Ventilation
HVAC	Heating, Ventilation, and Air Conditioning
HVOS	Heating, Ventilation Operating Station
HWSF	Hazardous Waste Storage Facility
i.d.	Inner Diameter
I&C	Instrumentation and Control
IA	Instrument Air
IC	Incident Commander
ICEA	Insulated Cable Engineers Association
ICP	Inductively Coupled Plasma
ICR	Instrument Calibration Recall
ICRP	International Commission on Radiological Protection
ID	Idaho
IDLH	Immediately Dangerous to Life and Health
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
IH&S	Industrial Hygiene and Safety
ILDS	Infrared Level Detection System
in	Inch
INEL	Idaho National Engineering Laboratory
INEEL	Idaho National Engineering and Environmental Laboratory
IRTS	Integrated Radwaste Treatment System
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
IV&V	Independent Validation and Verification
IWP	Industrial Work Permit
IWSF	Interim Waste Storage Facility
IX	Ion Exchange
JIC	Joint Information Center

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

JTG	Joint Test Group
k	Neutron Multiplication Factor
k	Kilo, prefix for 10^3
K_d	Partition Coefficient
k_{eff}	Effective Neutron Multiplication Factor
kg	Kilogram
K_h	Horizontal hydraulic conductivity
kN	Kilo-Newton
kPa	Kilo-Pascal
kPag	Kilo-Pascal gauge
kph	Kilometer per hour
kV	Kilo-Volt
K_v	Vertical hydraulic conductivity
kVA	Kilovolt-ampere
kW	kilo-Watt
L	Liter
LAH	Level Alarm High
LAN	Local Area Network
LANL	Los Alamos National Laboratory
LAP	Laboratory Accreditation Program
LAP	Lower Annealing Point
LASL	Los Alamos Scientific Laboratory
lb	Pound
LCO	Limiting Condition for Operation
lfpm	Linear feet per minute
LFR	Live Fire Range
LI	Level Indicate
LIMS	Laboratory Information Management System
LITCO	Lockheed Idaho Technologies Corporation
LLDS	Low-Level Drainage System
LLL	Lawrence Livermore Laboratory
LLNL	Lawrence Livermore National Laboratory
LLRW	Low-Level Radioactive Waste
LLW	Low-Level Waste
LLW2	Low-Level Waste Treatment Replacement Facility
LLWTF	Low-Level Waste Treatment Facility
LLWTS	Low-Level Waste Treatment System
LM	Liaison Manager
LMITCO	Lockheed-Martin Idaho Technologies Corporation
LOA	Letter of Agreement
LOS	Level of Service
LOVS	Loss of Voltage Signal
LPF	Leak Path Factor
LPG	Liquid Propane Gas
lpm	Liters per minute
LPM	Liters per minute
LPS	Liquid Pretreatment System

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

LR	Level Record
LSA	Lag Storage Area
LUNR	Land Use and Natural Resources
LWA	Lower Warm Aisle
LWC	Liquid Waste Cell
LWTS	Liquid Waste Treatment System
LXA	Lower Extraction Aisle
m	Meter
m/s	Meters per second
m	Milli, prefix for 10^{-3}
M	Mega, prefix for 10^{6}
M&O	Maintenance and Operations
M&O	Management and Operating
M&TE	Maintenance and Test Equipment
MAR	Material at Risk
m_b	Earthquake Magnitude
MBtu	Mega-British Thermal Units
MC	Miniature Cell
MCC	Materials Characterization Center
MCC	Motor Control Center
MCE	Maximum Credible Earthquake
mCi	milli-Curie
MEOSI	Maximally Exposed Off-Site Individual
MeV	Mega-electron Volt
MFHT	Melter Feed Hold Tank
mG	Muddy gravels
mi	Mile
MMI	Modified Mercalli Intensity
M&O	Management and Operating
MOA	Mechanical Operating Aisle
MOI	Maximally Exposed Off-Site Individual
mol	Mole
MOU	Memorandum of Understanding
MPag	Mega-Pascal gauge
MPC	Maximum Permissible Concentration
MPFL	Maximum Possible Fire Loss
mph	Miles per hour
MPO	Main Plant Operator
MPOSS	Main Plant Operations Shift Supervisor
mR/hr	Milli-Roentgen per hour
MRC	Master Records Center
mrem	Millirem
MRR	Manipulator Repair Room
MSDS	Material Safety Data Sheet
msG	Muddy Sandy Gravels
MSM	Master-Slave Manipulator
mSv	milli-Sievert
MT	Metric Ton

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

MTIHM	Metric Tons Initial Heavy Metal
MTU	Metric Tons Uranium
MUF	Material-Unaccounted-For
MW	Mega-Watt
MWD	Mega-Watt-Day
n	Nano, prefix for 10^{-9}
Na	Sodium
NAD	Nuclear Accident Dosimeter
NARA	National Archives and Records Administration
NDA	NRC-Licensed Disposal Area
NDA-LPS	NRC-Licensed Disposal Area - Liquid Pretreatment System
n_e	Effective porosity
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NESHAP	National Emission Standard for Hazardous Air Pollutants
NFPA	National Fire Protection Association
NFS	Nuclear Fuel Services, Inc.
NGVD	National Geodetic Vertical Datum
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
NMC	News Media Center
NMPC	Niagara Mohawk Power Corporation
NOAA	National Oceanic and Atmospheric Administration
NP	North Plateau
NPH	Natural Phenomena Hazard
NPPS	North Plateau Pump System
NPPTS	North Plateau Pump and Treatment System
NQA	Nuclear Quality Assurance
NR	Nonconformance Report
NRC	Nuclear Regulatory Commission
NRRPT	National Registry of Radiation Protection Technology
NTS	Nevada Test Site
NWS	National Weather Service
NY	New York
NYCRR	New York Code of Rules and Regulations
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSERDA	New York State Energy Research and Development Authority
NYSGS	New York State Geological Survey
o.d.	Outer Diameter
OAAM	Operational Accident Assessment Manager
OAM	Operational Assessment Manager
OB	Office Building
OBE	Operating Basis Earthquake
OEP	On-Site Evaluation Point

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

OGA	Off-Gas Aisle
OGBR	Off-Gas Blower Room
OGC	Off-Gas Cell
OGMR	Off-Gas Monitoring Room
OGTS	Off Gas Treatment System
OH	DOE, Ohio Field Office
OH/WVDP	Ohio Field Office, West Valley Demonstration Project
OITS	Open Item Tracking System
OJT	On-the-Job Training
OM	Operations Manager
OOS	Out-of-Service
ORNL	Oak Ridge National Laboratory
ORR	Operational Readiness Review
ORRB	Operational Readiness Review Board
ORT	Operations Response Team
OSC	Operations Support Center
OSHA	Occupational Safety and Health Act
OSHA	Occupational Safety and Health Administration
OSR	Operational Safety Requirement
oz	Ounce
p	Pico, prefix for 10^{-12}
P	Peta, prefix for 10^{15}
P&ID	Piping and Instrument Diagram
Pa	Pascal
PA	Project Appraisals
PAD	Public Access Defibrillation
PAG	Protective Action Guideline
PAH	Pressure Alarm High
PBT	Performance-Based Training
PC	Partition Coefficient
PCB	Polychlorinated Biphenyl
PCDOCS	Personal Computer Document Organization and Control Software
pcf	Pounds per cubic foot
PCH	Pressure Control High
PCM	Personal Contamination Monitor
PCR	Process Chemical Room
PD	Project Director
PDAH	Pressure Differential Alarm High
PDAL	Pressure Differential Alarm Low
PDCH	Pressure Differential Control High
PDCL	Pressure Differential Control Low
PDR	Pressure Differential Record
PEL	Permissible Exposure Limit
PF	Personnel Frisker
PGA	Peak Ground Acceleration
PGSC	Pasquill-Gifford Stability Class
PHA	Process Hazards Analysis
PHA	Product Handling Area

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

PID	Public Information Director
PLC	Programmable Logic Controller
PM	Preventive Maintenance
PMC	Process Mechanical Cell
PMCR	Process Mechanical Cell Crane Room
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PMP	Project Management Plan
PNL	Pacific Northwest Laboratory
PNNL	Pacific Northwest National Laboratory
PPB	Parts Per Billion
PPC	Product Purification Cell
ppm	Parts Per Million
PPM	Parts Per Million
PPS	Product Packaging and Shipping
PRC	Pressure Record Control
PRM	Process Radiation Monitor
PSAR	Preliminary Safety Analysis Report
psf	Pound per square foot
psi	Pound per square inch
psig	Pound per square inch gauge
PSO	Plant Systems Operations
PSO	Plant Systems Operator
PSR	Process Safety Requirement
Pu	Plutonium
PVC	Polyvinyl chloride
PVS	Permanent Ventilation System
PVU	Portable Ventilation Unit
PWR	Pressurized Water Reactor
PWS	Potable Water System
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAP	Quality Assurance Program
QAP	Quality Assurance Plan
QAPD	Quality Assurance Program Description
QARD	Quality Assurance Requirements Document
QCN	Qualification Change Notice
QM	Quality Management
R	Roentgen
R/hr	Roentgen per hour
R&S	Radiation and Safety
R&SC	Radiation and Safety Committee
RAP	Radiological Assistance Plan
RCO	Radiological Controls Operations
RCOS	Radiological Controls Operations Supervisor
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

RCTC	Radiological Control Team Commander
RCTL	Radiation Control Team Leader
REAAM	Radiological and Environmental Accident Assessment Manager
REAM	Radiological and Environmental Assessment Manager
REG	Robert E. Ginna
rem	Roentgen Equivalent Man
RER	Ram Equipment Room
RESL	Radiological and Environmental Sciences Laboratory
RF	Respirable Fraction
RID	Records Inventory and Disposition Schedule
RMW	Radioactive Mixed Waste
RP	Radiation Protection
rpm	Revolutions per minute
RPM	Revolutions Per Minute
RPM	Radiation Protection Manager
RPO	Radiation Protection Operations
RPOS	Radiation Protection Operations Supervisor
Rt	Route
RTS	Radwaste Treatment System
RWI	Radiological Worker I
RWII	Radiological Worker II
RWP	Radiation Work Permit
s	Second
S&EA	Safety and Environmental Assessment
SA&I	Safety Analysis and Integration
SAA	Satellite Accumulation Area
SAI	Science Applications International
SAR	Safety Analysis Report
SBS	Submerged Bed Scrubber
SCBA	Self-Contained Breathing Apparatus
scfm	Standard cubic feet per minute
SCR	Selective Catalytic Reduction
SCS	Soil Conservation Service
SCSSCs	Safety-Class Structures, Systems, and Components
SDA	New York State-Licensed Disposal Area
SEAM	Safety and Environmental Assessment Manager
sec	Second
SER	Site Environmental Report
SFCM	Slurry-Fed Ceramic Melter
SFPE	Society of Fire Protection Engineers
SFR	Secondary Filter Room
SGN	Society Generale pour les Techniques Nouvelles
SGR	Switch Gear Room
SI	International System of Units
SIP	Special Instruction Procedure
slpm	Standard liter per minute
SM	Security Manager
SMACNA	Sheet Metal and Air Conditioning Contractors National Association

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

SMS	Sludge Mobilization System
SMT	Slurry Mix Tank
SMWS	Sludge Mobilization and Wash System
SNF	Spent Nuclear Fuel
SNL	Sandia National Lab
SNM	Special Nuclear Material
SO	Security Officer
SOG	Seismic Owner's Group
SOP	Standard Operating Procedure
SPDES	State Pollutant Discharge Elimination System
SPO	Security Police Officer
Sr	Strontium
SR	Surveillance Requirement
SRE	Search and Reentry
SRL	Savannah River Laboratory
SRR	Scrap Removal Room
SRSS	Square-root-of-the-sum-of-the-squares
SS	Stainless Steel
SSC	Sample Storage Cell
SSCs	Structures, Systems, and Components
SSE	Safe Shutdown Earthquake
SSS	Slurry Sample System
SSWMU	Super Solid Waste Management Unit
STC	Sample Transfer Cell
STD	Standard
STP	Standard Temperature and Pressure
STS	Supernatant Treatment System
Sv	Sievert
SVS	Scale Vitrification System
SWC	Surge Withstand Capability
SWMU	Solid Waste Management Unit
T	Tera, prefix for 10^{12}
TBP	Tri-butyl phosphate
TE	Test Exception
TEDE	Total Effective Dose Equivalent
TEEL	Temporary Emergency Exposure Limit
Ti	Titanium
TID	Tamper-Indicating Device
TIG	Tungsten Inert Gas
TIP	Test Implementation Plan
TIP	Test In-Place
TIP	Test Instruction Procedure
TLD	Thermoluminescent Dosimeter
TLV	Threshold Limit Value
TN	Transnuclear, Inc.
TPC	Test Procedure Change
TPL	Test Plan
TR	Technical Requirement
TRG	Technical Review Group

LIST OF ACRONYMS AND ABBREVIATIONS

(Continued)

TRMS	Training Records Management System
TRR	Test Results Report
TRU	Transuranic
TSB	Test and Storage Building
TSC	Technical Support Center
TSCS	Technical Support Center Staff
TSD	Technical Support Document
TSR	Technical Safety Requirement
TVS	Temporary Ventilation System
UA	Utility Air
UAP	Upper Annealing Point
UBC	Uniform Building Code
UCRL	University of California Research Laboratory
UDF	Unit Dose Factor
UL	Underwriters Laboratories, Inc.
ULO	Uranium Load Out
UPC	Uranium Product Cell
UPS	Uninterruptible Power Supply
UR	Utility Room
USDOE	U. S. Department of Energy
USDOI	U. S. Department of the Interior
USDOL	U. S. Department of Labor
USDOT	U. S. Department of Transportation
USEPA	U. S. Environmental Protection Agency
USGS	U. S. Geological Survey
USNRC	U. S. Nuclear Regulatory Commission
USQ	Unreviewed Safety Question
USQD	Unreviewed Safety Question Determination
UWA	Upper Warm Aisle
UWS	Utility Water Supply
UXA	Upper Extraction Aisle
V	Volt
VA	Volt-Ampere
VAC	Volt Alternating Current
VDC	Volt Direct Current
V&S	Ventilation and Service Building
VEC	Ventilation Exhaust Cell
VF	Vitrification Facility
VFFCP	Vitrification Facility Fire Control Panel
VIV	Variable Inlet Vane
VL	Vitrification Liaison
VOG	Vessel Off-Gas
VOSS	Vitrification Operations Shift Supervisor
VPP	Voluntary Protection Program
VS	Vitrification System
VSR	Ventilation Supply Room
VTF	Vitrification Test Facility
VWR	Ventilation Wash Room
W	Watt
WAPS	Waste Acceptance Product Specifications
WC	Water Column

LIST OF ACRONYMS AND ABBREVIATIONS

(Concluded)

WCC	Warning Communications Center
WCCC	Warning Communications Center Communicator
WDC	Waste Dispensing Cell
WDV	Waste Dispensing Vessel
WGSG	Westinghouse Government Services Group
WHC	Westinghouse Hanford Company
WHSE	Warehouse
WIPP	Waste Isolation Pilot Plant
WMO	Waste Management Operations
WMO	Westinghouse Maintenance Operation
WMOA	West Mechanical Operating Aisle
WNYNSC	Western New York Nuclear Service Center
WO	Work Order
WQR	Waste Qualification Report
WRPA	Waste Reduction and Packaging Area
wt%	Weight percent
WTF	Waste Tank Farm
WTFVS	Waste Tank Farm Ventilation System
WVDP	West Valley Demonstration Project
WVNS	West Valley Nuclear Services Company
WVPP	West Valley Policies and Procedures
WVVHC	West Valley Volunteer Hose Company
XC-1	Extraction Cell 1
XC-2	Extraction Cell 2
XC-3	Extraction Cell 3
XCR	Extraction Chemical Room
XSA	Extraction Sample Aisle
y	Year
Y_d	Dry density
YOY	Young of Year
yr	Year
Y2K	Year 2000
°C	Degrees Celsius
°F	Degrees Fahrenheit
μ	Micro, prefix for 10^{-6}
χ/Q	Relative concentration

A.1.0 INTRODUCTION AND OVERALL DESCRIPTION OF THE FACILITY

The Western New York Nuclear Service Center (WNYNSC), at West Valley, New York, was the site of the first commercial nuclear fuel reprocessing operation in the United States. It was operated by Nuclear Fuel Services, Inc. (NFS) from 1966 to 1972 to recover useable uranium and plutonium. Approximately 640 metric tons of spent nuclear fuel was reprocessed generating about 600,000 gallons of liquid, high-level radioactive waste (HLW) that was stored in underground tanks contained within concrete vaults.

In 1980, Congress passed the West Valley Demonstration Project (WVDP) Act, Public Law 96-368 (U.S. Congress October 1, 1980), directing the U.S. Department of Energy (DOE) to carry out a HLW management project at the site (without taking title to the facilities or the wastes) to demonstrate solidification techniques for preparing the HLW for disposal. Vitrification, determined to be the best demonstrated available technology (BDAT) for the treatment of HLW, was selected as the preferred technique.

Through a contractual agreement with New York State, DOE is operating the Project in conjunction with the New York State Energy Research and Development Authority (NYSERDA). In 1981 DOE selected West Valley Nuclear Services Company, Inc. (WVNS), as prime Project contractor. DOE and WVNS assumed operational control of the site in 1982. At that time, WVNS was a wholly-owned subsidiary of Westinghouse Electric Company. Currently, WVNS is part of the Westinghouse Government Environmental Services Company (WGES), which was formed following acquisition of Westinghouse in March 1999 by a joint venture of Washington Group International, Inc. (formerly Morrison Knudsen Corporation), and BNFL, Inc. (a U.S. subsidiary of British Nuclear Fuels).

The WVDP (established to implement the WVDP Act) is located on approximately 80 hectares (220 acres) within the 1,335-hectare (3,345-acre) WNYNSC in rural Cattaraugus County, about 56 km (35 mi) south of Buffalo, New York. The WVDP site is within the Town (township) of Ashford, one of thirty-five distinct towns (a geopolitical subdivision) that comprise Cattaraugus County. The Project facilities include the former NFS plant and related facilities, portions of which have been decontaminated sufficiently for use by the WVDP. Several additional buildings and facilities have been and are being constructed to complete the WVDP mission. Figure A.1.0-1 is a local area map, showing the WVDP site in relation to the WNYNSC and the WNYNSC in relation to nearby communities and geographical features. Facilities located outside the WVDP premises, but within the WNYNSC which are related to the operations of the WVDP include the two reservoirs to the south, the Bulk Storage Warehouse to the southeast, the school house to the south, and environmental monitoring equipment surrounding the site. The reservoirs are the source of water for the Project facilities. The Bulk Storage Warehouse provides long-term storage for excess nonradioactive materials and equipment.

In addition to the facilities mentioned above, the WNYNSC includes two former disposal areas; the Nuclear Regulatory Commission Licensed Disposal Area (NDA) within the Project premises, and the State of New York Licensed Disposal Area (SDA), which is not part of the Project premises. Figure A.1.0-2 shows the relative location of these features within the WNYNSC.

The Act directs the Secretary of Energy to undertake five major activities, as follows:

i. Solidify the liquid HLW stored at the WNYNSC into a form suitable for transportation and disposal;

ii. Develop containers for the solidified HLW suitable for permanent disposal of the HLW;

iii. Transport the waste to a federal repository for disposal;

iv. Dispose of low-level radioactive waste (LLW) and transuranic (TRU) waste produced by the Project; and

v. Decontaminate and decommission the HLW storage tanks, the HLW solidification facilities, and any material and hardware used in connection with the Project.

Primary tasks, as determined by the WVDP, which must be completed to accomplish the mission objectives as identified in the Act include the following:

- Development and operation of a supernatant treatment system (STS), which processes the liquid supernate remaining after fuel reprocessing as well as the liquid from sludge washing;
- Development and operation of a liquid waste treatment system (LWTS);
- Development and operation of a cement solidification system (CSS) for LLW;
- Development and operation of a sludge mobilization and washing system, and HLW transfer system;
- Development and operation of a HLW vitrification facility;
- Development and operation of a vitrified HLW interim storage system; and
- Final decontamination and decommissioning (D&D) of the Project facilities and shipment of wastes designated for off-site disposal.

Ancillary tasks and supporting activities include the following:

- Maintenance and operation of the existing site and plant;
- Development and operation of a size reduction facility for contact-handleable, contaminated equipment;
- Development and operation of a compactor facility (removed from site);
- Development and operation of storage facilities to be used during the time interval between waste generation and waste disposal; and
- Disposal area operation and maintenance.

A phased approach has been adopted for the completion of the above activities. For example, the following facilities and systems are currently in operation or capable of operating: the Supernatant Treatment System (STS), Liquid Waste Treatment System (LWTS), Cement Solidification System (CSS), size reduction facility, lag storage facility, NRC-licensed disposal area, sludge wash system, and HLW transfer system. The vitrification system has been constructed, pre-operational check out has been completed, the system is currently operating in a routine radioactive mode, and as of June 2000, produced 247 canisters of HLW borosilicate glass. Final D&D and HLW shipment are still in a conceptual stage.

A.1.1 Structure of the Project Safety Analysis Report and this SAR

The purpose of the Project Safety Analysis Report is to document adequacy of safety analysis for the WVDP to ensure that the WVDP can be constructed, operated, maintained, shut down, decontaminated and decommissioned safely and in compliance with applicable laws and regulations. The Project Safety Analysis Report is a dynamic and evolving compilation of all facility-specific SAR modules that were initially written to meet the requirements of DOE Order 5481.1B, *Safety Analysis and Review System* (USDOE May 19, 1987), Supplemental Directive ID 5481.1B, *Safety Analysis and Review System* (USDOE October 18, 1991), and WV-906, *Radiation and Safety Committee* (WVNS). Revision 2 of SAR-001 was prepared to meet the requirements of DOE Order 5480.23, *Nuclear Safety Analysis Reports* (USDOE April 30, 1992), using the guidance of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports* (USDOE July 1994). This revision (Rev. 6) has been prepared to meet the requirements of periodic updates of Safety Analysis Reports as stated in DOE Order 5480.23, Section 9, paragraph c.

DOE orders provide direction with respect to the content of a safety analysis. An outline, consistent with this direction has been developed for this SAR. This outline is based upon the USNRC Regulatory Guide 3.26, *Standard Format and Content of Safety Analysis Reports for Fuel Reprocessing Plants* (USNRC 1975) with appropriate modifications. The outline is described fully in *Technical and Administrative Approach for the West Valley Demonstration Project Safety Program* (WVNS 1987).

In accordance with the Regulatory Guide 3.26 formatting requirements, it should be noted that the following chapters are not included herein: Chapter 5, "Facility Design"; Chapter 6, "Process Systems"; Chapter 9, "Accident Safety Analysis"; and Chapter 11, "Technical Specifications." However, as explained later in this chapter, other facility-specific SAR modules contain this information as appropriate.

In particular, this Safety Analysis Report provides a general description of site characteristics, including: site location; population distribution and trends; nearby land and water uses; meteorology; hydrology; geology; seismology; natural phenomena; and in addition, provides information on selected administrative systems used throughout the site. WVNS-SAR-001 is a unique module in the overall Project Safety Analysis Report because it does not describe in detail operational systems, components or facilities. Hence, operating characteristics are not applicable, and hazard classifications based on associated risks are not relevant. However, hazard classifications for the facilities that comprise the WVDP are presented in WVDP-227, *WVDP Facility Identification and Classification Matrix* (WVNS). The WVDP itself is classified as a Hazard Category 2 Nuclear Facility. The topics listed in DOE Order 5480.23, Section 8, paragraph b(3) will be found, as appropriate, in the sections indicated in Table A.1.1-1.

A.1.1.1 Structure of the Project Safety Analysis Report

Most of the major facilities of the WVDP are functionally interrelated; however, many of these facilities can and do function independently as well. For example, the STS functions to strip the cesium from the liquid phase (the supernate) of the HLW contained in Tank 8D-2. The LWTS processes the decontaminated solution by evaporation. The LWTS product consists of a concentrated solution that is sent to CSS for incorporation in a cement matrix. The relatively small volume (approximately 10,000 gallons) of THOREX (acidic HLW resulting from reprocessing of thorium fuel) previously contained in Tank 8D-4 has been transferred to Tank 8D-2 and the resulting liquid (including the remaining supernate from sludge washing) has been processed through the Integrated Radwaste Treatment System (STS, LWTS, CSS, and Drum Cell, see Section A.1.3.1). Additional activities included the transfer of cesium-loaded zeolite resin from the bottom of Tank 8D-1 to Tank 8D-2. The resulting mixture in Tank 8D-2 is currently being fed to the melter. Thus, the STS is related to both the sludge mobilization system and the vitrification process (as well as with other processes and systems). Notwithstanding these interrelationships, the STS has been and will be operated independently (in time) of the sludge mobilization system and the vitrification process.

A phased program that brings facilities (systems) on-line independently was implemented in part because of the complex nature of the WVDP. This approach recognized the fact that several major components required significant predesign developmental work and were subject to funding constraints.

In order to avoid the safety analysis preparation and review cycle becoming an impediment to the advancement of the Project as a whole, the concept of a modular safety analysis was developed. This scheme permits individual SARs to be written and approved so that major Project facilities, components and/or activities can be conceptualized, designed, analyzed, reviewed, constructed, subjected to readiness review, and operated on independent schedules. As a result, the integrated Project Safety Analysis Report covering the entire Project is evolving continuously. Subsequent updates and/or upgrades of the SARs are performed on a periodic basis and reflect the evolution of DOE Orders as well as the evolution of the WVDP.

Pursuant to the requirements of DOE Order 5480.21, *Unreviewed Safety Questions* (USDOE December 24, 1991), and WV-914, *Unreviewed Safety Question Determination (USQD)* (WVNS), which implements this order, no activity or system about which an unreviewed safety question exists will be operated. This procedure provides the guidance for conducting and documenting the review associated with the USQD process. Throughout the life of the WVDP, the safety analyses are revised as new information is obtained, as preliminary analyses are replaced with final analyses, as the DOE Orders evolve, and as the Project matures. Table A.1.1-2 reflects the status of SARs which have been written to comply with DOE Order 5480.23, using the guidance of DOE-STD-3009-94.

A.1.1.2 Safety Analysis Report Preparation, Review, Approval, and Distribution

It is the policy of WVNS that facilities and operations be analyzed to identify all hazards and potential accidents associated with the facilities and the process systems, components, equipment, or structures, and to establish design and operational means to mitigate these hazards and potential accidents.

WV-365, *Preparation of WVDP Safety Documents* (WVNS), establishes the administrative process for the initiation, preparation, and in-house and independent review of safety analyses. Once a given safety analysis has been approved by the WVNS Radiation and Safety Committee, it is forwarded to the DOE-OH/WVDP. Safety analyses for activities that might have a significant impact on public health and safety (e.g., vitrification, supernatant treatment, etc.) are reviewed by the NRC.

A.1.2 Overview of Safety Review Program

The DOE took operational control of the Project premises on February 25, 1982. Prior to taking control of the site, DOE reviewed the SAR prepared by NFS and the application for the U.S. Nuclear Regulatory Commission (NRC) license CSF-1.

Several portions of the existing plant were modified for use by the WVDP. Before these areas were put to new uses, they were analyzed for compliance with safety regulations. Initially, these presolidification activities were analyzed and reviewed on a case-by-case basis and the resulting safety analyses were documented in individual SAR modules. Many of the safety questions which arose in conjunction with such analyses were common to several areas. Such issues included control of airborne contamination, worker exposure, waste handling and packaging, criticality control, etc. Therefore, as indicated in the following section, consolidation of the individual SAR modules has been accomplished in the SAR which covers low-level waste processing and support activities as indicated in Table A.1.1-2.

A.1.3 Description of WVDP Activities

A.1.3.1 Overview of HLW Handling and Vitrification Operations

The HLW which is currently being vitrified is currently stored in two tanks, Tank 8D-1 and 8D-2. Tank 8D-2 contains an underlying sludge and overlying supernate liquid. Tank 8D-1 contains the Supernatant Treatment System (STS) consisting of ion-exchange columns and supporting equipment suspended from the top of the tank. Tank 8D-1 also contains the heel remaining after the transfer of cesium-loaded zeolite resin from the bottom of Tank 8D-1 to Tank 8D-2.

Figure A.1.3-1 is a simplified schematic of the HLW transfer and vitrification process employed at the West Valley Demonstration Project. In an early campaign, the supernatant phase of the HLW in Tank 8D-2 was decanted from Tank 8D-2 and processed through the STS. The STS includes a floating suction pump suspended in Tank 8D-2. In addition, a prefilter, a chiller/cooler, up to four zeolite-containing ion exchange columns in series, and a post filter are all contained within Tank 8D-1 (see Figure A.1.3-2). After the zeolite became loaded with cesium, it was dumped into the bottom of Tank 8D-1. Following decontamination via processing through the ion-exchange columns, the decontaminated supernate was routed through Tank 8D-3 and collected in a holding tank (typically Tank 5D-15B). The liquid was then processed through the Liquid Waste Treatment System (LWTS) where it was concentrated (by evaporation) and again collected in a holding tank (typically 5D-15A1 or 5D-15A2) as shown in Figure A.1.3-3. The concentrated decontaminated liquid then was mixed with cement in the Cement Solidification System (CSS) and the resulting mixture poured into 269 liter square drums (see Figure A.1.3-4). The cement solidified waste is stored in the Drum Cell.

This entire treatment system, including the STS (covered in WVNS-SAR-004), the LWTS (covered in WVNS-SAR-005), the CSS (covered in WVNS-SAR-008), and the Drum Cell (covered in WVNS-SAR-007) is known as the Integrated Radwaste Treatment System (IRTS). As indicated in Table A.1.1-2, these individual SARs have been consolidated into WVNS-SAR-002, which now covers low-level waste processing and the associated support activities. From May 1988 to May 1995, the integrated radwaste treatment system was used to pre-process the high-level liquid waste in Tank 8D-2, resulting in the production of 19,877 drums of low-level waste. To streamline the review process, apply the concept of graded approach, and meet the requirements of DOE Order 5480.23, the analyses of safety questions that pertain to low-level waste processing have been provided in WVNS-SAR-002, *Low-Level Waste Processing and Support Activities* (WVNS). WVNS-SAR-002 (Rev. 3) replaced the previously approved SAR modules listed above, as well as the others indicated in Table A.1.1-2. Thus, SAR-002 is an active, living document and part of the Authorization Basis. The note for Table A.1.1-2 relative to SAR-002 (Rev. 3) provides the historical record to document the various SAR modules and specific revisions which were incorporated into the new SAR-002. These listed SAR modules which have been replaced are no longer active (no longer part of the Authorization Basis) and are referenced throughout this SAR only as a source of historical information. Revisions of SAR-002 are prepared to meet the requirements for periodic updates of Safety Analysis Reports as stated in DOE Order 5480.23, Section 9, paragraph c.

The sludge fraction of the HLW in Tank 8D-2 has been washed to remove salts. During the vitrification process the mobilized sludge and cesium-loaded zeolite resin (which was transferred from Tank 8D-1 to Tank 8D-2), are transferred to the Concentrator Feed Make-up Tank in the Vitrification Cell, where excess water is removed and glass formers are added; the resulting mixture is then transferred to the Melter Feed Hold Tank. From this tank, the feed is delivered to the Slurry-Fed Ceramic Melter (SFCM), where it is joule-heated to form a molten, waste-loaded, borosilicate glass. The molten glass is poured into a stainless steel canister located in and positioned by a rotating turntable. Once a canister is filled, it remains on the turntable for initial cooling, then is removed from the turntable for further cooling, canister lid welding, and external decontamination. After decontamination, the canister is loaded onto a transfer cart that moves on rails through the Equipment Decontamination Room (EDR) and into the HLW Interim Storage (HLWIS) Facility located in the former Chemical Process Cell (CPC). (See WVNS-SAR-003, *Safety Analysis Report for Vitrification System Operations and High Level Waste Interim Storage* {WVNS} for facility specific details.) In the HLWIS Facility, the canisters are stored in racks until they are shipped off-site. The initial phase of the vitrification of the HLW began in July 1996 and was completed in June of 1998. Subsequent intermittent operation of the vitrification process is expected to last approximately 3 additional years. The combined output of the two phases is expected to produce approximately 550 metric tons of glass waste in less than 300 stainless steel canisters suitable for shipment.

Off-gas from the melter passes through a Submerged Bed Scrubber (SBS) and High Efficiency Mist Eliminator (HEME) before exiting the Vitrification Cell. The off-gas travels through a duct in the off-gas trench to the 01-14 Building where it is reheated, passed through one of two parallel filter trains, each containing two High-Efficiency Particulate Air (HEPA) filters in series, and combined with ammonia, in the presence of a catalyst, to convert nitrogen oxides (NO_x) to water vapor and nitrogen gas. To assure availability, redundant catalytic converters are installed in parallel. The details associated with the safety analysis of the vitrification process are contained in WVNS-SAR-003, *Safety Analysis Report for Vitrification System Operations and High Level Waste Interim Storage* (WVNS).

A.1.3.2 Overview of Waste Management, Storage, and Disposal

The various operations at the site, including plant operations, decontamination, vitrification, supernatant treatment, etc., all produce LLW streams that must be treated and prepared for disposal or shipment.

Typically, liquid wastes that were treated through the STS and the LWTS were fed to the Cement Solidification System, where the remaining low-level radioactive liquid was mixed with cement and placed in 269-liter square drums. These drums were then capped and swipe tested. The contents were allowed to solidify and the drums transferred to the Drum Cell. Currently, the concentrates from the LWTS are returned to Tank 8D-2 (see Figure A.1.3-1) for subsequent vitrification processing.

Several Lag Storage Buildings and weather structures (pre-engineered steel frame and fabric enclosures) are used to store LLW awaiting shipment or disposal and TRU waste awaiting shipment.

In 1998, the WVDP began shipping some Class A waste to a commercial facility in Utah for disposal. Although less than 10 percent of the low-level waste inventory has been shipped, sufficient on-site storage space is now available to accommodate waste generation. More than 35,630 cubic feet of low-level waste was shipped for disposal in FY1999; 30,000 to 50,000 cubic feet are targeted for off-site disposal annually for FY2000 and beyond. In 2000, work was also completed on replacement of LSA-4 with a durable sheet-metal building and construction of a low-level waste shipping depot.

A.1.3.3 Overview of Decontamination, Decommissioning and Waste Shipment

The safety analyses associated with decontamination, decommissioning, and waste shipment will be provided in a separate safety analysis report as indicated in Table

A.1.1-2 or, possibly, in several SARs covering different activities. However, before detailed planning and safety review can begin, the EIS for completion of the WVDP and closure or long-term management of the WNYNSC and a Record of Decision must be issued. A Draft EIS was issued for public comment in January, 1996. Following public review of the document, NYSERDA, with the cooperation of DOE, instituted a Citizen Task Force. The Task Force began meeting in January 1997 to review the Draft EIS in detail and in 1998 submitted a report summarizing its recommendations for long-term management of the WVDP. In 2000, work focused on technical issues while DOE and NYSERDA negotiations on delineation of responsibilities for long-term site management continued.

A.1.4 Identification of Project Participants

The Department of Energy Ohio Field Office (DOE-OH) has overall responsibility for the WVDP. The DOE on-site area office, DOE-OH/WVDP, is responsible for on-site administration of the Project.

The State of New York is the owner of the site and is required by the Act to participate in the funding of the Project. Therefore, a cooperative agreement between the DOE and the State has been established (Cooperative Agreement October 1980). The State is represented in this relationship on-site by the New York State Energy Research and Development Authority (NYSERDA).

The Act also requires the DOE to consult with the NRC concerning substantive aspects of the Project that could affect the health and safety of the public. In addition, the NRC must approve the final D&D criteria that must be met for site closure following completion of the Project. The relationship between the DOE and NRC has been outlined in a memorandum of understanding (MOU) between the two agencies (Memorandum of Understanding November 19, 1981).

In addition, the Act requires the DOE to consult with the U.S. Department of Transportation (USDOT), the U.S. Environmental Protection Agency (USEPA), and the U.S. Geological Survey (USGS) in matters relating to their respective areas of expertise and concern. These relationships have also been established, though less formally than those with the State of New York and the NRC.

The DOE has retained WVNS as the prime contractor for design and operation of the WVDP. Dames & Moore (D&M, recently renamed URS) joined with WVNS in the original procurement to provide geotechnical, environmental, safety analysis report preparation, and safety assessment services for the Project. Additional information on organizational structure is presented in Section A.10.1.

Pacific Northwest National Laboratory (PNNL) has been retained to provide research and development services for the WVDP. The contractor providing security services for the WVDP is Burns International Security Services.

The Project also consults with and is engaged in technology transfer on a national level by means of the Commercial Waste Treatment Program (CWTP), Defense Waste Processing Facility (DWPF), and other DOE government-owned, contractor-operated (GOCO) facilities, and on an international level with German, French, and Japanese nuclear program organizations.

These relationships are illustrated in Figure A.1.4-1.

REFERENCES FOR SECTION A.1.0

Cooperative Agreement between the USDOE and NYSERDA on the WNYNSC at West Valley, New York. October 1980, amended September 19, 1981 and February 1991.

Memorandum of Understanding Between the U.S. Department of Energy and the Nuclear Regulatory Commission: Implementation of the West Valley Demonstration Project Act of 1980. November 19, 1981. Federal Register Vol. 46, No. 223.

U.S. Congress. October 1, 1980. *An Act to Authorize the Department of Energy to Carry Out a High-Level Liquid Nuclear Waste Management Demonstration Project at the Western New York Nuclear Service Center in West Valley, New York.* Public Law 96-368 [S.2443]. Congressional Record, Vol. 126.

U.S. Department of Energy. December 24, 1991. DOE Order 5480.21: *Unreviewed Safety Questions.* Washington, D.C.: U.S. Department of Energy.

_______________. February 25, 1992. DOE Order 5480.22: *Technical Safety Requirements.* Washington, D.C.: U.S. Department of Energy.

_______________. April 30, 1992. DOE Order 5480.23: *Nuclear Safety Analysis Reports.* Washington, D.C.: U.S. Department of Energy.

_______________. May 19, 1987. DOE Order 5481.1B (Chg. 1): *Safety Analysis and Review System.* Washington, D.C.: U.S. Department of Energy.

_______________. October 18, 1991. DOE-ID 5481.1B Supplemental Directive: *Safety Analysis and Review System.* Washington, D.C.: U.S. Department of Energy.

_______________. July 1994. DOE-STD-3009-94: *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports.* Washington, D.C.: U.S. Department of Energy.

U.S. Department of Energy Idaho Field Office. October 18, 1991. Supplemental Directive to DOE Order 5481.1B: *Safety Analysis and Review System.*

REFERENCES FOR SECTION A.1.0

(Continued)

U.S. Nuclear Regulatory Commission. 1975. *Regulatory Guide 3.26: Standard Format and Content of Safety Analysis Reports for Fuel Reprocessing Plants.*

West Valley Nuclear Services Co. 1987. *Technical and Administrative Approach for the West Valley Demonstration Project Safety Program.* DOE/NE/44139.

________________. WV-365: *Preparation of WVDP Safety Documents.* (Latest Revision).

________________. WV-914: *Unreviewed Safety Question Determination (USQD).* (Latest Revision).

________________. WV-906: *Radiation and Safety Committee.* (Latest Revision).

________________. WVDP-227: *WVDP Facility Identification and Classification Matrix.* (Latest Revision).

________________. WVDP-146. *Operational Safety Requirements/Technical Specifications Manual.* (Latest Revision).

________________. Safety Analysis Report WVNS-SAR-001: *Project Overview and General Information.* (Latest Revision).

________________. Safety Analysis Report WVNS-SAR-002: *Existing Plant and Operation.* (Rev. 2).

________________. Safety Analysis Report WVNS-SAR-002: *Low-Level Waste Processing and Support Activities.* (Latest Revision).

________________. Safety Analysis Report WVNS-SAR-002: *Addendum 1, FRS Facilities.* (Rev. 3).

________________. Safety Analysis Report WVNS-SAR-003: *Preliminary Safety Analysis for the Vitrification System.* (Rev. 1).

REFERENCES FOR SECTION A.1.0

(Concluded)

________________. Safety Analysis Report WVNS-SAR-003: *Safety Analysis Report for Vitrification System Operations and High Level Waste Interim Storage.* (Latest Revision).

________________. Safety Analysis Report WVNS-SAR-004: *Supernatant Treatment System.* (Rev. 7).

________________. Safety Analysis Report WVNS-SAR-005: *Liquid Waste Treatment System.* (Rev. 3).

________________. Safety Analysis Report WVNS-SAR-007: *Low-Level Class B and Class C Radioactive Waste Handling and Disposal Operations for the Radwaste Treatment System Drum Cell.* (Rev. 3).

________________. Safety Analysis Report WVNS-SAR-008: *Cement Solidification System.* (Rev. 2).

________________. Safety Analysis Report WVNS-SAR-009: *Lag Storage and Supercompactor Operations.* (Rev. 2).

________________. Safety Analysis Report WVNS-SAR-010: *Size Reduction Facility.* (Rev. 0).

________________. Safety Analysis Report WVNS-SAR-012: *Fuel Receiving and Storage Facility.* (Latest Revision).

________________. Safety Analysis Report WVNS-SAR-013: *Safety Analysis for Sediment Sampling of the Low Level Waste Treatment Facility Lagoons 2 and 3.* (Rev. 0).

TABLE A.1.1-1

Location of DOE 5480.23 Topics in WVNS-SAR-001 Sections

DOE Order 5480.23 - 8.b(3) TOPICS	Section in WVNS-SAR-001 (Rev. 6)
a) Executive Summary	A.1.0 Introduction and Overall Description of the Facility A.2.0 Summary Safety Analysis
b) Applicable statutes, rules, regulations and Departmental Orders	Each section, as appropriate
c) Site characteristics	A.3.0 Site Characteristics
d) Facility description and operation, including design of principal structures, components, all systems, engineered safety features, and processes	A.4.0 Principal Design Criteria
e) Hazard analysis and classification of the facility	(Found in facility-specific SAR modules)
f) Principal health and safety criteria	A.8.0 Hazards Protection
g) Radioactive and hazardous material waste management	A.7.0 Waste Confinement and Management
h) Inadvertent criticality protection	(Found in facility-specific SAR modules)
i) Radiation Protection	A.8.0 Hazards Protection
j) Hazardous material protection	A.8.0 Hazards Protection
k) Analysis of normal, abnormal, and accident conditions, including design basis accidents; assessment of risks; consideration of natural and manmade external events; assessment of contributory and casual events, mechanisms, and phenomena; and evaluation of the need for an analysis of beyond-design-basis accidents; however, the SAR is to exclude acts of sabotage and other malevolent acts since these actions are covered under security protection of the facility	(Found in facility-specific SAR modules)
l) Management, organization, and institutional safety provisions	A.10.0 Conduct of Operations
m) Procedures and training	A.10.0 Conduct of Operations
n) Human factors	A.10.0 Conduct of Operations

TABLE A.1.1-1
(Concluded)

Location of DOE 5480.23 Topics in WVNS-SAR-001 Sections

DOE Order 5480.23 - 8.b(3) TOPICS	Section in WVNS-SAR-001 (Rev. 6)
o) Initial testing, in service surveillance, and maintenance	A.10.0 Conduct of Operations
p) Derivation of TSRs	(Found in facility-specific SAR modules)
q) Operational Safety	A.8.0 Hazards Protection A.4.0 Principal Design Criteria A.10.0 Conduct of Operations
r) Quality Assurance	A.12.0 Quality Assurance
s) Emergency Preparedness	A.10.0 Conduct of Operations
t) Provisions for decontamination and decommissioning	A.4.0 Principal Design Criteria A.10.0 Conduct of Operations
u) Applicable Facility design codes and standards	Each Chapter, as appropriate

TABLE A.1.1-2

STRUCTURE OF THE WEST VALLEY
DEMONSTRATION PROJECT SAFETY ANALYSIS REPORT
(August 2000)

Title	Part*	WVNS SAR Number Designation
• Project Overview and General Information (per DOE Order 5480.23)	A	001 (Rev. 6)
• Low-Level Waste Processing and Support Activities# (per DOE Order 5480.23)	B	002 (Rev. 7)
• Vitrification System Operations and High Level Waste Interim Storage (per DOE Order 5480.23)	C	003 (Rev. 8)
• Fuel Receiving and Storage Facility (per DOE Order 5480.23)		012 (Rev. 3)
• Final Decontamination, Decommissioning, and Waste Shipment		TBD

Notes:

* "Part" provides an alphabetical identifier which precedes the numerical identifier of the section within an individual SAR module.

\# WVNS-SAR-002 (Rev. 3) consolidated, updated, and replaced the following SARs:

1. SAR-002, Rev. 2, "Existing Plant and Operations"
2. SAR-004, Rev. 7, "Safety Analysis for Supernatant Treatment System"
3. SAR-005, Rev. 3, "Safety Analysis Report for Liquid Waste Treatment System"
4. SAR-007, Rev. 3, "Safety Analysis Report Low-Level Class B and C Radioactive Waste Handling and Storage Operations for the Radwaste Treatment System Drum Cell"
5. SAR-008, Rev. 2, "Safety Analysis for Cement Solidification System"
6. SAR-009, Rev. 2, "Safety Analysis for Lag Storage and Supercompactor Operations"
7. SAR-010, Rev. 0, "Safety Analysis for Size Reduction and Decontamination of Low Dose Rate, Low-Level and Transuranic Wastes"
8. SAR-013, Rev. 0, "Safety Analysis for Sediment Sampling of the Low Level Waste Treatment Facility Lagoons 2 and 3"

SR1-10-1.DWG

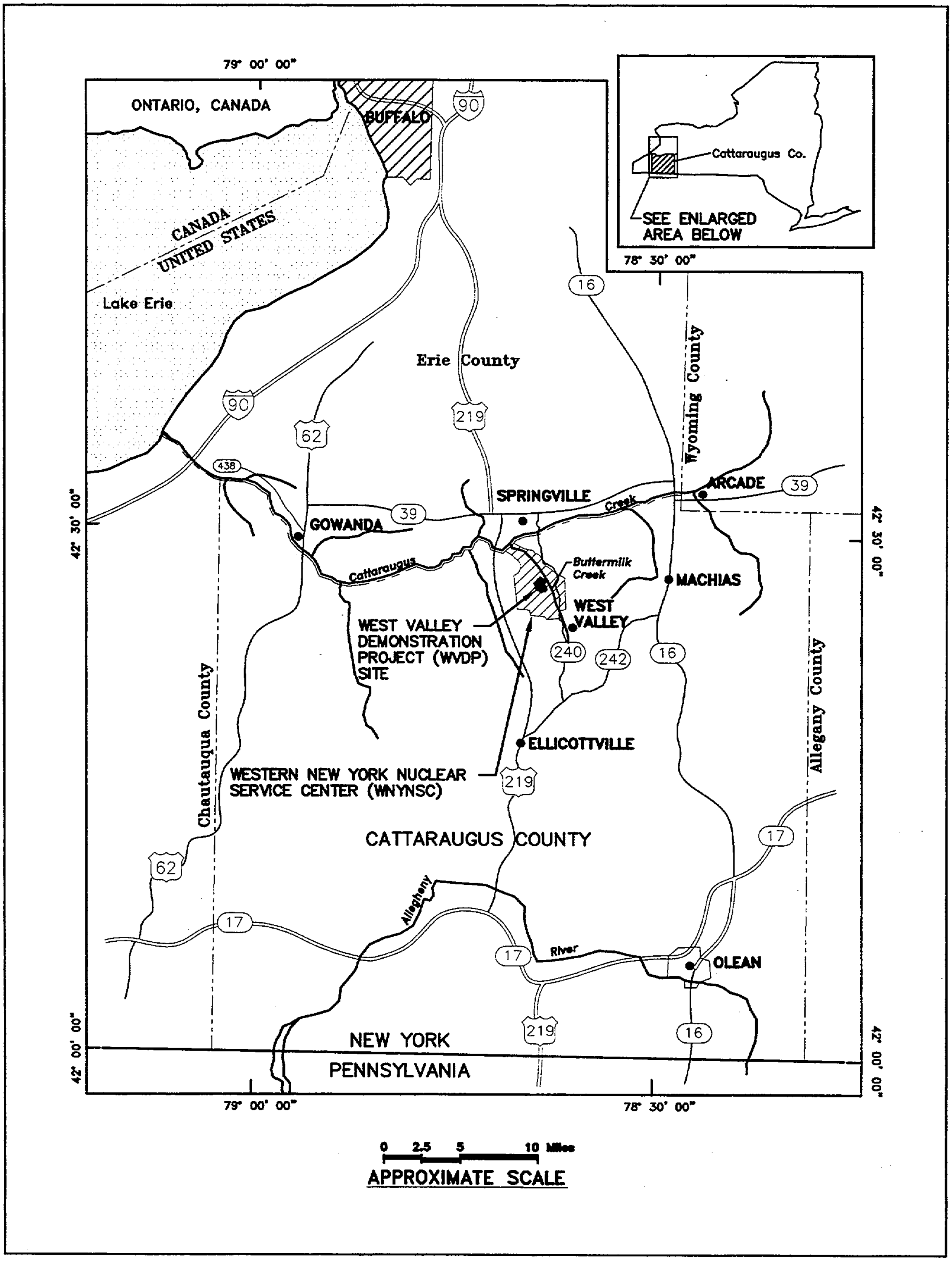


Figure A.1.0-1 Location of the Western New York Nuclear Service Center.

SR1-10-2.DWG

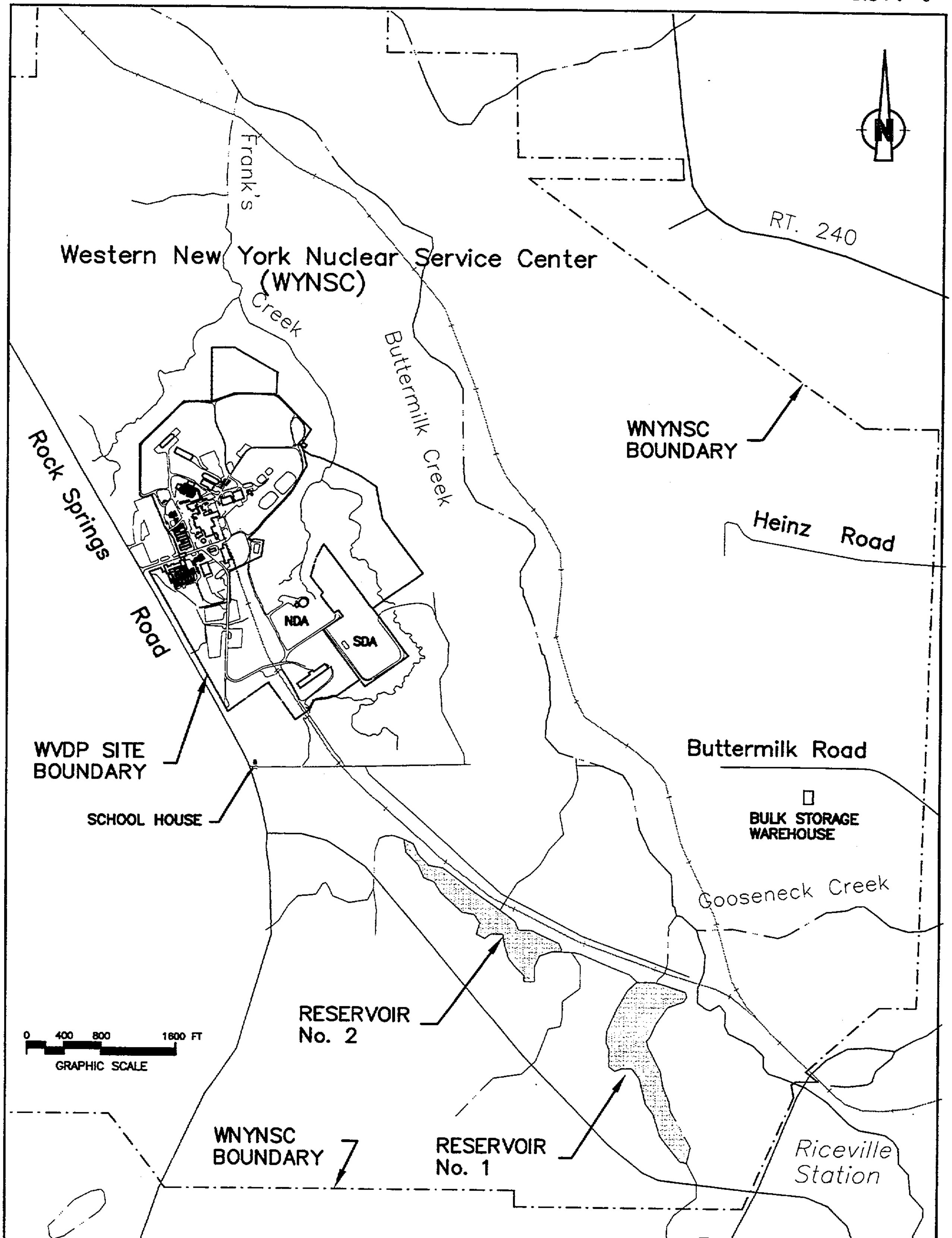


Figure A.1.0-2 Western New York Nuclear Service Center.

SR1-131.DWG

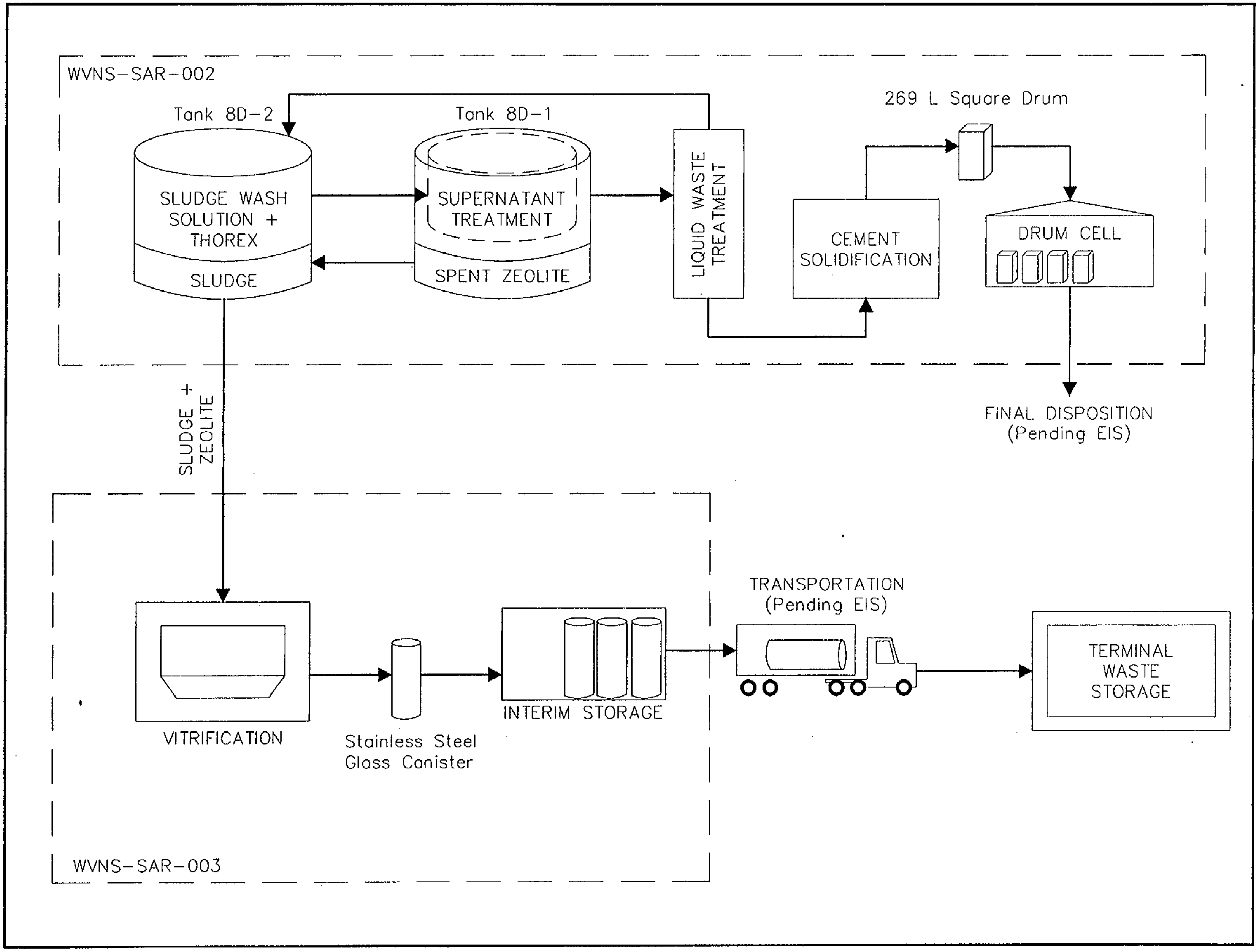


Figure A.1.3-1 Waste Processing Flow Diagram

SR1-132.DWG

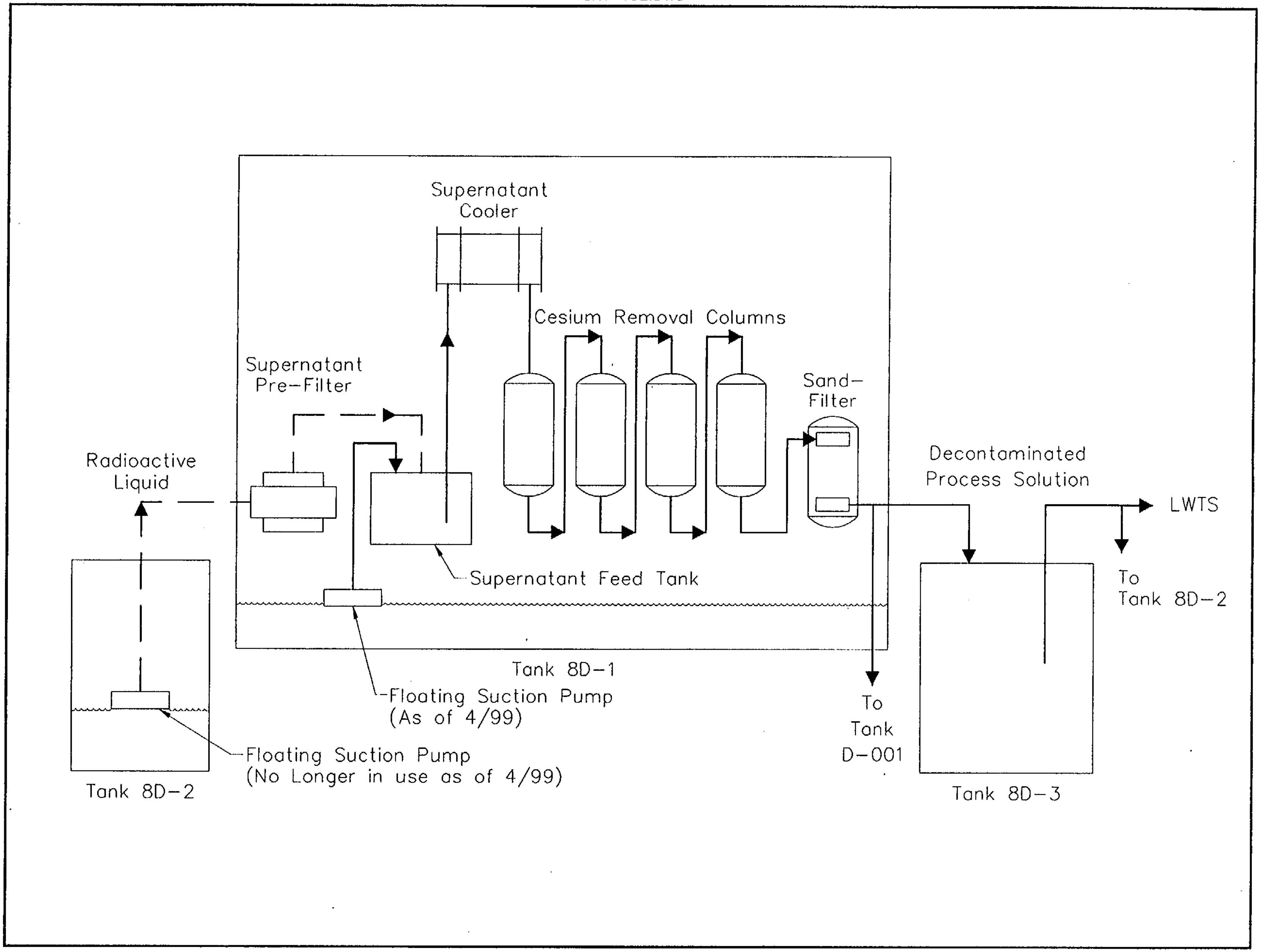


Figure A.1.3-2 Supernatant Treatment System Process Flow Diagram.

SR1-133.DWG

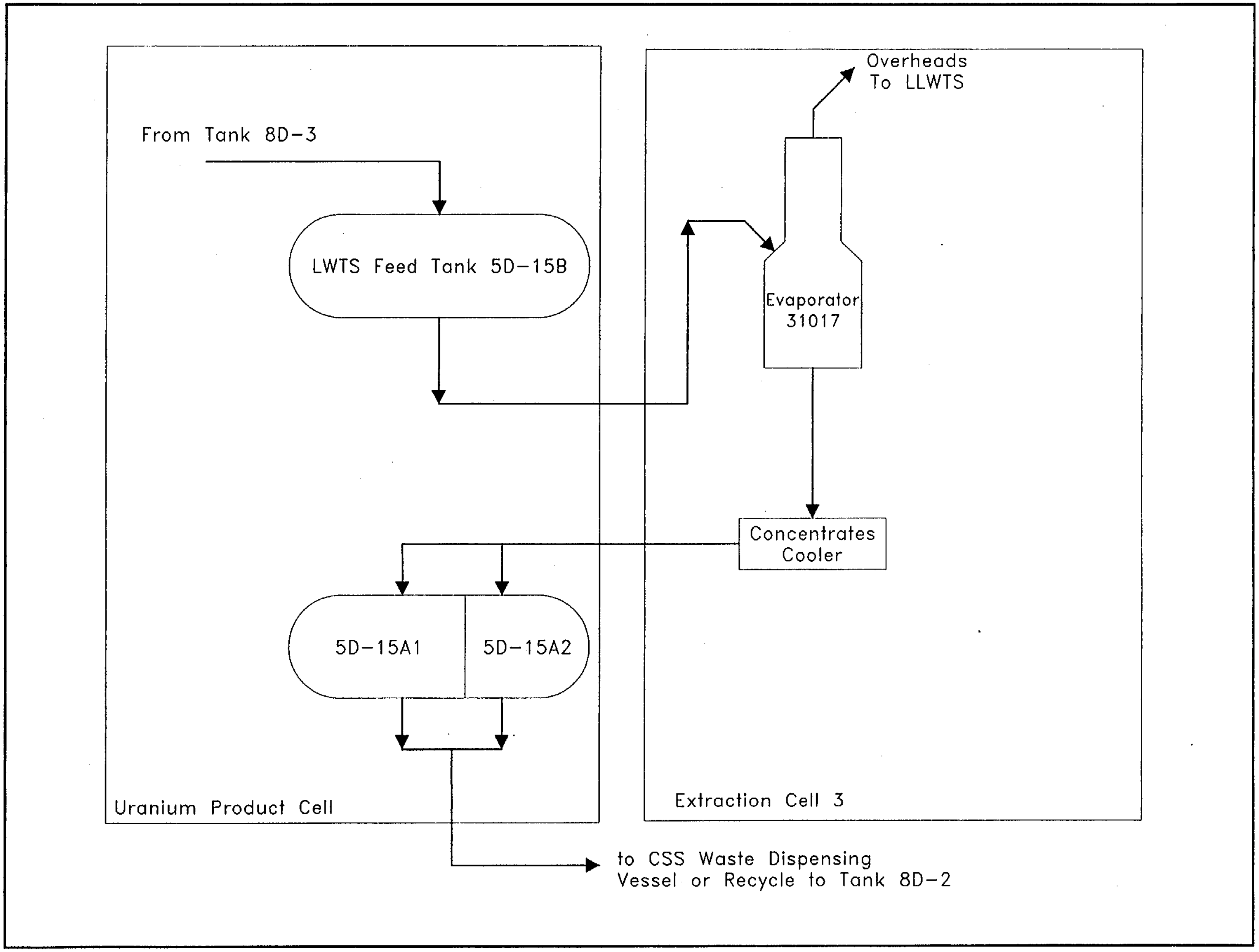


Figure A.1.3-3 Liquid Waste Treatment System Process Flow Diagram.

SR1-134.DWG

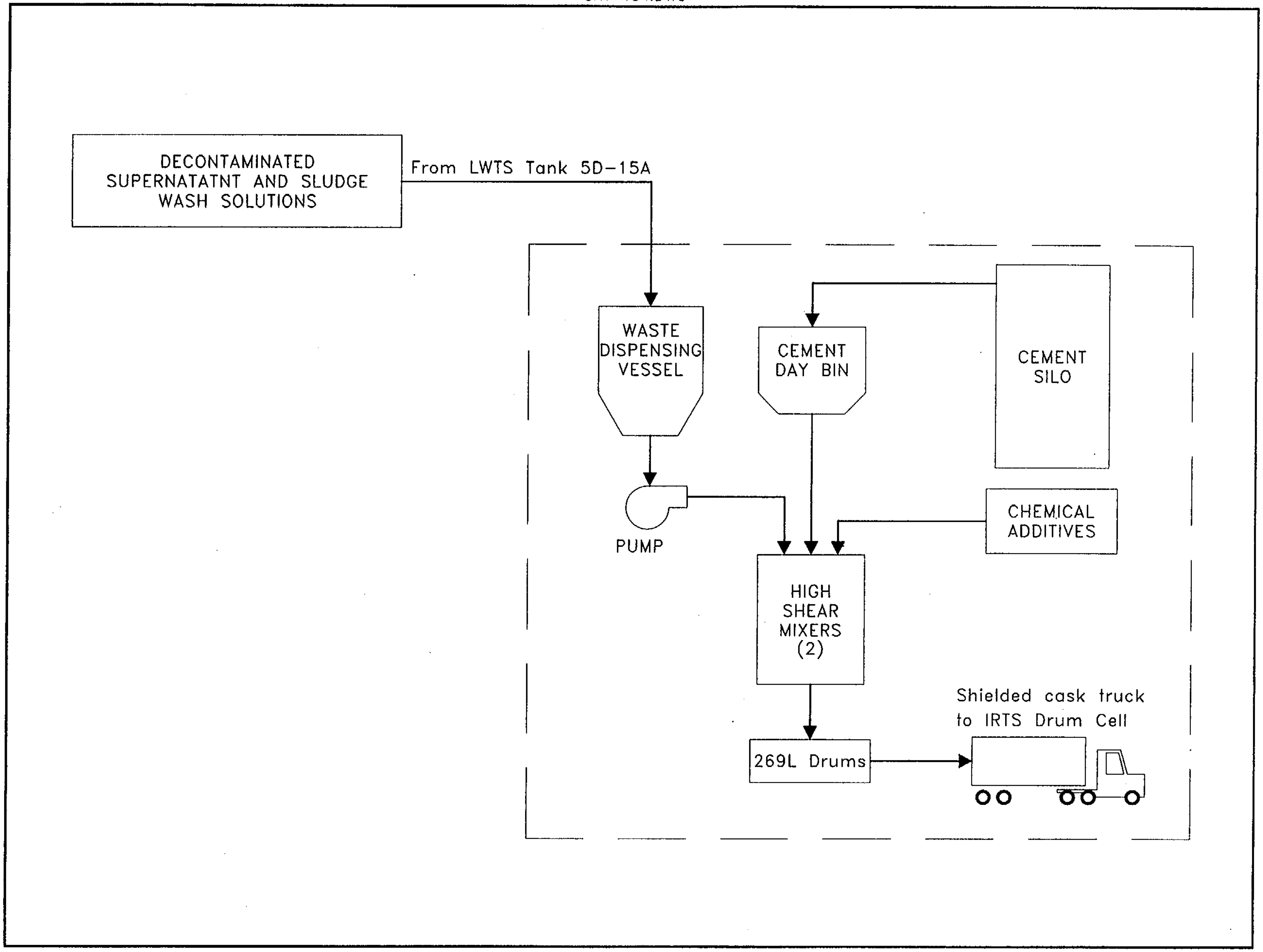


Figure A.1.3-4 Cement Solidification System Process Flow Diagram.

SR1-14-1.DWG

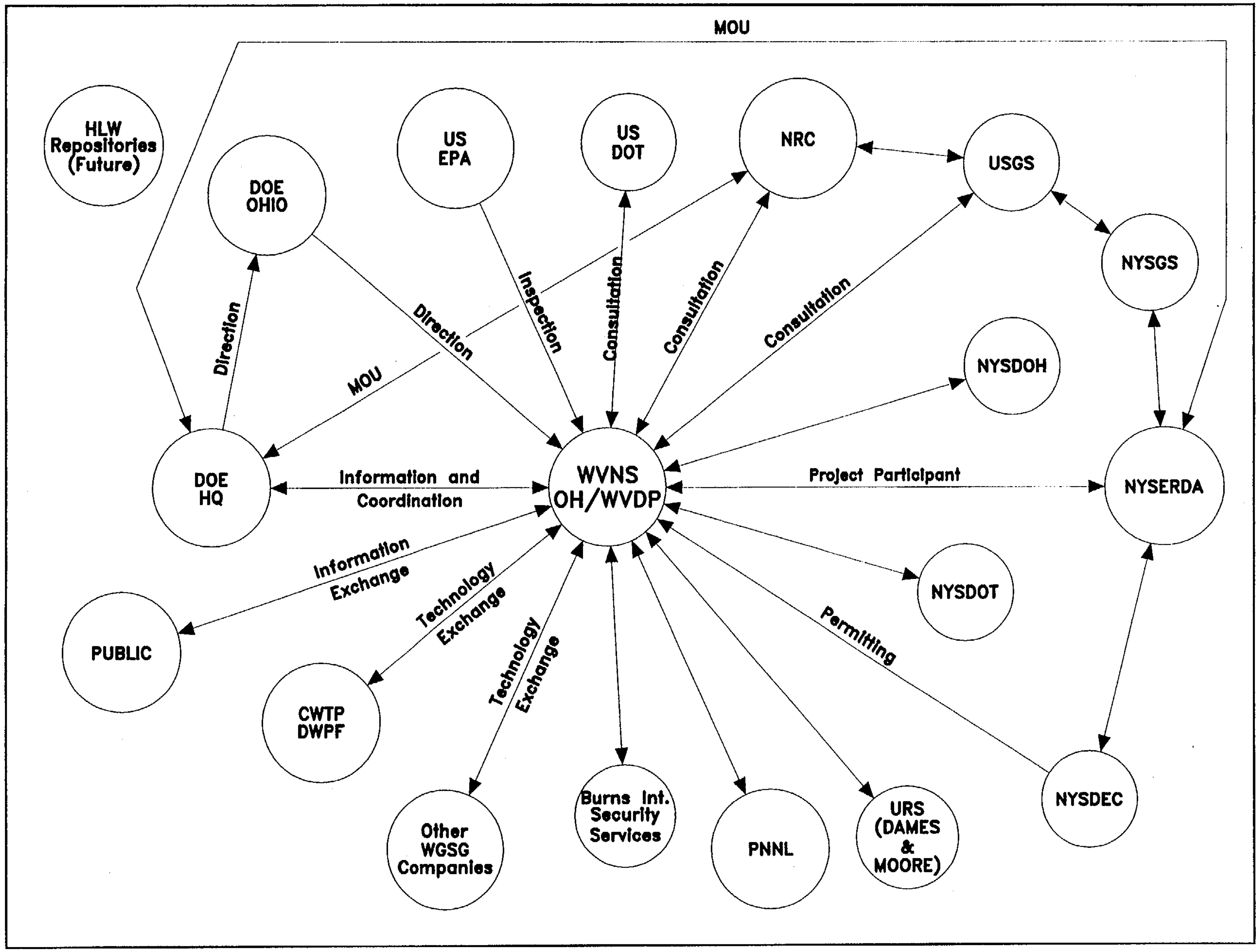


Figure A.1.4–1 Project Interfaces

A.2.0 SUMMARY OF SITE CHARACTERISTICS THAT AFFECT THE SAFETY ANALYSIS

This chapter provides an overview of site characteristics that affect the safety analysis, including such factors as natural phenomena, the effect of nearby industrial, transportation, and military facilities, and the impact of normal and abnormal operations and bounding accidents. The major conclusions resulting from this analysis are presented in Section A.2.5.

A.2.1 Site Analysis

Site characteristics enter into the safety analysis in two ways:

- As potential causes of accidents (e.g., natural phenomena or events); and

- As factors that can influence the impacts of accidents (e.g., meteorology, population distribution).

Site specific evaluations of natural phenomena hazards were used to quantify appropriate design basis events for the facility design using factors of safety appropriate for the facility mission. More recent site-specific natural phenomena hazard studies have been made to evaluate accident condition loadings for safety analysis evaluations.

Mechanisms which can cause accidents are analyzed explicitly. Dispersive mechanisms in the environment are analyzed in order to predict the potential consequences of accidents which might release radioactivity and/or hazardous substances off-site.

A.2.1.1 Natural Phenomena

Natural phenomena that can affect the safety of operations include earthquakes, tornadoes, and floods. The site is situated in a region that has experienced a moderate amount of relatively minor seismic activity. The record of earthquake activity in Western New York and the surrounding area dates back over 200 years. In that time period, the only significant (Modified Mercalli Intensity [MMI] VII) earthquake activity in Western New York occurred in the vicinity of Attica and is associated with the Clarendon-Linden Structure. Several smaller shocks in the Buffalo-Hamilton (Ontario) area were probably due to glacial rebound effects.

Outside the immediate West Valley area there is a zone of major seismic activity near LaMalbaie, Quebec, in the lower St. Lawrence River Valley. Major earthquakes (MMI IX or X) have occurred in the LaMalbaie area, most recently in 1988. The earthquakes were felt over the entire eastern section of Canada and the northeastern United States. The WVDP site probably experienced no more than mild MMI IV shock from any of these events.

The WVDP has adopted a probabilistic approach to establishing the design basis earthquake (DBE) for Project facilities requiring seismic protection. Since the early 1970's when Nuclear Fuel Services (NFS) sought an operating license from the Nuclear Regulatory Commission (NRC), the earthquake hazard at the site has been the subject of many studies. A summary of these studies from 1970 to a 1995 evaluation by Dames & Moore is provided in Technical Support Document (TSD) A.3.6-E. The seismic hazard at the site can be represented by a curve of peak ground acceleration versus recurrence interval. The DBE has a peak ground acceleration of 0.1 g which, using the site median seismic hazard curve (Figure A.3.6-10), corresponds to a recurrence interval of 2,000 years.

The frequency and intensity of tornadoes in Western New York is low in comparison to many other parts of the United States. An average of about two tornadoes of short and narrow path length strikes New York State each year. During the period 1950 through 1990, seventeen tornadoes were reported within 80 km of the Project site. The design basis tornado for the Project was developed based on detailed analyses of historical records of tornado occurrences in western New York State. The characteristics of the design basis tornado (DBT) are:

Recurrence time:	10^6 years
Maximum wind speed:	260 km/hr (160 mi/hr)
Rotational speed:	180 km/hr (110 mi/hr)
Translational speed:	80 km/hr (50 mi/hr)
Radius of maximum rotational wind:	46 m (150 ft)

Peak pressure differential:	2.4 kPa (0.35 psi)
Rate of pressure drop:	1.0 kPa/sec (0.15 psi/sec)

The 10^6 year recurrence interval for the design basis tornado is more conservative than current DOE general design criteria. The maximum windspeed associated with a site tornado which meets the DOE criteria is insufficient to mobilize missiles. Since it was of interest to examine the potential impacts of tornado-generated missiles, the more conservative 10^6 year interval was assumed for consistency with the hypothesis that missile generation was possible, though highly improbable.

Although the amount of precipitation in West Valley is relatively high (averaging about 104 cm a year), flooding is not expected to be a major hazard due to the local topography, the relatively even distribution of precipitation throughout the year, and the elevation of the site. Thunderstorms are infrequent because of the stabilizing influence of Lake Erie.

The WVDP strategy in response to the hazards described above is two-fold. First, designs and design criteria are selected to limit damage to facilities and/or the consequence of any damage that may be experienced, in a manner consistent with good industry practices for facilities with similar missions and hazards. Second, the WVDP has a comprehensive emergency preparedness program to protect the safety and health of on-site personnel, off-site populations, and the environment. The site's emergency program is described in WVDP-022, *WVDP Emergency Plan* (WVNS), and implemented via the procedures contained in WVDP-139, *WVDP Emergency Management Procedures, Volumes I and II* (WVNS). A detailed description of the sitewide Emergency Management Program is given in Section A.10.5.

A.2.1.2 Site Characteristics Affecting the Safety Analysis

The pathways by which radiologically and/or toxicologically hazardous materials may be dispersed into the environment may be broadly categorized as airborne or liquid. For airborne releases, the capacity of the atmosphere to dilute and disperse effluents is of prime importance in evaluating the environmental effects of site operations under both normal and abnormal conditions. The dispersive capability of the atmosphere is a function of wind speed and direction, and atmospheric stability.

Local climatological data have been and continue to be obtained from an on-site meteorological tower where wind speed, wind direction, and temperature are measured at 10 m and 60 m from the base.

The temperature difference, calculated by subtracting the temperature measured at the 10 m level from the temperature measured at the 60 m level, is used to determine atmospheric stability at the on-site meteorological tower. The 10 m and 60 m winds are channeled such that the wind blows predominantly from the south-southeast to the north-northwest and from the northwest to the southeast reflecting the topography in the vicinity of the site. Detailed technical information on meteorology may be found in Section A.3.3.

The major surface water drainage features of the site area are Cattaraugus Creek and Buttermilk Creek. Buttermilk Creek originates south of the site, but its lower portions, including its confluence with Cattaraugus Creek, are wholly within the boundaries of the WNYNSC. Buttermilk Creek drains an area of approximately 76 km^2, about 14 km^2 of which are within the WVDP boundaries. The average flow rate of the creek is 1.8 m^3/s.

The total drainage area of Cattaraugus Creek is about 1,400 km^2, including 560 km^2 upstream of its confluence with Buttermilk Creek, north of the site. Peak flow rates in Cattaraugus Creek occur in November-December and in March. In the vicinity of the Project, the typical maximum flow rate is 20 m^3/s. Cattaraugus Creek enters Lake Erie about 45 km southwest of Buffalo.

The West Valley site is underlain by two aquifer zones, neither of which can be considered highly permeable or productive. The upper aquifer consists of surficial, gravelly deposits. On the northwest side of the site, this unit consists of alluvial fan deposits; on the northeast side, it consists of fluvial gravelly or sandy deposits. The thickness of these surficial deposits ranges from about 1 to 12 m. The second aquifer zone consists of weathered, fractured, and decomposed shale and rubble at the contact between the overlying till and shale bedrock. This zone is generally 0.5-1.0 m in thickness.

The groundwater flow patterns pertinent to the site relate to recharge and downgradient movement for these two aquifers. Groundwater in the surficial unit tends to move in an easterly or northeasterly direction from the western boundary of the site, close to Rock Springs Road. Most of the groundwater in this unit discharges via springs and seeps into Frank's Creek or into small tributaries (e.g., Erdman Brook) of that creek. Groundwater recharging the weathered shale and rubble zone tends to move eastward toward the thalweg of the buried valley (the locus of the lowest points in the cross section of the buried valley), located about 300 to 350 m west of Buttermilk Creek. Once attaining the thalweg, the direction of groundwater movement shifts to the direction of the thalweg, about north 25° west, and proceeds toward the northwest.

The site's topographic setting renders the likelihood of major flooding not credible, and local run-off and flooding is adequately accommodated by natural and man-made drainage systems in and around the WVDP as described in Section A.3.4. Detailed technical information on surface hydrology may be found in Section A.3.4.

A.2.1.3 Effect of Nearby Industrial, Transportation, and Military Facilities

Nearby industrial and transportation facilities are not considered high-risk threats to site operations, based on their distance from the site and the relatively low consequence of their operations. The most proximate industries are at least 4 km from the site and are relatively small and relatively low-threat in nature (see Section A.3.2.2). The impact to site operations due to military facilities is discussed in Section A.3.2.3.

There are two State highways, classified as rural arterial highways that are fairly distant from the site -- US Route 219 and NY Route 240. US Route 219 is a two-lane, major north-south road between Buffalo and the Pennsylvania border. Located about 4 km west of the site, US Route 219 has an annual average daily traffic volume of 6100 vehicles (1994 data). NY Route 240, also a two-lane road, is about 3 km to the east. The annual average daily traffic on NY Route 240 in the hamlet of West Valley is 1850 vehicles (1993 data). (New York State Department of Transportation. 1995. Traffic Volume Report. Albany, New York).

NY Route 240 is closer to the site than US Route 219. Route 240 is a north-south, low-use, rural, connector between the hamlet of Ashford Junction in the south to East Aurora in the north. It is not a connector road to large population or industrial centers that would normally be the cause of high traffic volumes.

The New York State Department of Transportation (NYSDOT) has resurfaced, restored and rehabilitated 3.56 miles (5.73 km) of US Route 219 between the Village of Springville, Erie County, and Ashford, Cattaraugus County. For Springville, a two-way center left-turn lane and a sidewalk in the commercial area along US Route 219 were constructed. In Cattaraugus County, Henrietta Road was realigned to intersect US Route 219 at Schwartz Road. Dedicated left-turn lanes were constructed on US Route 219 to both Schwartz and Henrietta Roads. Additionally, a 2200-foot (670-m) climbing lane to accommodate slow-moving vehicles was constructed on US Route 219 south from the intersections of US Route 219, Schwartz and Henrietta Roads. This project was completed in May, 1998.

The New York State Department of Transportation, in cooperation with the Federal Highway Administration, has prepared a Draft Environmental Impact Statement (DEIS) on a proposal to improve a 46-km (28-mile) section of US Route 219 from the current terminus of the Southern Expressway (US Route 219) at Route 39, Springville, Erie County, to NY Route 17 near Salamanca, Cattaraugus County.

From Springville (Erie County) at Route 39, the corridor for a new divided 4-lane limited access highway is proposed to be located behind existing commercial development along the west side of US Route 219. After crossing the Cattaraugus Creek, the proposed corridor is between the east side of the existing US Route 219 and Dutch Hill Road (Town of Ashford, Cattaraugus County). Interchanges are proposed for the Schwartz/Henrietta Road intersection with the existing US Route 219, at the intersection of Snake Run Road and US Route 219 as well as at Springville, Ellicottville, Great Valley and Salamanca. Alternatives under consideration include: a four-lane upgrade of the existing 2-lane highway; routine maintenance and minor improvements; improvement of other transportation facilities such as rail, bus, and park-and-ride locations; as well as the proposed divided 4-lane limited-access highway.

US Route 219 has a higher volume of traffic than NY Route 240. It is a transportation connector between Buffalo and points south including Washington and the rest of the southern United States. The road pavement is in good condition and the highway has the capacity for all types of vehicles including some requiring special highway use permits. Speed limits range from 35-45 miles-per-hour (mph) in hamlets to 55 mph in the open rural areas.

While US Route 219 has a higher traffic volume than NY Route 240, US Route 219 has a safe road design speed capacity averaging 50 miles per hour (mph) and good road pavement conditions that generally support the traffic volumes. The Project and US Route 219 and NY Route 240 are generally in a rural area. At the closest points US Route 219 is 2.37 miles west and NY Route 240 is 1.23 miles northeast of the Project, respectively. Both roads are of no consequence relative to the site safety analysis.

The Buffalo and Pittsburgh (B&P) railroad line is located within 800 m of the Project premises. Running from Salamanca, NY north to Buffalo, the B&P carries a variety of freight and coal north and freight and newly manufactured vehicles south from Canada. As a result of the general decline of heavy industry on the Niagara Frontier and of rail traffic in the northeast, use of this route has also declined. In recent years, the tracks have also experienced several washouts and kindred problems, forcing traffic rerouting for extended periods. While railroad accidents are not uncommon in the United States, the relatively low utilization of the line in the vicinity of the WVDP, coupled with the demographic factors outlined above, tends to minimize the likelihood of an accident with consequences for site operations. This conclusion is reinforced by the presence of a deep ravine with perennial streams between the tracks and the Project premises. These features reduce the threat of rail accident which might result in a fire or a spill affecting the Project. An airborne threat from a rail accident still exists, but is also significantly mitigated by both distance and topography of the site from the rail line.

In 1999, the Buffalo & Pittsburgh (B&P) Railroad completed connection of track between Ashford Junction and Machias, New York. Service by B&P on the rail line from the WVDP to Ashford Junction and then to Machias now provides the WVDP rail access.

A.2.2 Impact of Normal Operations

Small amounts of radioactivity are discharged during normal Project activities. Based on the analyses presented in the individual facility SARs, doses to the maximally exposed off-site individual from normal operations will be within the guidelines of DOE Order 5400.5, *Radiation Protection of the Public & the Environment* (USDOE June 5, 1990), and will have negligible impact on human health.

Doses to workers are monitored for Project activities. Doses are maintained as low as reasonably achievable (ALARA) and will be kept below the requirements as set forth in 10 CFR 835, *Occupational Radiation Protection* (USDOE). WVDP-227, *WVDP Facility Identification and Classification Matrix* (WVNS), identifies the facilities at the WVDP, classifies them according to the quantity of potentially releasable radiological and hazardous material within each facility, and indicates the safety documentation associated with the facility.

In addition, based on the analyses presented in the individual facility SARs (Table A.1.1-2), the release of hazardous material from normal operations will also have minimal impact on the health of the surrounding population.

The WVDP programmatically monitors the surrounding environment and effluent from on-site facilities to fulfill federal and state requirements. The results of this program show that during the course of activities at the WVDP, public health and safety and the environment are being protected. The Site Environmental Report for Calendar Year 1999 (WVNS, 2000) summarizes the environmental monitoring data collected during calendar year 1999. On-site and off-site radiological monitoring in 1999 confirmed that site activities were conducted well within state and federal regulatory limits. Results of data analyzed show that the Project did not exceed any of the limits on radioactivity or radiation doses in 1999, including the emission standards promulgated by the U.S. Environmental Protection Agency (EPA) and incorporated in DOE Orders.

A.2.3 Impact from Abnormal Operations

Abnormal operations include expected process upsets or operation of equipment or facilities beyond design limits. Abnormal operations do not include accidents (accidents are addressed in Section 9 of each SAR).

Based on the analyses presented in the facility-specific SAR modules (Table A.1.1-2), the radiological and toxicological impacts from abnormal operations will be somewhat greater than but similar to impacts from normal operations, and will have no significant impact on personnel on-site or off-site or on the environment. Events considered to pose a significant risk were analyzed as evaluation basis accidents in other WVDP SARs.

A.2.4 Impact of Bounding Accidents

In order to bound the consequences of accidents analyzed in the SARs listed in Table A.1.1-2, assumed source terms are typically based on the entire inventory of material at risk; that is, damage ratios and leakpath factors, as described in DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (USDOE December 1994), are assumed to be equal to 1. Calculation of radiological source terms are therefore given as MAR x ARF/ARR x RF where MAR is the material at risk, ARF is the airborne release fraction, ARR is the airborne release rate, and RF is the respirable fraction. Source terms for nonradiological releases are calculated using the *Emergency Prediction Information Code (EPIcode)* (Homann Associates 1993), based on the quantity of material at risk.

Consequences of radiological accidents in SAR-002, -003, and -012 are calculated for individuals at the On-site Evaluation Point (OEP) located 640 m from the center of the accident release, for off-site individuals located at the nearest site boundary (1050 m) and at the distance that produces the maximum exposure using 95% meteorology. The magnitude of radiological consequences is calculated through multiplication of the accident source term by unit dose factors. Only nuclides contributing greater than 0.1% of the total dose are reported. Unit dose factors are calculated from site-specific χ/Q values and inhalation dose conversion factors from DOE/EH-0070, *External Dose-Rate Conversion Factors for Calculation of Dose to the*

Public (USDOE July 1988) and DOE/EH-0071, *Internal Dose Conversion Factors for Calculation of Dose to the Public* (USDOE July 1988). Consequences are calculated for several meteorological conditions including the following: stability class "D", wind speed 4.5 m/s; stability class "F", wind speed 1 m/s; and site-specific 95% meteorology.

Consequences due to the release of radioactive liquids are calculated through multiplication of an ingested quantity by dose factors given in DOE/EH-0071. The ingested quantity is determined from the original accident source term, subsequent dilution factors and ingestion rates taken from NRC Regulatory Guide 1.109, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I* (USNRC October 1977).

Consequences of nonradiological airborne releases are also calculated for individuals at 640 m (on-site) and 1050 m (off-site). The magnitudes of these consequences are calculated through use of the EPIcode, which uses a straight-line Gaussian plume model to calculate peak ground-level concentrations downwind of a release.

A.2.5 Conclusions

Analysis of the site and design-related data results in the following principal conclusions:

- New construction and operation of facilities to implement the WVDP Act are compatible with the site characteristics, including anticipated natural phenomena. (See Section A.3.8 for a summary of significant site characteristics impacting design and the associated principal design consequence).

- There are no nearby industrial, transportation, or military facilities that could adversely affect the safety of the operations at the WVDP.

- Analyses described in the facility SARs have shown that the potential impacts of the plant on the health and safety of the public and operating personnel are within the requirements of 10 CFR 835, *Occupational Radiation Protection* (USDOE) and 5400.5, *Radiation Protection of the Public and the Environment* (USDOE June 5, 1990).

REFERENCES FOR SECTION A.2.0

Homann Associates. 1993. Emergency Prediction Information Code (EPIcode), Version 5.04.

New York State Department of Transportation. 1995 Traffic Volume Report. Albany, New York.

U.S. Department of Energy. June 5, 1990. DOE Order 5400.5: *Radiation Protection of the Public & the Environment.* Washington, D.C.: U.S. Department of Energy.

____________________. December, 1994. DOE-HDBK-3010-94: *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities.* Washington, D.C.: U.S. Department of Energy.

____________________. July, 1988. DOE/EH-0070: *External Dose-Rate Conversion Factors for Calculation of Dose to the Public.* Washington, D.C.: U.S. Department of Energy.

____________________. July, 1988. DOE/EH-0071: *Internal Dose Conversion Factors for Calculation of Dose to the Public.* Washington, D.C.: U.S. Department of Energy.

____________________. *Occupational Radiation Protection,* 10 CFR 835.

U.S. Nuclear Regulatory Commission. October, 1977. Regulatory Guide 1.109: *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I.* Revision 1.

West Valley Nuclear Service Co. WVDP-022: *WVDP Emergency Plan.* (Latest Revision).

____________________. WVDP-139: *WVDP Emergency Management Procedures, Volumes I and II.* (Latest Revision).

____________________. WVDP-227: *WVDP Facility Identification and Classification Matrix (WVNS).* (Latest Revision).

REFERENCES FOR SECTION A.2.0

(Concluded)

West Valley Nuclear Services Co., and Dames and Moore. June, 2000. *West Valley Demonstration Project Site Environmental Report Calendar Year 1999.*

A.3.0 SITE CHARACTERISTICS

A.3.1 Geography and Demography

A.3.1.1 Site Location

The WVDP site is located in Ashford Township, Cattaraugus County, N.Y., at approximately 42.45°N latitude and 78.646°W longitude. The New York state plane coordinates are approximately 892800 N and 480840 E. The site location with respect to major natural and man-made features in Western New York State is shown in Figures A.3.1-1a, A.3.1-1b, A.3.1-2a, A.3.1-2b, A.3.1-3a, and A.3.1-3b.

The facility is 3.8 km (2.4 miles) southeast of Cattaraugus Creek at its nearest approach. Cattaraugus Creek forms the boundary between Cattaraugus and Erie counties, N.Y. Buttermilk Creek, a tributary to Cattaraugus Creek, is 0.8 km (0.5 mile) east of the plant site. The nearest incorporated village is Springville, N.Y., 0.8 km (0.5 mile) north of Cattaraugus Creek and 5.6 km (3.5 miles) north of the plant.

A.3.1.2 Site Description

The WVDP site consists of approximately 220 acres within the 3,345-acre WNYNSC. The WVDP site is shown co-located along with the WNYNSC on Figure A.3.1-2. The WNYNSC is located within the Cattaraugus highlands, which is a transitional zone between the Appalachian Plateau to the south and east and the Great Lakes Plain to the north and west. The Cattaraugus highlands range in elevation from 1,000 to 1,800 feet above National Geodetic Vertical Datum (NGVD). Deep valleys dissect rather flat-topped plateaus and support a climax plant community of northern hardwoods substantially reduced by agricultural activities.

Slopes range from <5% to >25%, with 5 to 15% slopes predominant. The WNYNSC is drained by Buttermilk Creek, which flows into Cattaraugus Creek. Much of the WNYNSC was previously cleared (prior to 1961) for agriculture. As a result, the WNYNSC now consists of a mixture of abandoned agricultural areas in various stages of ecological succession, forested tracts, and wetlands and transitional ecotones between these areas. The generally acidic and poorly drained soils influence the occurrence, distribution, and relative abundance of plant communities and their associated faunal species. The WNYNSC area experiences an average of 42 inches of precipitation per year, including 100 to 150 inches of snow. The region's temperate climate is not prone to natural forest or grassland fires.

The WVDP is on a plateau in the central portion of the WNYNSC. The WVDP plateau elevation is approximately 1,410 feet NGVD. The plateau margins are subject to erosion especially along the banks of gully and stream drainageways that cut into the plateau and feed to several named streams that feed in turn to Buttermilk Creek. The WVDP topography is shown on Figure A.3.1-4.

The WNYNSC is owned and controlled by NYSERDA. However, by cooperative agreement between NYSERDA and DOE, NYSERDA has agreed not to use or authorize use of the WNYNSC in a manner that would interfere with DOE's carrying out the waste solidification project that is the Project objective. During the term of the Project, DOE will provide general surveillance and security services for the entire WNYNSC, including the WVDP site.

Rock Springs Road, a county road, traverses the WNYNSC immediately to the west of the WVDP site. If required by an emergency situation at the Project, access to this road can be controlled by Cattaraugus County authorities.

A.3.1.2.1 Site Boundary

Figure A.3.1-2 delineates the boundaries of the WNYNSC and the WVDP. The WNYNSC, which is also referred to as the exclusion zone, is fenced with barbed wire and posted, and the boundary is patrolled by security officers in vehicles at random times several times a day. The WVDP site, also referred to as the Security Area, is surrounded by a high chain-link fence and can be entered only through one of three gates. Access is controlled through the use of magnetically coded picture badges, which must also be displayed at all times within the Security Area. The current facility layout, which includes several changes to the site through 1998, is presented in Figure A.3.1-5. Changes primarily consist of the removal and/or addition of office trailers and canvas-covered waste storage buildings.

All Project-specific activities are performed within the WVDP site boundary. The New York State licensed low-level waste burial area (SDA), which is currently inactive, is located within the WVDP site boundary but is not part of the Project.

A.3.1.2.2 Boundaries for Establishing Effluent Release Limits

The WNYNSC boundary (shown on Figures A.3.1-2a, A.3.1-2b, A.3.1-3a and A.3.1-3b) is used to establish effluent release limits.

A.3.1.3 Population Distribution and Trends

The information regarding population and population distribution was obtained from WVDP-EIS-012, Revision 0, *Environmental Information Document Volume IX, Socioeconomics of the Area Surrounding the Western New York Nuclear Service Center* (WVNS, October, 1992).

A.3.1.3.1 Current Population

The area within 16 km (10 miles) of the site lies within Cattaraugus and Erie counties. The 1960 to 1990 resident populations of towns and villages within this area are presented in Table A.3.1-1. The populations of New York and Pennsylvania counties within 80 km (50 miles) of the site are presented in Table A.3.1-2.

Cattaraugus County is predominantly rural and contains 32 townships and 16 villages. It is 3,460 sq km (1336 sq miles) in size, has a 1990 population of 84,234 people, and a density of 24 persons per sq km (63 persons per sq mile). This relatively low population density is characteristic of rural-agricultural areas. The county population occurs primarily in rural residential areas and in villages with populations less than 2,000. There are two incorporated cities in the county: Olean (population 18,207) and Salamanca (population 6,890). Olean is located 43.5 km (27 miles) southeast of the site. Salamanca is located 32 km (19.8 miles) south of the site.

Between 1960 and 1990, Cattaraugus County's population grew from 80,187 to 84,234, an increase of 5.0%. This increase does not exceed the average for New York State

(+7.2%) during the same period. Neighboring Erie County had a net decline in population (-9.0%) during this period.

Erie County, population 968,532, is not as homogeneous as Cattaraugus County. The southern third of Erie County, near the WVDP site, consists of rural townships in which the population is concentrated primarily in small villages and along roadways, much like in Cattaraugus County. Traditionally, the majority of people residing in this area worked in agriculture or nearby small industries. This contrasts sharply with the City of Buffalo and surrounding metropolitan area which economically and demographically dominates the northern portion of Erie County. Overall, Erie County is experiencing a population outmigration. From 1960 to 1990 the population of the City of Buffalo has declined steadily by 38.4 percent overall. The portion of Erie County south of Buffalo generally has not lost population. Several of the towns south of the city have increased in population such that the population decline for the county as a whole was held to 9.0% for the period from 1960 to 1990.

The nearest village to the WVDP site is Springville, in Erie County. Springville is 5.6 km (3.47 miles) north of the site. Springville had a 1990 resident population of 4,310, an increase of 0.6% from 1980. The only other incorporated village within 16 km (10 miles) of the site is Delevan, 14.5 km (9.0 miles) east-northeast, which had a 1990 resident population of 1,214, up 9.1% from 1980. The nearest hamlets are more than 5 km (3.1 miles) away. Since hamlets, because they are unincorporated, do not have defined boundaries, population statistics are generally unavailable. The West Valley area, approximately 5.5 km (3.4 miles) southeast of the site, is estimated to have a resident population of 600, making it one of the most populous unincorporated areas in the Town of Ashford.

A.3.1.3.2 Population Distribution and Projections

Population projections were made using a computer model (DEMOG2) based upon U.S. Bureau of Census population projections for the areas within 0-10 kilometers and 10-80 kilometers of the site. Slight increases in population are projected for the area within 0-10 and 0-80 kilometers (0 - 6.2 miles and 0 - 50 miles) of the site over the next decade and the subsequent decade through 2010. The DEMOG2 program was originally developed for use on nuclear power plant projects (Greenberg and Krueckeberg 1973).

A.3.1.3.2.1 Population Within 10 km (6.2 miles) of the Site

The 1990 population within 10 km (6.2 miles) was 9,192 (Table A.3.1-4) and was projected to increase to 9,201 (Table A.3.1-7) by 1995, to increase to 9,225 (Table A.3.1-9) by 2000 and remain at 9,225 (Tables A.3.1-11 and A.3.1-13) to the year 2010. These represent population increases of 0.4 percent and 0.0 percent for these decades, respectively. Graphical figures associated with the tabulated data are contained in the EID document covering the Socioeconomics of the Area Surrounding the Western New York Nuclear Service Center (WVNS October, 1992).

A.3.1.3.2.2 Population Within 80 km (50 miles) of the Site

The 1990 population within 80 km (50 miles) of the site was 1,339,280 (Table A.3.1-6), and was projected to increase to 1,349,602 (Table A.3.1-10) by 2000 and 1,353,479 by 2010 (Table A.3.1-14). These represent population increases of 0.8% and 0.3% for these decades, respectively.

A.3.1.3.2.3 1996 Demographic Survey within 5 km

In the summer of 1996, a demographic survey was conducted by WVDP personnel in the area surrounding the WVDP site. The survey was conducted out to a 5-kilometer (3.1-mile) radius and included all permanent structures that may be inhabited in that area. Information on some of the homes in this area was limited, as their owners were either not available or declined comment. For known inhabited houses, the full average was used and one half this value would be used for known part-time or summer residences. Results of this survey are presented in Table A.3.1-3.

A.3.1.3.3 Transient Population

The transient population around the site includes daily and seasonal transients. The daily category is insignificant and therefore is not included in the population distribution and projection figures above. The seasonal transient population is associated with the area's numerous small recreation sites. Where significant, this transient population is included in the distribution and projection figures.

A.3.1.3.4 Population Density

Using the 1980 census data, the maximum population density of 61.4 persons per square kilometer occurs between 32 and 48 km (20 and 30 miles) from the site. The maximum density projected for the year 2000 remains between 32 and 48 km (20 and 30 miles) from the site and is estimated to be 69.5 persons per square kilometer.

A.3.1.4 Uses of Nearby Land and Waters

A.3.1.4.1 Site Vicinity Land Use

Land use within 8 km (5 miles) of the site is predominantly agricultural (active and inactive) and forestry uses. The major exception is the Village of Springville, which is comprised of residential, commercial, and industrial land uses. Other major nonagricultural land uses in the site vicinity are as follows:

Hamlet of West Valley - residential/commercial/land use, 5.5 km (3.4 miles) to the southeast

Cattaraugus County Forest - forestry/recreation - 6 km (3.7 miles) to the south, campground - 8 km to the southwest

West Valley Demonstration Project (WVDP) Ashford Office Complex - commercial - (3.9 miles) to the south

machine shop - industrial land use - 6.4 km (4 miles) to the northwest (presently being expanded)

2 retail shopping complexes - commercial land use - 6.4 km (4 miles) to the north northwest

an offsite storage complex - commercial land use - 6 km (3.8 miles) to the north northwest (Village of Springville on Waverly Street) a roller skating rink - commercial land use - 4 km (2.5 miles) to the west

an offsite storage/antique shop - commercial land use - 3.8 km (2.4 miles) west southwest of the site

concrete readi-mix and equipment manufacturer - industrial land use - 4.5 km (2.8 miles) to the northwest

a commercial radio transmitter tower - commercial land use - 5.5 km (3.4 miles) SSW of the site

a cellular telephone tower - commercial land use - 5 km (3.1 miles) to the northwest

a cellular telephone tower - commercial land use - 4.5 km (2.8 miles) to the south

propane gas storage tank and supplier - commercial land use - 3.8 km (2.4 miles) to the west southwest

propane gas storage tank and supplier - commercial land use - 1.2 km (.75 miles) to the southwest

The dominant agricultural activity is related to the dairy industry, with meat production occurring on a smaller scale. In order to determine the spatial distribution of dairy and meat production for a small area, such as the area within 16 km (9.9 miles) of the site, the land area suitable for agricultural activities related to this activity must be determined. Basically, two types of farmland are considered important for the spatial distribution of milk cows and meat-producing animals: cropland and active pasture. These determine the carrying capacity of the land with respect to production of feed and grazing. In the site vicinity, these lands are identified from 1991 land satellite imagery (1991 LandSat TM Imagery). The existing land use is shown on Figures A.3.1-6 and A.3.1-7.

The number of dairy cows in the site vicinity was estimated by distance and direction to produce the distributions shown in Figures A.3.1-8 and A.3.1-9. This estimate is based on statistics on dairy cows/meat-producing animals obtained from the 1992 U.S. Census of Agriculture (U.S. Department of Commerce, Bureau of the Census 1995) and the 1994 NYS agricultural statistics (New York State Agricultural Statistics Service 1994). These data indicate that in the site vicinity, dairy cows are found at a rate of approximately one head for each 1.1 hectares (ha) of active pastureland/cropland. Meat-producing animals are found at a rate of approximately one head for each 0.8 ha. Meat-producing animals include cull cows, heifers, calves, beef cows, sheep, lambs, hogs, and bison. The distribution of these animals is shown in Figures A.3.1-10 and A.3.1-11.

Agricultural production statistics are available for counties, but are not disaggregated by township. However, the amount of cropland and pastureland for each township in the site vicinity is provided in U.S. Soil Conservation Service (SCS) reports. For the purposes of this analysis, it is assumed that the quantity of cropland and pastureland in each township is proportional to each township's share of county agricultural production. Production and sale of important agricultural commodities in Cattaraugus County and Erie County are shown in Tables A.3.1-15 and A.3.1-16.

Annual milk production per cow averaged 7,466 kg (16,500 lbs) in 1997 in Cattaraugus County (New York State Agricultural Statistics Service 1998). Approximately 0.8 ha (2 acres) of cropland was required to produce 7,893 kg (17,400 lbs)(dry) of feed annually for each head of cattle. Most of the silage and hay crop produced locally is consumed by local livestock; therefore, much of the reported "cropland" actually serves the same function as "pasture" (Ryan 1982). This local feed production source is supplemented by purchase of feed concentrates from other sources, at an average of 6.8 kg (15.0 lbs) of supplements per cow/day for New York farms in 1996 (New York State Agricultural Statistics Service, 1997).

Agricultural lands cultivated to produce fruits and vegetables are not as pervasive as cropland/pastureland. Fruit and vegetable fields also tend to be smaller than dairy fields, and are not distributed in proportion to the occurrence of farmland in general; rather, it has been determined that a few towns contain a disproportionately large share of these lands. The distribution of these lands in the site vicinity relies on estimates of each town's share of the productive lands of its county. Such estimates were provided by county Cooperative Extension agents. Crops include lettuce, cabbage, broccoli, spinach, snap beans, tomatoes, sweet corn, potatoes, grapes, and apples. Total land area devoted to such production in Erie and Cattaraugus counties is estimated at 4,152 ha (10,189 acres) and 939 ha (2,319 acres), respectively. The estimated distribution of this land in the site vicinity is shown in Figures A.3.1-12 and A.3.1-13.

A.3.1.4.2 Community Facilities and Institutions

The WNYNSC vicinity is rural and there are few places where population is grouped in large numbers except for the schools and hospital in Springville and the Town of Ashford. These locations are shown in Figure A.3.1-14. Table A.3.1-17 provides the number of students, teachers, and school districts in Cattaraugus and Erie counties.

A.3.1.4.3 Water Use

Upper Cattaraugus Creek extends from Springville to Gowanda (32 km [20 miles] downstream of the site), and lower Cattaraugus Creek extends from Gowanda to Lake Erie (62 km [38.5 miles] downstream from the site).

A field review of the land use patterns downstream of the site indicated the predominant land uses are rural in nature -- agricultural (both active and inactive), forest, scattered residential, and open space proximate to the Creek. Closer to Lake Erie, the land uses along NY Routes 5 and 20 are commercial. At the mouth of Cattaraugus Creek, the Sunset Bay area is dense residential with mixed recreation - swimming beaches, marinas, boating and fishing. The Cattaraugus Creek is not used as a source of public drinking water, and the creek is not developed for organized water contact recreation activities.

Fishing occurs primarily near the mouth of the creek at Lake Erie, and at the Springville Dam which is located on Cattaraugus Creek downstream from where Route 219 crosses the creek (see Figure A.3.1-2b). Unsupervised swimming takes place throughout the creek. Boating is generally limited to the stretch of water within 3 km of the mouth of the creek. There is whitewater rafting and canoeing occurring on the creek especially in the Zoar Valley, west of the site, when the water depth permits. There are no data available on recreational uses of the creek.

A.3.1.4.3.1 Lake Erie Commercial Fishery

Recent information on commercial fishing in the New York waters of Lake Erie is contained in the NYSDEC 1998 Annual Report to the Great Lakes Fishery Commission's Lake Erie Committee (NYSDEC 1998). The following information, unless otherwise noted, is abstracted from this report.

The commercial fishing industry operating today in New York waters of Lake Erie is a small fraction of the fishery that flourished from the late 1800's to approximately 1960 (NYSDEC 1995). That deep water fishery harvested lake trout, lake herring, lake whitefish, and blue pike. By 1960, the high-value species of the deep-water fish community had been eliminated or drastically reduced in abundance by a combination of overfishing, environmental degradation, and proliferation and naturalization of exotic fish populations, primarily by rainbow smelt. The deep-water niche became occupied primarily by smelt which are the target of a major commercial fishing industry on the Ontario, Canada side of Lake Erie, but are not fished in the United States waters.

Since 1960, New York commercial fishing efforts has focused on walleye and yellow perch. The relatively deep eastern basin, which includes all of New York's Lake Erie waters, does not provide inshore percoid habitat comparable to that found in western Lake Erie, so landings of yellow perch and walleye from New York were usually never more than a small fraction (<5%) of total Lake Erie landings for those species.

Until the mid- 1980's, the commercial fishery on New York's Lake Erie waters was in controversy because walleye and yellow perch are highly valued by both the sport and commercial fisheries. The by-catch of trout and salmon in commercial gill nets set for walleye and yellow perch had become an increasing concern of sport fishermen. In 1986, the New York legislature enacted a law banning the use of gill nets. Today, commercial fisheries use trap and hoop nets.

During 1997, one fisherman purchased a license for commercial fishing activity. Marketable harvests by this fisherman totaled 563 kg (1244 lbs) of yellow perch and 1306 kg (2986 lbs) of burbot. Commercial landings were distributed from April through September, with most of the perch caught in May and June. The yellow perch harvest decreased by more than 50% from 1996. The burbot harvest has decreased about 14% from the 1996 harvest.

Table A.3.1-18 summarizes commercial fish landings from New York waters of Lake Erie during 1993 - 1997.

A.3.1.4.3.2 Lake Erie Sport Fishery

The Lake Erie waters provide a combination of coldwater and cool/warmwater fish habitat. New York State's fisheries management program recognizes and contributes to the continued development and improvement of a well-balanced fisheries management program in eastern Lake Erie (NYSDEC 1984).

A major thrust of the coldwater fisheries management program is the rehabilitation of a self-sustaining lake trout population in the eastern basin of Lake Erie. Survival estimates for various age groups and from annual catch curves indicate continued improvements. In 1996, significant numbers of wild, juvenile steelhead trout were collected in Spooner Creek, Derby Brook, and Coon Brook. This indicates good reproductive success in these small high-quality tributaries. A special fishing regulation, to become effective in October 1998 is designed to protect spawning, adult steelhead. Angling will be prohibited from the 1st of January to the 30th of April on Spooner Creek and the North Branch of Clear Creek and their tributaries (NYSDEC 1998). Based upon 1997 assessments of the NY Lake Erie waters, it appears that the lake trout population is making progress toward rehabilitation goals.

In April 1999, the NYS DEC released 20,000, 8.5" Rainbow Trout into Lake Erie off Sturgeon Point.

For 1997 the overall abundance index for walleyes was low relative to the long-term average abundance, but was very similar to indices since 1992. The fall trawling for Young of Year (YOY) produced the lowest values seen in six years of this assessment. Only four larval walleyes were collected, the lowest since the program's inception in 1987. The age-1 (year) and age-3 (year) walleyes were the most abundant. The continuing walleye survival and exploitation estimates produced for New York's spawning stocks suggest total mortality remains low. Overall, the walleye numbers were near average for the period since 1992. (NYS DEC 1998).

Since 1988, a direct contact sport fishery survey has been conducted from May through October each year of the Lake Erie open lake sport fishing activities (NYSDEC 1995). Fishermen effort and catch information is collected as independent samples with two collections schedules of stratified random sampling (NYSDEC 1993).

Aerial counts of fishing boats have been conducted to measure daytime fishing effort. Beginning in 1993, a nighttime creel survey has been conducted of the nighttime walleye fishermen to collect data on a previously unmeasured component of the walleye fishing activities. Walleye are nocturnal feeders benefiting from increased water clarity. Catch and harvest data are obtained by interviews of boat anglers who had just completed their fishing trip (NYSDEC 1993).

Table A.3.1-19, "Lake Erie Open Sport Fishery Harvest," provides information on the year the survey was conducted, the number of fish caught, the number of angler hours expended on each trip, and the number of fishing trips.

A review of the data in Table A.3.1-19 indicates the open Lake Erie sport fishery effort, estimated at 605,294 angler-hours, represents a 4% increase since 1998. Estimated daylight harvest of walleye was 34,090 fish, ranking it very similar to all annual harvests since 1990. The smallmouth bass harvest was 24,496 fish, the second highest catch for an 11-year survey. The yellow perch harvest and lake trout sport harvests increased marginally but remained near the lowest levels observed during the 11-year survey. The rainbow trout harvest estimate was the second lowest of the 10-year survey. The brown trout, coho and chinook salmon, rarely encountered during the angler survey in recent years, have been deleted from the Annual Report (NYS DEC 1998). Chinook Salmon stocking of Lake Erie has been discontinued (NYS DEC 1999).

A.3.1.4.3.3 Cattaraugus Creek Sport Fishery

Cattaraugus Creek empties into Lake Erie at the hamlet of Sunset Bay, on the boundary of Erie and Cattaraugus Counties. The fish and wildlife habitat of the Creek extends approximately 42 miles from Lake Erie to the Springville dam. An approximately two mile segment of the creek passes partially within the Cattaraugus Indian Reservation and a 16 mile segment passes wholly within the reservation.

This is the largest New York State tributary to Lake Erie: relatively undisturbed streams of this size that provide habitat for lake-based fisheries are rare in the Great Lakes Plain ecological region. It is one of the most popular recreational fishing areas in western New York and is the top salmonid spawning stream among Lake Erie tributaries: concentrations are unusual in New York State.

In 1994, New York initiated a plan to rehabilitate or establish stream spawning walleye stocks in New York's Lake Erie tributaries. Cattaraugus Creek and Big Sister Creek are two of the streams identified for rehabilitation. Cattaraugus Creek flows through the Seneca Nation of Indians' Cattaraugus Reservation. Consensus was attained with the Seneca Nation regarding implementation of fishing and gravel mining practices that are compatible with the stream spawning rehabilitation objectives. As a result of the consensus, 3.3 million walleye sac fry were planted in Cattaraugus Creek.

The evaluation of this rehabilitation effort includes annual stream electrofishing (stream-shocking) surveys of Cattaraugus Creek to monitor spawning-phase walleye abundance, age structure, and pre- and post-shocking fry surveys to monitor spawning and stocking success. Adult walleye electrofishing failed to capture any spawning phase walleyes in 1994. However, sampling and collection of six larval walleyes in the Cattaraugus Creek estuary indicates there is some limited degree of successful reproduction in this stream (NYSDEC 1995). In the 1996 stocking program, 2.5 million walleye fry were released. In an effort to deal with the lack of adult spawning walleyes being collected during the electrofishing surveys, the remaining 50,000 fry were reared to 25-30 mm fingerling size and then released into Cattaraugus Creek. (NYSDEC, 1997).

In 1997, 1,500,000 fry and 11,000 fingerlings were stocked in the Creek. The survey of larval walleye densities have remained low throughout the monitoring period. (NYS DEC 1998.)

Based upon the 1997 sampling of five Cattaraugus Creek tributaries, it is estimated that approximately 19,500 YOY and 1,100 yearling wild steelhead trout found in 11.1 ha. (27.4 acres) of stream habitat. These estimates reflect variable year class strengths when compared to previous years' collections.

During the spring of 1998, there were 500,000 Chinook Salmon fingerlings stocked in the Cattaraugus Creek segment within the Town of Hanover, Chautauqua County. In April 1999, the NYS DEC released 90,000, 5" Steelhead into Cattaraugus Creek below the Springville Dam. Trout stocking is annually conducted in the upper reaches of Cattaraugus Creek along NY Route 16 in the Town of Java, Wyoming County. In 1998, 5900 Brown Trout, (8-8.5" long) and 1250 Brown Trout, (14.5" long) were stocked. During 1999, the following were released in Wyoming County reaches of Cattaraugus Creek: March, 550, 2-year old 12" - 15" Brown Trout; April, 3,700, 8" - 9" Brown Trout, 400, 2-year, old 13" - 15" Brown Trout; and June, 2,600, 8" - 9" Brown Trout. In Erie County reaches of the Creek, the following were released: March, 550, 2-year old, 13" - 15" Brown Trout; April, 350, 2-year old, 11" Brown Trout; and April, 3,400, 8" - 9" Brown Trout. No direct contact sport fishery information for inland fisheries is available.

A.3.2 Nearby Industrial, Transportation, and Military Facilities

A.3.2.1 Nuclear Facilities

The State University of New York at Buffalo, Main Street, has a research reactor, located roughly 60 km (37 miles) north of the site. It is presently shut down.

A.3.2.2 Industries

The industry within 8 km (5 miles) of the site is light-industrial and commercial - either retail or service oriented. A field review of the 5 mile radius did not indicate the presence of any industrial facilities that would present a hazard in terms of safe operation of the site.

A similar land use field review of the Village of Springville and the Town of Concord does not indicate the presence of any significant industrial facilities. Industrial facilities near the WNYNSC include Winsmith-Peerless Winsmith, Inc., a gear reducer manufacturing facility; Robinson/Fiddlers Green Manufacturing Company, Inc., a plastic housewares and knives manufacturing facility; Ashford Concrete Co., Inc., a readi-mix concrete supplier and concrete equipment manufacturing facility; and Springville Manufacturing, a fabricating facility for air cylinders.

Table A.3.2-1 provides information about those local facilities that store and use SARA Title III hazardous materials. The Village of Springville, Robinson/Fiddler's Green, and Winsmith-Peerless Winsmith maintain quantities of hazardous materials which require an EPA vulnerability Zone designation which encompasses the WVDP.

The WVDP is the only facility in northern Cattaraugus County identified as storing quantities of hazardous materials that requires an EPA vulnerability zone designation.

The industries within the Village of Springville and the Town of Concord, Erie County, are located in a valley approximately 6 km (4 miles) to the north and east of the WVDP. There are two propane storage and supply locations on NY RT 219: NORCO Propane, located on the east side of NY RT 219, approximately 1.6 km (1 mile) south of the intersection of NY RT 219 and Schwartz Rd; and M&M Holland Propane, which is located on the west side of NY RT 219, approximately 2 km (1.25 miles) south of the intersection of NY RT 219 and Schwartz Road.

Due to the distance and topography between the WVDP and the Village of Springville, between the WVDP and the propane supply and storage facilities, as well as the conservative assumptions upon which EPA's Vulnerable Zones have been defined, it is unlikely that even a catastrophic incident at any of the identified industries and facilities would impact operations at the WVDP.

A.3.2.3 Military Installations

A small military research installation was located in Cattaraugus County approximately 5 km northeast of the WVDP. The facility, operated by Calspan Corporation was used to conduct research operations for the United States Government's Department of Defense Air Force Automatic Liquid Agent Detector Program for detection of chemical attacks (Lanigan, January 26, 1993). The facility did not produce any products of a hazardous nature, but provided services through performing research projects. The combined aggregate storage total of the particularly hazardous compounds never exceeded one liter. Operations using these compounds were conducted with milliliter quantities. Mishap scenarios were developed and analyzed by Calspan. If the maximum credible event (worst case realistic mishap) occurred there would be no hazard experienced at the WVDP (Baker, April 9, 1993). Following conversion work during the third quarter of 1997, the facility will be used by University at Buffalo Civil Engineering Department researchers for a two year period to evaluate how persistent organic pollutants change as weather conditions change (Buffalo News, August 8, 1997).

A.3.2.4 Transportation Facilities

The transportation facilities near the WVDP include: highways in the vicinity of the WVDP, transport repair and refueling services, rail lines, and aviation facilities.

The primary method of transportation in the site vicinity is motor vehicle traffic on the highway system shown in Figures A.3.1-2, A.3.1-3a, and A.3.1-3b.

In Cattaraugus County, all roads with the exception of those within the cities of Olean and Salamanca are considered rural roads. Rural principal arterial highways are connectors of population and industrial centers. This category, includes U.S. Route 219, located 4.2 km (2.6 miles) west of the site, NY RT 17, the Southern Tier Expressway located approximately 35 km (21.7 miles) south of the site, and the New York State Thruway (I-90), approximately 35 km (21.7 miles) north of the site. Traffic volume along U.S. 219 between the intersection with NY RT 39 at Springville and the intersection with Cattaraugus County RT 12 (East Otto Rd) ranges from a low average annual daily traffic (AADT) volume of 6,100 to a high volume of 7,500 (NYSDOT 1995). Seasonal holiday traffic is as much as 128% of the AADT. Approximately 18% of the traffic consists of trucks. This route operates at a level of service (LOS) B, which indicates a stable traffic flow, an operating speed of 80 km per hour (50 mph), and reasonable driver freedom to maneuver (Cattaraugus County Planning Board 1979).

Collectors are roads connecting smaller communities and industrial centers to the arterials. They frequently are intra-county in nature and serve short hauls and cross-county traffic. There are three county collector roads within 2 km (1.2 miles) of the site. Rock Springs Road, adjacent to the site on the west, serves as the principal site access road. A portion of this collector road is known as Schwartz Road between Edies Rd. and NY 219. Along this road, between the site and the intersection of NY 219, there are fewer than 24 residences. State Route 240, also identified as County RT 32, is 2 km (1.2 miles) northeast of the site. AADT on the portion of NY RT 240 proximate to the site (between County Route 16 - Rosick Hill Rd. and NY RT 39) ranges from a low of 440 AADT to a high of 2,250 AADT (NYSDOT 1993).

Dutch Hill Road is approximately 2 km (1 mile) west of the WVDP. South of the intersection with Schwartz Road, Dutch Hill Road is maintained by the Town of Ashford. Designed to accommodate local, lightweight vehicles, it is an oil and stone chip hard surface on a gravel base.

North of the intersection with Schwartz Road to the Cattaraugus/Erie county line, Edies Road is designed for local lightweight vehicle traffic. It is an oil and stone chip surface on a gravel base. In Erie County, Edies Road continues, but is known as Mill Street. It is maintained as a county road. While part of Mill Street was recently paved with an asphalt course over a gravel base, the road is located on unstable soils. The road surface deteriorates and the driving conditions discourage use by heavy trucks and through traffic.

All other roads within the site vicinity are within the jurisdiction of towns and are classified as local.

There is a truck repair facility on NY RT 219, south of Waverly St., and a truck refueling facility on the NE corner of NY RT 219 and Waverly St.

Railroad service in a north-south direction is provided to the central part of Cattaraugus County. The Buffalo and Pittsburgh railroad transects the WNYNSC approximately 800 m (0.5 miles) east of the WVDP site at its nearest point. The site is served by a railroad siding from this line.

There are no commercial airports in the site vicinity. The only major aviation facility in Cattaraugus County is the Olean Municipal Airport, located in the Town of Ischua, 34 km (21.1 miles) southeast of the site. Regularly scheduled commercial air service was terminated at this airport in early 1972. The nearest major airport is Greater Buffalo International Airport, 55 km (34.2 miles) north of the site.

A.3.3 Meteorology

A.3.3.1 Regional Climatology for Western New York

The West Valley Demonstration Project is situated approximately 50 km inland from the eastern end of Lake Erie in Western New York State, at approximately 42°27′ north latitude and 78°39′ west longitude. The climate of Western New York State is of the moist continental type prevalent in the northeastern United States. The climate is diverse due to the influence of several atmospheric and geographic factors or controls.

Western New York is exposed to a variety of air masses. Cold dry air masses that form over Canada reach the area from the northwesterly quadrant. Prevailing winds from the southwest and south bring warm, humid air masses from the Gulf of Mexico and neighboring waters of the subtropical Atlantic Ocean. On occasion, cool, cloudy, and damp weather affects Western New York through air flow from the east and northeast.

Western New York is affected by a variety of cyclonic and anticyclonic pressure systems as they move across the continent. The path of continental storms and frontal systems is frequently across or in close proximity to this region. In addition, Western New York usually feels the effects of well-developed storms moving up the Atlantic Coast. Consequently, a variety of weather is often experienced within a period of a few days. Temperature, sunshine, wind and other atmospheric conditions during one week can be quite different from those of the preceding or following week. At times, however, a particular type of weather may persist from several days to a week or more. Seasonal weather, too, often varies considerably from one year to the next.

Western New York is bordered by two of the Great Lakes; Lake Erie on the west and Lake Ontario on the north. These exert a major controlling influence on the climate of the region.

Topography also affects the climate. Elevations in Western New York range from about 350 feet National Geodetic Vertical Datum (NGVD) along the Lake Ontario shore in Oswego County to more than 2,000 feet NGVD in the southwestern highlands of

Cattaraugus and Allegheny counties. The lake plain extends inland about 25 miles from Lake Ontario, but along Lake Erie it gradually narrows from about 10 miles in the Buffalo area to 5 miles or less in Chautauqua County. The southern two-thirds of the region is composed of hilly, occasionally rugged terrain with elevations generally above 1,000 feet NGVD. This area is interspersed with numerous river valleys and gently sloping plateau areas. Such topographic features may produce locally significant variation of climatic elements within relatively short distances.

The winters are long and cold. Persistent cloudiness is a characteristic of the colder months and causes the temperatures at night to be more moderate than those occurring at similar elevations and latitudes in the less cloudy regions of central and eastern New York. In November and December, the western half of the state receives only 25 to 30 percent of the possible sunshine, though the amount gradually increases during the latter half of the winter.

The coldest temperature in most winters varies between 5°F below zero and 10°F below zero near the Great Lakes, 5°F below zero to 15°F below zero in the Finger Lakes and Chemung River Valley, and from 10°F below to 20°F below zero in the southwestern highlands. Extreme winter temperatures as cold as 40°F below zero have been recorded in the higher elevations of Cattaraugus and Allegheny Counties. Severe winter cold with below-zero minimums and/or lengthy periods of continuous subfreezing temperatures occur between early December and mid March. Winter thaws result in temperatures in the 40s to low 50s for a few days at a time, with rare maximums in the 60s.

The winter climate of Western New York is marked by abundant snowfall. The areas with the lightest snowfall, with average seasonal accumulations of 40 to 50 inches, are the lower Chemung Valley, the western Finger Lakes, and northern Niagara County. The heaviest snowfall occurs in the eastern lee of Lake Erie, where the average total is in excess of 120 inches. The snow season normally begins in mid November and extends into mid or late March. Snow cover is continuous from early December until the middle of March, although occasional midwinter thaws greatly reduce or eliminate the cover for brief periods.

Snowfall produced in the eastern lee of Lake Erie is a distinguishing and very important feature of Western New York's climate. As cold air crosses the unfrozen lake waters and is warmed in the lower layers, it picks up moisture and reaches the land in an unstable condition. Precipitation in the form of snow occurs as the air stream moves inland over a gradually higher terrain. Heavy snow squalls frequently occur, producing from one to two feet of snow and occasionally as much as four feet. Snowfall generated by the Great Lakes may extend as far inland as the Finger Lakes and the southern tier counties in bands of a few miles or more in width. Counties to the lee of Lake Erie are subject to these lake-effect snows in November and December, but in mid-winter, as the lake gradually freezes, these snows become less frequent. Areas south of Lake Ontario are exposed to heavy snow squalls well into February, as the lake generally retains considerable open water through the winter months. The principal design consequence of snowfall is additional loading on structures (particularly roofs). Snow loads are one of the factors considered in the development of design criteria for critical structures (see Chapter A.4).

The summer season is cool in the southwestern highland, but warm elsewhere. On average, the weather is sunny for 65 percent of the total daylight hours during this season. High temperatures and high humidity are infrequent during the summer and seldom persist for more than a few days at a time. Temperatures of 90°F or higher are recorded on five days or less per year at the higher elevations and along the shore of the Great Lakes, but the remainder of Western New York has an average frequency of from 8 to 15 days. Such temperatures occur between early June and early September. Readings of 100°F or higher are rare. The range of temperature on summer days is commonly from near 60° at night to the low 80s in the afternoon.

Summer season precipitation increases to the south, ranging from about 8 inches along the Lake Ontario shore to 10 to 12 inches in the counties along the Pennsylvania border. Showers and thundershowers account for much of the warm season rainfall and the distribution pattern reflects the contrasting influences of the cool Lake Ontario waters to the north and the hilly terrain in the Southern Tier.

Temperatures rise gradually during the spring season and in some years the warming trend is delayed by recurring periods of cool weather. The cold water of the Great Lakes reduces daytime warming and the frequent cloudiness moderates both extremes of the diurnal temperature cycle.

The influence of the Great Lakes is diminished in the southern half of the region, where the chance of a damaging frost remains high through the middle of May.

The autumn season is marked by frequent periods of sunny, dry, weather. Summer warmth persists until about mid September, whereupon temperatures noticeably decline as the hours of darkness rapidly increase. With less cloud cover, temperatures from mid September to mid October frequently rise to the 60s and 70s in the daytime and cool to the 30s and low 40s at night. The comparatively warm waters of the Great Lakes reduce cooling at night to the extent that freezing temperatures in lakeside counties are normally delayed until mid October or later.

A.3.3.2 Local Meteorology for Buffalo, New York

Off-site data for representation of the general regional climate and the local meteorological conditions are collected from the National Weather Service (NWS) observing station at Buffalo, New York (on the eastern end of Lake Erie, 55 km north northwest of the WVDP, at latitude 42.93°N, longitude 78.73°W). Relevant historical meteorological data collected at the Buffalo NWS is provided in WVDP-EIS-015, "Air Resources Environmental Information Document," (WVNS, 1992), which summarizes meteorological information and analyzes trends. A correlation between the meteorological data collected at the Buffalo NWS and the data collected at the Site's regional and primary monitoring stations is also provided.

A.3.3.3 On-Site Meteorological Program for the WVDP

The measurement program for meteorological parameters at the WVDP consists of:

- A primary location with measurement levels of 10 and 60 m above ground, located on site;

- A hilltop location off the site, measuring wind parameters at 10 m above the ground for the purpose of monitoring regional wind.

At the primary monitoring location, wind speed, wind direction, and air temperature are measured at both 10 m and 60 m. The standard deviation of the horizontal wind (sigma theta) at both heights is calculated from 5-second interval samplings of the direction monitor. Data are recorded directly on a digital data acquisition system with backup on a chart recorder. The data are automatically transmitted to the Chicago office of URS (Dames & Moore) for processing and storage.

The regional meteorological tower is a 10 m tall wooden telephone pole equipped with a crossarm and wind monitoring instruments. This site is located on Dutch Hill, approximately 5.2 km south-southwest of the project facilities. This site is on some of the highest terrain in the area, at an elevation of approximately 2,000 ft NGVD (approximately 180 m above the elevation of the site). Parameters measured at the regional site include wind speed, wind direction, and sigma theta.

The regional site will remain in operation for the life of the project to provide real-time data on regional airflow for emergency preparedness purposes. Because these data are required in real time by emergency response personnel at the project, the data are transmitted back to the site via a dedicated telephone line. At the WVDP site, the data are recorded by the data acquisition system (DAS) and an analog strip chart recorder in the same manner as data from the on-site tower. Meteorological data collected from both the regional and primary monitoring locations are summarized and reported in the Annual Meteorological Data Reports (URS (Dames & Moore)).

A.3.3.4 Short-term (Accident) Dispersion

On-site and off-site dose predictions are a function of the assumed meteorological dispersion parameters. DOE-STD-1027-92 defines the distances and meteorological parameters to be used to calculate off-site and on-site doses to maximally exposed individuals from short-term releases. The DOE Standard discusses the adoption of the NRC-recommended (10 CFR 30) parameters (1 m/sec wind speed and Pasquill-Gifford Stability Class [PGSC] F) and a less conservative alternative for ground-level releases (4.5 m/sec, PGSC D). In order to comply with the NRC recommendation, the more conservative values of 1 m/sec, PGSC F have been assumed for all accident analyses involving ground-level releases. This approach results in calculated doses from ground level releases that are approximately twenty-four (24) times the doses that would be predicted by assuming a wind velocity of 4.5 m/sec and PGSC D.

A.3.3.5 Long-term Dispersion Estimates

Five year average and annual average χ/Q values are computed for distances out to 80 km (50 mi) from the plant for elevated and ground level releases. The 5-year average χ/Q values are derived from data collected between January 1, 1987 through December 31, 1991. Annual average χ/Q values are derived from the meteorological data reported in the most recent Annual Meteorological Data Report (URS (Dames & Moore)). All long term ($\geq$ 1 year) χ/Q values are calculated using the CAP88-PC computer code (USEPA, 1992). Five year average χ/Q values are used for prospective dose assessments such as demonstrating compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) permitting requirements. Annual average χ/Q values are used in retrospective dose assessments performed for the NESHAP Annual Report and demonstrating compliance with DOE Order 5400.5.

A.3.4 Surface Hydrology

A.3.4.1 Hydrologic Description

The WVDP project facilities and its two water supply reservoirs lie in separate watersheds, both of which are drained by Buttermilk Creek (see Figure A.3.4-1). Buttermilk Creek, which roughly bisects the WNYNSC, flows in a northwestward direction to its confluence with Cattaraugus Creek, at the northwest end of the WNYNSC. Several tributary streams flow into Buttermilk Creek in the WNYNSC. The flow length of Buttermilk Creek through the WNYNSC is about 25,000 feet. About 9,000 feet of this is adjacent to the project facilities and the water supply reservoirs.

In addition to the two main watersheds, a small, 18-acre watershed on the east side of Buttermilk Creek drains the area around the bulk storage warehouse, which is used for general equipment and furniture storage. Hydrological events and conditions in this area would not affect safety-related main plant facilities; therefore, this 18-acre area will not be further discussed in this section.

Buttermilk Creek lies in a deep, narrow valley cut into glacial soils. A downstream portion of the creek has downcut to shale bedrock. The reach of stream to the east of the facilities has downcut through the Lavery till and the underlying Kent recessional units, and is presently incising the Kent till. The stream invert drops from an elevation of 1,310 feet National Geodetic Vertical Datum (NGVD) at the southern site boundary, to 1,215 feet NGVD at the northern edge of the project facilities, to 1,110 feet NGVD at the confluence with Cattaraugus Creek. The drainage area of the Buttermilk Creek basin was estimated to be 19,600 acres (Boothroyd et al. 1982a). The U.S. Geological Survey (USGS) operated a gaging station at the Bond Road bridge about 5,000 feet upstream of the mouth of Buttermilk Creek from October 1961 to September 1968. The drainage area to this point is estimated to be about 18,820 acres (29.4 sq. mi.).

Cattaraugus Creek flows westward from the Buttermilk Creek confluence to Lake Erie, 39 miles downstream. The total drainage area is estimated to be 335,060 acres (524 sq mi). A gaging station has been maintained at Gowanda, N.Y., since 1939. The drainage basin to this point is estimated to be about 276,480 acres (432 sq mi). The drainage area of Cattaraugus Creek upstream of the Buttermilk Creek confluence is 139,450 acres (220 sq mi).

A small hydroelectric dam and water impoundment is located on Cattaraugus Creek about 1,000 feet upstream of the Scoby Road bridge, southwest of Springville, N.Y. Neither Buttermilk Creek nor Cattaraugus Creek downstream of the WVDP are used as a regular source of potable or agricultural water. The steep-walled nature of the downstream valley and the region's ample precipitation combine to make irrigation and livestock watering from the creeks impracticable and unnecessary. Because Buttermilk Creek downstream of the site is entirely within the WNYNSC, there are no other uses made of these waters. Cattaraugus Creek downstream of Buttermilk is a popular fishing and canoeing/rafting waterway. As such, Cattaraugus Creek water, fish, and sediments are monitored as part of the WVDP environmental monitoring program (WVDP Annual Site Environmental Reports).

The two water supply reservoirs, which are interconnected by a short canal, are located to the south of the main project facilities. They were formed by blocking off two tributaries to Buttermilk Creek with earthen dams. The south reservoir drains to the north reservoir, which then discharges to Buttermilk Creek through a sluice gate water level control structure. The emergency spillway is located on the south reservoir. The reservoirs collect drainage from numerous small streams over a

3,100-acre drainage basin. The watershed ground cover is a mix of forest, cultivated fields, and pastures. Several small farm ponds are located throughout the basin.

The project facilities drainage basin is relatively small, consisting of approximately 1,200 acres. The outfall of the watershed, that is, the point where all surface runoff from the site reaches a single stream channel, is at the confluence of Frank's Creek and Quarry Creek, north of the main project facilities. The watershed extends in a southwest direction from this point. Ground cover consists of the main project facilities, forest, abandoned farmlands, and a small amount of active farmland.

The project facilities watershed is drained by three named streams: Quarry Creek, Frank's Creek, and Erdman Brook. Erdman Brook and Quarry Creek are tributaries to Frank's Creek, which in turn flows into Buttermilk Creek. Erdman Brook, the smallest of the three streams, drains the central and largest fraction of the developed Project premises, including a large portion of the disposal areas and the areas surrounding the lagoon system; the plant, office, and warehouse areas; and a major part of the parking lots. Following treatment, the Project's waste waters are also discharged to this brook. Erdman Brook flows from a height of over 1,400 feet NGVD west of Rock Springs Road to 1,305 feet NGVD at the confluence with Frank's Creek northeast of the lagoons. It flows for about 3,000 feet through the project facilities.

Quarry Creek, which drains the largest area of the three named streams, receives runoff from the HLW tank farm, the north half of the northern parking lot, and the temporary radioactive waste storage tents. It flows from an elevation of 1,930 feet NGVD west of Dutch Hill Road to 1,245 feet NGVD at its confluence with Frank's Creek. The segment that flows along the north side of the project is about 3,000 feet in length.

Frank's Creek receives runoff from the east side of the project, including the Drum Cell, part of the state radioactive waste burial area, and the former construction demolition and debris landfill. It flows into Buttermilk Creek about 2,000 feet downstream of its confluence with Quarry Creek. It flows from an elevation of 1,790 feet NGVD west of Rock Springs Road, to 1,245 feet NGVD at the Quarry Creek confluence, to 1,180 feet NGVD at the Buttermilk Creek confluence. About 6,000 feet of its length is adjacent to WVDP project facilities.

Flow impediments (log jams, bridges, etc.) in the main stream channels are located at elevations below the plateau on which the project facilities are located. Thus, the stream flow could overtop the impediments and not flood the site. Numerous culverts for drainage ditches and the channels of the stream headwaters are located on or above the site. The most significant of these are culverts under the site railroad spur and under Rock Springs Road because of their large storage capacity. The locations, number, and flow directions of storm drain systems associated with the former processing plant are not precisely known. There is a man-made constriction on Erdman Brook downstream of the radioactive burial areas, consisting of a former road embankment. Potential impediments from beaver activity are also a concern. However, the beaver dams can be cleared away if necessary.

Supplemental information on surface water hydrology may be found in WVDP-EIS-009 (Part 2). Additionally, information pertaining to the geomorphology of stream valleys, both on- and off-site, is presented in WVDP-EIS-009 (Part 1).

A.3.4.1.1 Site and Facilities

The main project facilities and burial areas are located on a plateau, divided into a North Plateau and South Plateau by Erdman Brook (Figure A.3.4-2). The entire plateau is being actively incised by the three main streams and their tributary gullies. These gullies are growing at various rates, influenced by the amount of runoff through them. Since the start of the project, increased runoff has resulted from the construction of parking lots, buildings, and office trailers. Project facilities which are likely to be first affected by the stream and gully growth are the radioactive waste treatment lagoons, the access road along the north perimeter of the WVDP, the NDA, and some perimeter fence sections. Erosion protection measures are limited to small-scale, irregular efforts around on-site facilities and do not involve the main stream channels and their tributary gullies. Critical slopes (particularly along Frank's Creek and Erdman Brook [see Figure A.3.4-2]) are being monitored, and operations are being conducted to minimize potential erosion and consequences of failure.

Erosion monitoring primarily consists of general visual observations of site areas and intermittent monitoring of previously installed instrumentation, such as erosion frames. The frequency of such monitoring is based on measured rates of change and visual observations. Additionally, in 1991, an investigation was conducted to evaluate the stability of the lagoon no. 3 slope embankment and provide recommendations for slope stabilization (Empire Soils Investigations, Inc., 1991). The investigation included drilling and installation of slope indicators (i.e., inclinometers) for monitoring deep movements within the slope.

A.3.4.1.2 Hydrosphere

The WVDP is underlain by the following water-bearing units in ascending order: 1) weathered shale bedrock; 2) inter- and intra-till sand units; and 3) alluvial/fluvial sand and gravel deposits overlying the uppermost till on the North Plateau but absent on the South Plateau. The uppermost water-bearing unit on the South Plateau is the upper, fractured Lavery till. Refer to section A.3.5 for an expanded discussion of subsurface hydrology.

Kappel and Harding (1987) estimated that 70% of the total streamflow from the North Plateau is base flow, while only 20% of streamflow on the South Plateau is base flow. This is due to the clayey, silty till at the South Plateau surface, which limits infiltration and causes more precipitation to run off directly to channels. Although the North Plateau surface sands and gravels permit more infiltration, construction activities have left much of the surface area impermeable.

The surface water regime of the WVDP includes Frank's Creek, Quarry Creek, and Erdman Brook and their associated tributaries and gullies, and the two water supply reservoirs and their feeder streams.

The project low-level radioactive waste treatment facility includes four in-series lagoons (lagoons 2, 3, 4, and 5). The largest is Lagoon 3, which has a capacity of 467,900 cubic feet (10.7 acre-ft). Lagoon 3 is also the final lagoon in the system before the wastewater is discharged into Erdman Brook. A fifth basin, Lagoon 1, was decommissioned in 1984 and filled with material dug from a radioactively contaminated hardstand. The site's sewage treatment plant (STP) discharges to a gully that flows into Erdman Brook. A former equalization basin for the STP now acts as a sludge pond for utility room discharges.

The two water supply reservoirs were formed by damming tributaries to Buttermilk Creek. Transects were surveyed in 1980 to estimate the amount of sedimentation that had occurred and the remaining storage volume. Survey data from 1963 and 1980, together with data extrapolations to 1991, are shown in Table A.3.4-1 It is estimated that 21% of the original volume of the reservoirs has been lost to sedimentation.

A.3.4.2 Floods

A.3.4.2.1 Flood History

Cattaraugus and Buttermilk creeks lie in deep, narrow valleys. Therefore, the effects on the WVDP of flooding by these creeks is negligible, as supported by historical data.

Frank's Creek, Quarry Creek, and Erdman Brook are also located in deep valleys. Historical evidence and computer modeling indicate that flood conditions (including the probable maximum flood) will not result in stream flows overtopping their banks and flooding the plateau. However, indirect damage from the erosional effects of high stream flows and excessive slope saturation during flood conditions is a possibility. The facilities likely to be most affected by bank failure and gully head advancement due to extreme precipitation are lagoons 2 and 3, the NDA, and site access roads in several places.

Constriction of the stream channels is not likely to result in flooding. Major constriction points on the WVDP site are the culverts through the railroad spur, the wreckage of the old Rock Springs Road bridge, and the remnants of a road embankment that crossed Erdman Brook downstream of the SDA. There are also numerous culverts for drainage ditches throughout the site.

In the past, flow monitoring equipment was located at the Frank's Creek-Quarry Creek confluence; the Erdman Brook-Frank's Creek confluence; and Erdman Brook just below the NRC-licensed disposal area. Peak stream flows occur in the spring, usually during a heavy rainfall event on a snow cover while the ground is frozen. Other high flow events come from summer thunderstorms and long, soaking rains. Peak flows, measured on March 27, 1991, were 340.3 cubic feet per second (cfs) at the confluence of Quarry Creek and Frank's Creek, 161 cfs where Frank's Creek leaves the WVDP, and >60 cfs in Erdman Brook downstream of the SDA. The peak flow measured at the USGS gage station at the Bond Road Bridge over Buttermilk Creek was 3,910 cfs on September 28, 1967. The historic high-water level in the reservoirs of 1,358.6 feet NGVD was recorded on the same day in 1967.

Computer modeling in 1991 of the probable maximum flood (PMF) (which is based on a hypothetical probable maximum precipitation [PMP] of 24.9 inches of rain in 24 hours) has yielded estimates of a peak flow of 14,021 cfs at the confluence of Frank's and Quarry creeks, and 3,670 cfs at the confluence of Frank's Creek and Erdman Brook. The hydrologic modeling is further discussed below. Detailed information is provided in TSD A.3.4-B, TSD A.3.4-C, and WVDP-EIS-009 (Part 2). Improvements to the site since 1991, especially, the addition of impervious areas, are likely to result in greater peak discharges in the creeks.

A.3.4.2.2 Flood Design Considerations

Floodplain analyses have been performed using the U.S. Army Corps of Engineers HEC-2 computer modeling program (U.S. Army Corps of Engineers, 1982). Creeks that border or cut into the plateau were modeled. Storm return frequencies of 2, 10, and 100 years were analyzed. Results of the 100-year calculation are represented in Figure A.3.4-2. (For more information regarding the model, see Section A.3.4.3.3.)

The steep-walled nature of these creeks produces a well-confined floodplain, and sufficient reservations have been allowed for headwater pools. As a result, the 100-year floodwater elevations would not impact any safety-related facilities, nor is it necessary to design or provide flood-protection measures anywhere on-site.

In the case of the hypothetical PMF, which has a peak discharge nearly eight times that of the 100-year flood, it was demonstrated using the TR-20 program (Soil Conservation Service, 1983) that culvert headwaters would overtop Rock Springs Road and some part of the floodwaters would flow across the plant area. Based on the topography in the plant area, it is likely that some portions of the site would experience shallow flows of moderate velocity. Flows would recede quickly, however, since the ditches that drain the site have gradients of up to 5%. It is difficult to quantify the effects of such an extreme event. Part of the difficulty stems from the likelihood that drainage areas would become interconnected and flow paths would be altered. The effects of ground saturation on site facilities is also hard to predict.

The separate issue of erosion resulting from catastrophic rainfall events is of particular significance at this site. Slopes adjacent to facilities such as the lagoons and burial areas would be especially susceptible to failure as a result of severe channel downcutting coupled with excessive soil moisture.

A.3.4.2.3 Effects of Local Intense Precipitation

The 24-hour PMP for this watershed as supplied by the U.S. Weather Bureau is 24.9 inches. An expanded discussion of the PMP is contained in Section A.3.4.3.1.

As noted in the section above, the effects of the PMP on site drainage systems would be overwhelming. Capacities of storm drain inlets at grade and in sumps would be exceeded. Ditches along open section roadways would overflow, flooding roadways and adjacent areas. None of the culverts within the watershed would be expected to prevent overtopping of its embankments, which raises the possibility of embankment failures. In the case of the 24-inch corrugated metal pipe (CMP) culvert beneath the railroad embankment along Frank's Creek (structure 1 in the TR-20 computer model [see TSD A.3.4-A]), flow would be directed to the water supply reservoirs before the embankment elevation was exceeded. Failures of culvert embankments would not threaten any safety-related facilities in the plant area. However, the erosion produced by a failure-induced flood wave at the railroad embankment would likely compromise the integrity of the northern slope of the SDA. This, in turn, could adversely affect downstream surface water channels within the Project premises.

The principal design consequences of precipitation are flooding and erosion. Design considerations for ditches along roadways, culverts, and culvert embankments are provided in Chapter A.4.0. The principal design consequence of snow is increased loading on rooftops. Design considerations for snow loading on rooftops are provided in Chapter A.4.0.

For more information regarding the rainfall-runoff relationship of the PMP, refer to Section A.3.4.3.3.

A.3.4.3 Probable Maximum Flood (PMF) on Streams

Peak discharges of the PMF have been generated for the subareas constituting the watershed using the U.S. Soil Conservation Service (SCS) TR-20 computer modeling program. These discharges were then used in a Manning's equation-based analysis of depth of flow at four cross sections on streams adjacent to safety-related facilities (these locations coincide with HEC-2 cross sections, 10790, 20160, 21090, and 6695). The results of these analyses demonstrate that the depths of flow associated with the PMF on area streams is well below the elevations of site facilities (see TSD A.3.4-A). The lowest portion of the main plant is approximately 1,410 feet NGVD, whereas under PMF conditions, the nearest stream would rise to only 1347.2 feet NGVD. The results of the analyses are summarized in Table A.3.4-2.

The PMF peak discharge generated by the model for the WVDP facilities watershed to the confluence of Frank's and Quarry creeks is 14,021 cfs. This number correlates very well with a discharge of 14,500 cfs, which was generated by the method presented in Appendix B of NRC Regulatory Guide 1.59 (Design Basis Floods for Nuclear Power Plants, 1977). Supplemental information on this method can be found in TSD A.3.4-A.

A.3.4.3.1 Probable Maximum Precipitation (PMP)

According to U.S. Weather Bureau meteorological analysis, the theoretically greatest precipitation that could be expected over the applicable drainage area in a 24-hour period is 24.9 inches. Factors figuring into this estimate include the size of the 1,200-acre drainage area, its topography, and seasonal effects.

The synthetic rainfall distribution used for the TR-20 model and to generate discharge hydrographs is referred to as the 24-hour Type-II distribution. Refer to Section A.3.4.3.3 for more information regarding application of rainfall in the hydrologic model.

A.3.4.3.2 Precipitation Losses

The absorption capability of the basin is relatively low because the watershed is dominated by hydrologic soil groups "C" and "D." Rock Springs Road serves to separate the upper watershed, dominated by "C" soil, from the lower watershed, which is predominantly "D" soil. Texturally, the soils range from clays to silts and infiltration rates for such soils range from 0.02 inches per hour to 0.27 inches per hour (Rauls, Brakensick, and Saxton 1982). Initial abstraction refers to precipitation losses prior to runoff and tends to vary according to soil and cover parameters. The SCS TR-55 (Soil Conservation Service, 1986) procedure for calculating runoff states that initial abstraction can be approximated as a function of runoff curve number. Overall, the watershed's composite runoff curve number is equal to 76. This method yields an initial abstraction of 0.63 inches, which includes losses due to surface storage, evapotranspiration, and infiltration.

A.3.4.3.3 Runoff Model

The watershed drainage area to the confluence of Frank's Creek and Quarry Creek has been subdivided into 22 subareas as shown in Figure A.3.4-3. A total of 46 cross sections is used to characterize the runoff from these 22 subareas. Discharge was routed through the watershed using the TR-20 model. Four structures and three stream reaches were modeled. TSD A.3.4-B presents a schematic diagram of the runoff areas and illustrates input coding, input data, and results for the TR-20 model.

The TR-55 method of hydrologic analysis was used to describe soil types, land uses, and times of concentration. Hydrographs were generated for the 2-year, 10-year, 100-year, and PMP synthetic rainfall events. Results for the WVDP facilities watershed are summarized in Table A.3.4-3. Elevations of headwater pools at the four culverts (two at Rock Springs Road and two at the railroad spur embankment) for all storms can be found in TSD A.3.4-C. In the case of the PMP, it is evident that headwaters will exceed the confining embankments. However, the 100-year storm is contained at all four locations, as shown in Figure A.3.4-2.

Storms with periods of intensity which exceed model intensity distributions have combined with snowmelt in some instances to produce peak discharges slightly less than 2-year model predictions. The conditions in such cases have served as some verification of the model calculation for the 2-year storm.

A.3.4.3.4 Probable Maximum Flood Flow

As noted in Section A.3.4.3, the PMF discharge as calculated by the NRC method correlates very well with that generated by the TR-20 model. The NRC method predicts a PMF discharge of 14,500 cfs, while the model predicts 14,021 cfs.

A.3.4.3.5 Water Level Determinations

Water level elevations have been estimated for the 2-, 10-, and 100-year storms by the U.S. Army Corps of Engineers HEC-2 computer program. The results of the runs are presented in TSD A.3.4-C and the 100-year floodplain is delineated on Figure A.3.4-2. Estimates of PMF elevations at the major culverts/reservoirs were made using the TR-20 program. Four structures were modeled. Based on the analyses, the PMF flood would overtop the structures in all four cases. Normal depth calculations by Manning's Equation at four stream sites adjacent to the plant show that PMF flooding of safety-related facilities will not occur. Effects of downstream backwater have also been shown to fall well below the plant elevation (see TSD A.3.4-A). For more information regarding model input and cross section data, refer to TSD A.3.4-C.

A.3.4.3.6 Coincident Wind Wave Activity

Not Applicable

A.3.4.4 Potential Dam Failures

TSD A.3.4-A shows that the two water supply reservoirs cannot contain the PMP without the dam crest being overtopped and subsequent dam failure. Nor are the dams designed to withstand a design basis earthquake.

The emergency spillway, located at the south end of Reservoir 1, is a 6-foot-deep, 175-foot-long trapezoidal channel. In 1996, the spillway was regraded and stabilized using a geosynthetic to control erosion. Gabions are located at the toe of the slope.

While dam failure would not present a direct flooding hazard to the Project facilities, it would require a significant reduction of site operations until a large-volume supply could be restored. Given the WVDP mission objectives and the cost of the upgrades necessary to insure a long-term water supply, this has been judged an acceptable risk. The dams are not on Project premises, but since they are the source of Project water, the WVDP has performed limited maintenance on them.

Moreover, it is estimated that the flood wave peak discharge would be entirely attenuated within the WNYNSC property limits (i.e., within approximately 3.5 miles downstream of the dam). There are no private residences in the attenuation area.

A.3.4.4.1 Reservoir, Pumphouse, and Pipeline Descriptions

The reservoirs watershed area is about 3,100 acres, of which 2,000 acres drain directly to Reservoir 1 and 1,100 acres drain directly to Reservoir 2. The reservoirs were formed by building earthen dams across two tributaries of Buttermilk Creek south of the main plant facilities. To prevent seepage at Dam 1, sheet piling was driven across the 50-foot width of the stream bed at the base of the dam to a depth of 35 feet. Dam 2 lacks sheet piling. Dam characteristics are listed in Table A.3.4-4.

The level for the reservoirs is controlled by an outflow weir and floodgate housed in a control structure/pumphouse at Reservoir 2. The floodgate starts to open when the reservoir level reaches 1,349 feet NGVD. Storage at the 1,353 feet NGVD elevation was originally 19,815,435 ft^3 (455 acre-ft). To allow additional discharge, a 2-foot-square port was cut into the control structure at 1,350.5 feet NGVD. The storage at this level was originally about 17,857,265 ft^3 (410 acre-ft). The port can be closed to restrict flow.

An emergency spillway is located at the south end of Reservoir 1. The spillway elevation is 1,354 feet NGVD. The spillway is 175 feet wide and has side slopes of 1.5:1, and discharges down a vegetated fill embankment to a point on Buttermilk Creek approximately 1,200 feet from the dam.

The 14-square-foot control structure at Reservoir 2 has reinforced concrete walls 15 inches thick and is mounted on a 35-inch concrete slab supported by piling. The 8-

inch-thick floor of the pumphouse is located at 1,350 feet NGVD. The primary outflow barrel is a 36-inch corrugated metal pipe directed to a channel at the toe of the slope. To supply water from Reservoir 2 to the main plant facilities, two pumps located in the control structure pump through an 8-inch cast iron line to a 63,560-cubic-foot tank located next to the former reprocessing plant. Normally, one pump is in service and the other is on standby, although both can be used at the same time. The pumphouse is located 60 feet west of Dam 2, in about 25 feet of water. The pump intakes are at 1,330 feet NGVD.

Loss of water supply from the reservoirs would not result in any immediate safety concerns at the WVDP site. However, orderly shutdown of plant facilities would be implemented to retain the bulk of the 63,560 cubic feet of reserve water for potential firefighting needs. In addition, effects on specific facilities are discussed in individual facility SAR modules.

A.3.4.4.2 Dam Failure Permutations

The two reservoir dams were not designed to withstand the PMP or the design basis earthquake. They could be expected to fail in either event. The reservoir watershed drains to Buttermilk Creek upstream of the main project facilities. Failure of the dams under PMF conditions would not raise the level of Buttermilk Creek sufficiently to impact the site. However, dam failure would result in a loss of makeup water to the on-site storage tank. Water would then need to be supplied by an alternative method.

Dam failure was modeled using two methods, the HEC-1 (U.S. Army Corps of Engineers, 1974) computer program and the SCS TR-60 method. Model input included data from a 1986 investigation for emergency spillway remediation and the PMP rainfall event. Additional data were used to provide for storage to the dam crests and for emergency spillway flow rates.

A simultaneous failure of both dams was analyzed using HEC-1 to simulate worst-case conditions. The peak discharge of 28,000 cfs occurred while both dams were being overtopped.

The TR-60 method resulted in a peak flow of 81,000 cfs. This peak flow would result in an added flow depth to Buttermilk Creek of 16 feet. Coupled with the PMF flow on Buttermilk Creek, this would amount to a peak depth of about 40 feet, a level that would remain well within the valley walls. The 40-foot depth correlates to an elevation of about 1,290 feet NGVD in Buttermilk Creek opposite the main project site. There are no project facilities that would be directly affected by the dam failure stream flow. However, the high precipitation associated with dam failure would result in stream flows and associated erosive effects capable of negative impacts on the facilities. In addition, the only non-project facilities that could be affected by dam failure flow include the railroad track and embankment east of Buttermilk Creek.

Although the failure permutations were calculated for overtopping the dams at 1,360 feet NGVD, the steep slope and lack of armoring on the emergency spillway indicate that dam failure could occur at lower reservoir elevations. For instance, 2 feet of flow depth over the spillway weir corresponds to a velocity of 4.4 feet per second (fps), which is considered erosive with respect to grass stabilization.

A.3.4.4.3 Unsteady Flow Analysis of Potential Dam Failures

Refer to Section A.3.4.4.2 for a discussion of dam failures and resulting floodwave impacts on Buttermilk Creek. Domino-type failures of downstream structures have not been considered because floodwave attenuation would occur in the broad downstream floodplain before reaching the first structure at the railroad crossing (approximately 1.5 miles downstream).

A.3.4.4.4 Water Levels at Site Facilities and Disposal Areas

As mentioned previously, the most critical water levels occur as a result of dam failures associated with the PMF. The two culvert reservoirs at Rock Springs Road would threaten the plant facilities, while the two at the railroad embankment would affect the disposal areas. Storage routing indicates embankments would be overtopped, but specifics are difficult to predict.

In the case of the Rock Springs Road culverts, backwater would likely spill into adjacent side ditches, filling them rapidly until the centerline road elevation was exceeded. Shallow sheet flow would then approach the plant area. Flows due to dam failure (i.e., road embankment failure) would be confined to the Quarry Creek valley, based on topography.

The culverts at the railroad embankment also have significant storage capacity and a failure at either location would threaten the burial areas due to erosion. Discharges due to breach of the culvert structures would flow at extreme velocities through critical valley reaches, which are already considered unstable. Safety-related facilities do not exist in these areas and flood elevations are a lesser concern.

Naturally occurring timber dams are quite common throughout the area. They typically stand less than three feet above the stream invert and are composed of small-diameter trees which were transported downstream during heavy storm flows. Heavy timber dams were not considered at any length in the hydrologic studies because they do not constitute a potential threat to site safety. This is primarily a function of the small watershed size (less than two square miles) and the inability of the relatively small upper watershed drainage courses to transport heavy timber in even the most severe meteorological event. The smaller dams do not result in significant flooding, and in the event of a dam break they would be washed away or would not otherwise seriously affect water flow downstream of the break.

A.3.4.5 Probable Maximum Surge and Seiche Flooding

Not applicable because the nearest standing bodies of water, the water supply reservoirs, are approximately 2,000 feet from main plant facilities.

A.3.4.6 Probable Maximum Tsunami Flooding

Not applicable because the West Valley site is approximately 40 miles from Lake Erie, which is believed to be the nearest body of water capable of such flooding.

A.3.4.7 Ice Flooding

Flooding of the plant by ice jams on Buttermilk Creek is not possible since overflow would occur before backwater neared the plant elevation, nearly 200 feet above

Buttermilk Creek. In tributaries adjacent to the plant, flows tend to be slight except during storms. Significant threat could only occur in the event of an ice jam, followed by a rain storm or heavy snowmelt. The probability of such a combination of events is remote; the temperature required for a rainstorm or snowmelt would likely melt the ice jam over the period of time required to generate flood discharges.

A.3.4.8 Water Canals and Reservoirs

Figure A.3.4-4 illustrates the configuration of the two reservoirs and the interconnecting canal.

A.3.4.8.1 Canals

The interconnecting channel between the two water supply reservoirs may be considered a canal. The canal was originally designed to have an 8-foot bottom width and a constant bed elevation of 1,340 feet NGVD, and the canal walls rise to an elevation of at least 1,360 feet NGVD. Sides were to be sloped at a 1:1 ratio. Water elevation would be the same as in the reservoirs.

Actual construction resulted in a canal bottom depth between 1,345 and 1,350 feet NGVD. A connecting pipe was also placed below the canal, but appears to now be in a non-operational state. The canal bottom has undergone some sedimentation and the walls have experienced some erosion and slumping.

As the canal is in a deep channel and is surrounded by heavy forest, wind-induced waves are not a concern. In a PMF event, the reservoir dams would overtop prior to the canal. See Section A.3.4.4 for design data.

A.3.4.8.2 Reservoirs

Information on the reservoirs may be found in Sections A.3.4.1.2 and A.3.4.4.2 and TSD A.3.4-A.

A.3.4.9 Channel Diversions

Diversion of the water flowing through the main project facilities has not been implemented nor is it planned. Potential upstream diversion of the supply for the reservoirs is considered low due to the sparse population.

Beaver dams could partially divert flow from the reservoirs. However, should these dams become too much of a problem, they would be destroyed and the animals trapped and removed from the area.

A.3.4.10 Flood Protection Requirements

Stream valleys surrounding the WVDP facilities and disposal areas are sufficiently wide and steep to accommodate PMF flow depths without flooding safety-related features (see Section A.3.4.2.2).

The Project reservoir embankments would likely fail under PMF conditions, disrupting the plant water supply. To provide for continued operation during such an event, plans for increasing reserve quantities or temporary emergency delivery should be made. No processes or facilities at the WVDP would present an immediate safety problem if the water supply was lost.

A.3.4.11 Low Water Considerations

The two water supply reservoirs act as the fill source and backup to an on-site storage tank. Uses of the reservoir water (depending on the status and volume in the on-site storage tank) include: firefighting; make-up and cooling water for the fuel receiving and storage area (FRS), cement solidification system (CSS), melter, and other plant systems; and drinking water.

A.3.4.11.1 Low Flow in Rivers and Streams

The streams that supply the water reservoirs are intermittent. Low flows occur during the summer. The length of time a low (i.e., essentially zero) flow condition lasts is dependent on precipitation and temperature. Although no specific historical data exists it is reasonable to believe that the low-flow condition can last for 30 days.

Water is supplied to the main site from Reservoir 2 via a pumping station and pipeline. During low-flow periods, water level can drop below the level of the interconnecting canal (1,345 to 1,350 feet NGVD). In this case, the volume in Reservoir 2 is the only reservoir water source.

A.3.4.11.2 Low Water Resulting from a Seiche

A seismic event of sufficient magnitude to produce a seiche would likely cause a direct dam failure, resulting in a zero level in both reservoirs.

A.3.4.11.3 Historical Low Water

The streams that supply the reservoirs routinely dry up during the summer months. Although historical flow records do not exist for the feeder streams, short-term data on nearby streams indicate that low-flow conditions can last for a month. If the water level in the reservoirs falls below the intakes (1,330 feet NGVD), make-up water could be pumped from Buttermilk Creek into the reservoirs.

A.3.4.11.4 Future Control

See Section A.3.4.11.3 for low-flow conditions. At present, there is no provision for flow augmentation in the event of a severe low-flow period.

A.3.4.12 Environmental Acceptance of Effluents

Project effluents discharged to surface waters must meet limits prescribed by the New York State Department of Environmental Conservation (DEC) for nonradiological parameters in a State Pollution Discharge Elimination System (SPDES) permit and by DOE for radiological parameters (per DOE Order 5480.1B). Discharges are monitored to ensure that all standards are met. Monitoring is performed at the point of discharge and at several downstream locations. Sampling and surveys were performed both prior to and after project initiation. Highest radiation levels in surface water are found in Erdman Brook near the Lagoon 3 discharge.

Since radioactive isotopes tend to adhere most readily to clay particles, highest levels can be expected in pools and debris traps where the water velocity is low. Contaminated sediment may accumulate in depositional areas, or migrate downstream when velocities are sufficient to transport suspended particles.

Accidental spills to surface waters would be distributed in much the same way as planned discharges. Inadvertent discharges involving gross failure of a system component have the potential of extensive downstream contamination.

Elevated levels of gross beta activity (due to Sr-90) have been observed in groundwater samples taken from North Plateau monitoring wells located downgradient of the main plant (WVDP-220). The primary (but not the sole) source of this contamination is believed to have been the Off-Gas Cell. Transfer lines in this recovery area are known to have leaked during NFS fuel reprocessing operations. The evidence pointing to this cell as the major contributor to the groundwater contamination is described more fully in a 1995 report of the subsurface probe investigation of this area (WVDP-220). The activity is localized to the surficial sand and gravel layer and has traveled over 900 feet (as of January 1995) in a northeast direction in no more than 30 years. Groundwater in the sand and gravel layer ultimately discharges at seepage faces along the rim of the plateau adjoining the Quarry Creek and Frank's Creek valleys. Evidence of this contamination has been detected in drainage swales near the plateau rim.

On the South Plateau where the sand and gravel is absent, the weathered and fractured Lavery till exhibits some lateral flow component that presents a threat of contamination migration from the burial areas. An overflow effect, commonly referred to as "bathtubbing," may occur in the burial areas if infiltration through the caps and/or lateral groundwater flow enters at rates greater than the steady-state outflow (via vertical seepage) from the holes and trenches. If the volumetric capacity of the disposal trench is exceeded, this inflow-outflow imbalance will manifest itself as surface seeps of leachate. This has been documented once in the NDA since the Project was initiated and resulted in no detectable release beyond the Project premises.

A.3.4.13 Chemical and Biological Composition of Adjacent Watercourses

An aquatic ecological survey of the WVDP environs is presented in Section A.3.7.

A.3.5 Subsurface Hydrology

A.3.5.1 Regional and Area Characteristics

The hydrostratigraphy of the region and of Buttermilk Creek basin are discussed in TSD A.3.6-A under the heading Regional Groundwater Considerations. The basin-wide cross sections, in particular, provide a frame of reference for examining and describing the groundwater systems beneath the WNYNSC and the WVDP.

The hydrostratigraphic system beneath the WNYNSC consists of a sequence of unlithified Holocene and Pleistocene deposits occupying a steep-sided valley carved in Devonian bedrock. The Holocene deposits are mainly high-level alluvial fans and aprons derived from the till cover on the uplands surrounding the WNYNSC, and low-level fans and associations of floodplain deposits derived from the Pleistocene valley-fill sequence; the latter consist mainly of lag from the Lavery till. The valley fill is an interstratified succession of glacial tills of low permeability and periglacial water-laid deposits of somewhat higher permeability. Hydraulic gradients within the till sheets are predominantly vertical; in the non-till units the gradients are characteristically lateral and directed toward the channel of Buttermilk Creek.

The hydrostratigraphy of the WVDP is represented schematically in Figure A.3.5-1, which shows east-west sections through the southern and northern sectors of the site. These lines of section are approximately parallel to the prevailing direction of groundwater migration in the transmissive units.

The complete sequence for the WVDP comprises, in ascending order: 1) shale bedrock, characterized by enhanced permeability due to disintegration and decomposition near the bedrock-overburden interface; 2) a sequence of three glacial tills separated by intervals of stratified drift; and 3) an association of alluvial-fluvial deposits that directly overlies the uppermost till (Lavery) in the plant area and is absent in the southern sector of the WVDP.

Excepting the uppermost weathered and fractured zone of the Lavery till, flow patterns within the shallow units—alluvial fan, the main mass of the Lavery till, and the upper lacustrine sequence (Figure A.3.5.1[A]) are well understood and are supported by abundant potentiometric data and computer simulations. Flow patterns within the lower unit are supported by a few data such as the geologic and potentiometric data from well 83-4E, but are consistent with anticipated hydraulic relationships. Water levels measured during construction of well 83-4E in July 1983 (Figure A.3.5.1[B]) indicate that the entire interval below the upper lacustrine sequence is saturated, that the bedrock aquifer and the lower lacustrine aquifer are artesian beneath the WVDP, and that groundwater flow within the two lower confining units (tills) is characterized by very weak upward gradients. The indicated head relationships and the low permeability of the tills indicate that passage of groundwater through the lower part of the sequence occurs mainly within the lower lacustrine sequence (unit 11 in Figure A.3.5-1) and is directed toward the axis of the bedrock valley.

The term lacustrine sequence has historically referred to the interval of stratified drift deposited between the Kent and Lavery tills. These sediments were deposited during recession of the Kent ice sheet and are represented by a variety of facies including lakes, kames and deltas. More recently, this assemblage of deposits has been referred to in other site reports as the Kent recessional sequence, thus encompassing the various depositional environments and simplifying its usage.

The Lavery till and the Kent recessional sequence unit directly beneath the Lavery generally are regarded as containing all of the potential routes for the migration of contaminants to the surface water system and to off-site areas. Each unit in that sequence, and bedrock, is described below as to its distribution, fundamental hydrologic properties, capacity to retard the passage of solutes, and potential for being perceived as a source of usable groundwater.

A.3.5.1.1 Unsaturated Zone Characterization

The unsaturated zone characterization studies that were performed at the WVDP were used to develop a conceptual model of the seasonally variable, unsaturated flow regime in the subsurface of the site. TSD A.3.5-A describes the lateral extent and thickness of the vadose zone, its qualitative unsaturated flow characteristics, as well as quantitative data used in analytic flow models fully described in WVDP-EIS-009, Part 5.

A total of fifteen monitoring arrays were installed at the WVDP since 1985 to monitor soil moisture movement in the vadose zone. Eight of these arrays (the 1985 and 1986 series) were decommissioned in 1991 and their data incorporated into WVDP-EIS-009, Part 5. Seven were installed in 1990 to supplement the previous data with detailed information from the near surface vadose zone. Hydrogeologic data obtained during monitoring array operation were used to determine the following parameters: total soil porosity and void ratio, temporally and spatially variable in-situ soil-water content, field-saturated hydraulic conductivity, soil characteristic curves for the on-site soils, water content-pressure head-hydraulic conductivity relationships for on-site soils, and seasonal in-situ wetting and drying cycles.

The effects that textural and structural soil characteristics have on vadose zone water flow and contaminant flow were addressed in TSD A.3.5.A and comprehensively discussed in WVDP-EIS-009, Part 5. The vadose zone studies defined the spatially variable infiltration rates in to the on-site soils and their significance when predicting the integrity of the disposal trenches for use as long-term storage vaults.

A.3.5.1.2 Bedrock Aquifer

Properties of the bedrock aquifer at the WVDP are essentially those of shallowest bedrock throughout the site region, as discussed in Section A.3.6 under Regional Groundwater Considerations. Additional information on the significance of bedrock groundwater in the near vicinity of the site is provided in Section A.3.5.1.6, Groundwater Use Inventory. The most complete description of stratigraphic variation in bedrock is contained in the log for borehole 69-USGSI-5, located at the bulk storage warehouse, about 2 km southeast of the main plant (see TSD A.3.6-B – Borehole Logs). Section A.3.5.1.6 contains most of the data presently available on the hydraulic characteristics of the bedrock aquifer.

As presently characterized, shallowest bedrock is effectively permeable to depths of up to 3 m, has horizontal conductivity of 10^{-5} cm/sec, supplies groundwater of good quality to wells at rates of 40-60 L/min (10-15 gpm), and is typically confined by relatively impermeable overburden.

Although bedrock lies at or very near the surface along Rock Springs Road, the abrupt decline eastward in the elevation of the bedrock surface, and the commensurate abrupt increase in the thickness of the valley fill, assures that the Site Security Area (see Figure A.3.1-4) and all source terms are separated from the bedrock aquifer by about 30 m (100 ft) of drift and, most significantly, by a nominal 15 m (50 ft) of relatively impermeable Lavery till.

Plant operations currently do not involve withdrawal of groundwater from bedrock and such withdrawal is not contemplated. Groundwater flow patterns in this aquifer are well established and tightly constrained by the bedrock configuration, and significant pattern changes are not likely to occur, even under pumping. This aquifer is not recharged within the Security Area and site operations are not likely to adversely affect its value as a groundwater resource.

A.3.5.1.3 Surficial Sand and Gravel Layer

The surficial sand and gravel layer is a silty, sandy gravel deposit which incorporates two overlapping units of different ages and origins. The older unit is a Wisconsinan glaciofluvial gravel deposited in Buttermilk Creek valley by draining glacial meltwaters of Lavery-age ice. The younger unit is a post-glacial Holocene alluvial fan deposited by streams entering Buttermilk valley. It overlies the Lavery till and onlaps the older glaciofluvial gravel deposit along the valley axis (LaFleur 1979).

These two units together can be referred to as the sand and gravel unit complex; they cover an elevated plain known as the North Plateau (Figure A.3.5-2). The layer is bounded to the north, east, and south by Quarry Creek, Frank's Creek and Erdman Brook, respectively, and on the west by bedrock where it rises to land surface. Figure A.3.5-2 also illustrates the active groundwater monitoring locations during 1996, including monitoring of groundwater seepage at the eastern edge of the North Plateau. The main plant building and adjacent facilities are built upon the alluvial fan deposit, which in turn overlaps the glaciofluvial terrace approximately 260 m northeast of the plant (Bergeron et al. 1987).

The composition of the sand and gravel unit varies, but on the average it is a mixture of gravel (55%), sand (20%), and silt and clay (25%). The thickness of the unit ranges from 0 to over 12 m, as shown in the contour map in Figure A.3.5-3. Additional data pertaining to physical and chemical properties of the surficical sand and gravel layer can be found in WVDP-EIS-004 (Parts 3 and 4) and WVDP-EIS-009 (Part 4).

Subsurface information acquired during a 1993 soil boring program was used to divide this layer into two units - an upper thick-bedded sequence of muddy gravels and muddy sandy gravels, and a lower thin-bedded sequence of clays, silts, sands, and very fine-grained gravels (WVDP-EIS-008). This thin-bedded sequence has been found within the medial portion of the north plateau coincident with a structural "low" on the top of the Lavery till.

Groundwater Flow in the Surficial Sand and Gravel Deposits

Due to similarity of composition, the alluvial and glaciofluvial deposits behave hydrologically as one unit. Groundwater in the sand and gravel unit flows radially away from the apex of the plateau at the upland (western) boundary, and travels northeastward across the North Plateau. Figure A.3.5-4 is a contour map of the potentiometric surface, showing groundwater elevation on October 17-19, 1990. A similar map, showing water elevation data recorded in 1994, is presented in WVDP-220, Rev.0.

Groundwater flow in the fan-terrace deposits is predominantly horizontal, and vertical migration into the underlying till has been described as inconsequential (Yager 1987). The saturated thickness of the sand and gravel deposit, determined from water levels collected in October 1990, ranges from approximately 1 to 30 ft. Measurements recorded over the period from October 1989-November 1995 show overall water table fluctuations of up to 10.4 ft (3.2 m).

Plant buildings and site facilities affect the general groundwater flow patterns by either blocking and restricting flow or providing preferential pathways. The HLW tank complex and part of the fuel storage pool (i.e., cask unloading pool [CUP]) penetrate fully through the fan-terrace deposits into the till, diverting flow around these facilities. In addition, the backfill which surrounds the facilities is described as "select backfill"on the drawings inherited from NFS. This description together with the groundwater hydrology data in hand suggest that the backfill is less permeable than the natural sand and gravel, thus restricting flow.

A ditch connecting the central wetland to discharge point NP-3 (see Fig. A.3.5-2) diverts groundwater in this area towards itself. The french drain along Lagoons 2 and 3 diverts a portion of the groundwater from entering the lagoons and discharges to Erdman Brook (Bergeron et al. 1987). Supplemental information on groundwater flow in the surficial sand and gravel layer is presented in WVDP-EIS-009 (Part 4).

Hydraulic Properties

Bergeron et al. (1987) determined hydraulic conductivity of the fan-terrace complex using slug test data from wells 80-1 through 80-8 (see Fig. A.3.5-5) screened throughout the saturated thickness of the unit. Results were analyzed by the type curve method of Cooper et al. (1967) using drawdown versus time. Values for hydraulic conductivity ranged from 1.0×10^{-4} to 9.1×10^{-3} cm/s, with a geometric mean of 7.0×10^{-4} cm/s (Bergeron et al. 1987). Table A.3.5-1 shows the calculated hydraulic conductivities and saturated thickness at each well.

Hydraulic conductivity testing of selected wells has been performed annually since 1992. Table A.3.5-2 presents results for sand and gravel unit wells tested. Values derived from slug tests range from 8.0×10^{-6} to 7.5×10^{-3} cm/s, with a geometric mean of 2.2×10^{-4} cm/s. Locations of the monitoring wells tested are presented in Figure A.3.5-6.

Yager (1987) constructed a map showing the assumed lateral distribution of hydraulic conductivity values, based on data from 1980 wells (Fig. A.3.5-7). Low values are associated with backfilled areas near the main plant, the HLW tank complex, and the LLWTF lagoons, which cause a steeper hydraulic gradient west of the main plant than to the north. Areas of high conductivity correspond to a suspected buried stream channel (Yager, 1987) on the surface of the till (Figure A.3.5-8), producing a flatter gradient north of the plant. This channel may be an erosional feature. The resulting channel fill would be coarser-grained than the surrounding deposits.

Yager (1987) assumed that specific yield, the ratio of the volume of water a soil will yield by gravity drainage per volume of soil, ranged from 0.10 to 0.25. Lower values were believed to correspond to areas with a high silt content. Higher values were assumed to correspond to areas of well-sorted sand and gravel.

Change in storage was estimated from differences between water levels recorded in observation wells 80-1 through 80-8 (see Fig. A.3.5-5) in October 1982 and in September 1983. Two wells on the upper (south) part of the plateau (80-1 and 80-2) showed an increase in water level, 80-8 showed no change, and the rest showed declines. The combined change indicated a net decline of 0.2 m. Assuming a specific yield of 0.20, the change in storage represents a net groundwater discharge of 4 cm/y. Supplemental information pertaining to hydraulic characteristics of the surficial sand and gravel is presented in WVDP-EIS-009 (Part 4).

Recharge and Discharge

Yager (1987) estimated total annual recharge to the fan-terrace at 66 cm/y. This includes contributions from: 1) precipitation; 2) underflow from fractured bedrock; and 3) leakage from the plant's outfall channel, which discharges steam condensate from the plant to Erdman Brook. Avenues of discharge are: 1) drainage to stream channels, springs, and seeps; 2) seepage into the french drain and LLWTF; 3) vertical migration into the underlying till; and 4) evapotranspiration from the water table. Total discharge was calculated at 60 cm/y, which leaves a mass balance error of 8%. Table A.3.5-3, the estimated annual groundwater budget for the water year October 1982-September 1983, shows the contributions from each recharge source, and the amount of groundwater lost to each discharge point. The calculations used to determine recharge and discharge are provided in TSD A.3.5-B. Updated recharge estimates for the surficial sand and gravel as well as the Lavery till are provided in WVDP-EIS-009 (Part 5).

Improvements made in 1997 to the site's north parking lot to divert runoff are intended to reduce groundwater recharge upgradient of the former processing building.

Reducing recharge is a means of lowering the volume of groundwater that comes into contact with the source area of contamination in the vicinity of the main plant.

Computer Simulation of Groundwater Flow

Yager (1987) used a three-dimensional finite-difference model (MODFLOW: McDonald and Harbaugh, 1984) to simulate groundwater flowpaths and travel times from sources of radioisotopes to discharge areas on the North Plateau. The model also was used to investigate possible sources of the tritium that was found in groundwater discharging to the wetland in 1972.

Steady-state simulations were used to calibrate the groundwater model to predict the mean annual water table altitude. Computer-generated water levels closely matched those measured in 23 observation wells, with an average error of 0.5 m. Simulated groundwater discharges to NP-1, NP-3, and the french drain (see Figure A.3.5-7) were within 4% of measured field values. Transient-state simulations of an annual cycle including seasonal variation in recharge and evapotranspiration closely matched water levels measured in eight observation wells.

The model predicted that the french drain and the NP-3 stream channel exiting the wetland would intercept most of the flow downgradient of the fuel storage pool and the HLW tank complex, with the rest discharging at seeps along the east boundary of the plateau. Groundwater originating at the main plant area would reach either NP-3 or the french drain within approximately 500 days and would arrive at the seepage faces within 800 days. The area of high permeability northeast of the main plant significantly decreased the predicted travel time of water to the NP-3 channel. Doubling the model hydraulic conductivity did not significantly alter the predicted travel times. Decreasing conductivity by 50% increased travel time from the main plant area to the NP-3 channel from 500 to 800 days.

Although groundwater flowpaths predicted by steady-state simulations for 1972 did not support the theory that tritium found in the groundwater discharging to the wetland was emanating from wastewater lagoons 4 and 5, the analysis by Yager (1987) did suggest that storage of tritiated material on the old hardstand and leakage from beneath the reprocessing plant were among the more likely sources.

Effect on Facility Design

The plant facilities have altered the natural groundwater flow pattern in the sand and gravel layer by obstructing flow in some areas and providing preferential discharge points in others. Groundwater contributes to loads on foundations both laterally and via uplift forces. For conservatism, the hydrostatic surface is considered to be at ground level. These loads are included in the various load combinations considered for foundation designs (see Chapter A.4.0).

A.3.5.1.4 Lavery Till

The Lavery till is predominantly a silty clay till with minor amounts of incorporated lenses of sand, gravel, silt, and rhythmic clay-silt laminations (Albanese et al. 1983). Grain size, on the average, is clay (50%), silt (30%), sand (10%), and gravel (10%). The mineral composition of the till largely resembles that of local bedrock. As much as 3 to 4 m of the upper till is altered by the processes of chemical oxidation, fracturing, weathering, and/or penetration by root tubes, all of which provide secondary porosity (Bergeron et al. 1987). A complete description of the physical and chemical properties of the till is contained in Section A.3.6.4 and A.3.6.6, respectively.

On the North Plateau, the till is covered by the fan-terrace deposit, and the weathered layer is thin or nonexistent; on the South Plateau, the till occurs at the surface. Both radioactive waste burial areas at the site, the SDA and the NDA, are located in the till on the South Plateau. Much of the research concerning the Lavery till has been performed in and around the burial areas (Bergeron and Bugliosi, 1988; Bergeron et al., 1987; Prudic, 1986).

Supplemental data on the Lavery till, pertaining to its physical and geochemical characteristics, can be found in WVDP-EIS-004 (Parts 3 and 4).

Groundwater Flow in the Lavery Till

The hydraulic gradient in the Lavery till, based on data from several nested piezometers, is predominantly downward, even beneath adjacent small stream valleys, where discharge of groundwater might be expected (Prudic, 1986). Figure A.3.5-9 shows the distribution of hydraulic head along cross sections across the South Plateau in February 1976 and May 1983. In general, groundwater flows from areas of higher hydraulic head to areas of lower hydraulic head; thus, the direction of seepage from the SDA trenches was mostly downward, with some outward movement within a few meters of the trenches.

Observations from the NDA area, indicate lateral groundwater movement in the weathered till. In December 1983, kerosene containing radioactive tributyl phosphate was detected in a shallow observation well on the north side of the NDA. It was discovered that the liquid had migrated approximately 18 m laterally through the upper 3 to 4 m of weathered till from its suspected origin--one or more burial pits about 3.0 to 4.5 m deep that extended into the unweathered till, containing tanks filled with solvent which were placed around 1970 (Bergeron et al. 1987). Subsequent to this initial discovery, additional work was performed within this area of the site in an effort to address this issue (WVDP-042; DOE/NE/44139-38; WVNS:EIS-996).

Further information pertaining to groundwater flow in the Lavery till is presented in WVDP-EIS-009 (Part 4).

Hydraulic Properties

Prudic (1986) noted the abundant fractures in the weathered till zone, indicating that fractures with oxidized walls a few meters wide extended down to about 4.5m. The oxidized zones bordering the fractures, as well as thin coatings of manganese and/or iron oxide, calcite, root hairs, and thin gray (reduced) zones on the inner surfaces of some fractures, clearly suggest water movement along the fractures. Hydraulic conductivity of three shallow piezometers, all 3 m or less in depth, ranged from that of unoxidized till to as much as 200 times greater.

Results of permeability tests performed primarily by the U.S. Geological Survey and Dames & Moore are provided in TSD A.3.5-C. Each table provides the depth of the sampled interval, the type of material tested, its hydraulic conductivity, the test method used, and the primary source of the data.

A summary of hydraulic conductivity data for weathered and unweathered till is presented in Table A.3.5-4, and shows statistical parameters generated for each set of data--arithmetic mean, geometric mean, range of values, and standard deviation. Where the range of values spans two or more orders of magnitude, the geometric mean is taken to be more reliable than the arithmetic mean. Table A.3.5-4 also summarizes the other hydraulic properties discussed in this section.

Based on the results contained in Table A.3.5-4, the geometric mean is essentially the same for the K_v of the weathered till, the K_v of the unweathered till, and the K_h of the unweathered till (3.5×10^{-8}, 3.2×10^{-8}, and 4.1×10^{-8} cm/sec, respectively). Significantly higher values were obtained for the K_h of the weathered till (3.1×10^{-7} cm/sec) and for the K_h of lenses of stratified drift in the till (1.8×10^{-6} cm/sec).

Limited testing for horizontal hydraulic conductivity was performed by Dames & Moore on selected 1989-1990 monitoring wells screened in the Lavery till. Values for samples from the SDA area ranged from 7.32×10^{-7} to 7.25×10^{-6} cm/s for weathered till and 9.07×10^{-7} to 4.40×10^{-6} cm/s for unweathered till. Table A.3.5-5 shows the values obtained at each well tested and the arithmetic mean for the weathered and unweathered till units. In-situ testing of 16 unweathered Lavery till wells in 1995 estimated the mean hydraulic conductivity to be 4.23×10^{-8} cm/s.

The limited data collected thus far cannot be used to estimate the spatial distribution of hydraulic conductivity in the till. Since no extensive zones of low or high permeability have been identified in the vicinity of the burial areas, it is reasonable to assume that varying hydraulic conductivities occur randomly in the till and that no preferential pathways exist which have higher than average permeability and are continuous over several tens of meters.

Vertical hydraulic conductivity calculated from consolidation tests was used to determine the effects of increased confining pressure (Prudic 1982). In general, vertical conductivity decreased as confining pressures increased, suggesting that increased overburden pressure reduces conductivity within the lower Lavery till.

The equivalent hydraulic conductivity of the till unit may be determined as a weighted average of the hydraulic conductivity of the till itself and that of the randomly distributed lenses of silt, sand, and rarely, gravel. Thickness of the sorted material is estimated to be 7% of the total thickness of the till (Prudic and

Randall 1979). Prudic (1986) calculated an equivalent hydraulic conductivity of 4 x 10^{-8} cm/s ± 2 x 10^{-8} cm/s.

Prudic (1982) tested nine till samples for both vertical and horizontal conductivity and did not discover anisotropy. Examinations of 18 thin-section samples of till showed no preferential horizontal layering of the clay grains, also indicating no anisotropy.

The total porosity (n) of a material is that fraction of the mass comprising voids. Effective porosity (n_e) generally is less than the total porosity and represents the fraction of the total void volume that is interconnected and therefore, provides a continual subsurface flow path.

Total porosity values for the Lavery till have been computed from dry-density determinations performed on 32 samples taken during drilling by the USGS of Borings 82-1B through 82-5B, and 83-1E through 83-3E, in the vicinity of the NDA (Figure A.3.5-10). These data and the results of the calculations are shown in Table A.3.5-6. Also shown are the depth interval of the sample, percent moisture content, and the computed percent saturation (S). Total porosity (n) was computed from dry density according to the formula

$$n = 1 - Y_d/G_s$$

where G_s is the specific gravity of the till in gm/cm^3, and Y_d is the dry density of the till in gm/cm^3. In this case, G_s was assumed to be constant at 2.70 gm/cm^3, based on specific gravity determinations on three till samples obtained in a boring located about 375 m north of the NDA (Dames & Moore 1975).

The computed total porosity of the 32 samples (Table A.3.5-6) ranged from 0.16 to 0.50, with an arithmetic mean of 0.311. Dry density of the samples ranged from 1.36 gm/cm^3 to 2.26 gm/cm^3, with a mean of 1.86 gm/cm^3. Percent saturation (S) was computed according to the formula

$$S = WY_d / n$$

where W is the percent moisture content on a weight basis. In Table A.3.5-6, S ranges from 80 to 164%, with a mean of 103%. This implies that on the average the samples were at or near saturation. It also implies that the computed porosity was somewhat lower than the actual porosity. The calculation of porosity depends upon the specific gravity (G_s), which was assumed on the basis of only three till samples. (The assumed value for specific gravity may have been too low.) Assuming that on the average, the 32 samples were saturated, then based on the mean S value, the value for the mean total porosity was determined to be 0.320.

Prudic (1986) reported an average n value of 0.324 for 28 till samples obtained at the SDA and nearby locations. Combining this value with the corrected value given in the previous paragraph, the weighted mean total porosity is 0.322.

Porosity determinations were performed on three samples of laminated silt and clay taken in the vicinity of the NDA and SDA (Prudic 1986; WVNS 1985). The values ranged from 0.33 to 0.41, with a mean of 0.36.

Effective porosity was also determined for seven soil samples (six till and one lacustrine sample) from the area of the SDA and NDA. Effective porosity (n_e) was arbitrarily defined as the porosity of those pores with entrance diameters greater than 0.1 micron, and was determined by mercury injection into the samples. As shown in Table A.3.5-7, total porosity among the six till samples ranged from 0.25 to 0.37, while effective porosity ranged from 0.14 to 0.23 and averaged 0.17. In this group, n_e/n ranged from 0.45 to 0.72, with a mean of 0.57. The one lacustrine layer sample was determined to have a total porosity of 0.33, an effective porosity of 0.23, and an n_e/n of 0.70.

Dry density was determined for 17 core samples of Lavery till taken at the SDA (Prudic 1986). The mean dry density of these samples was 1.82 gm/cm^3, as compared to 1.86 gm/cm^3 for the 32 samples reported in Table A.3.5-6. The weighted mean dry density for all 49 samples is 1.85 gm/cm^3.

Specific storage, defined as the volume of water released from storage under a unit decline in hydraulic head, is equal to the compression of the medium and the expansion of the water. Prudic (1986) determined the specific storage of till near the burial trenches from four consolidation tests of core samples from depths between

6 and 16 m. The specific storage decreased from 16 x 10^{-6} per cm at a depth of 5.8 m to 2 x 10^{-6} per cm at a depth of 16 m, and averaged 8 x 10^{-6} per cm. These values are in the lower part of the range for medium-hard clay.

Specific flux of the fractured, weathered till and the fractured, unweathered till were calculated by Bergeron and Bugliosi (1988) at 3.2 and 2.4 cm/yr, respectively. The specific flux of the unweathered till was 2.0 cm/yr. The specific flux of the till was found by Prudic (1986) to be between 0.3 and 2.3 cm/yr, with perhaps slightly higher rates in the weathered till along the slopes bordering the burial area.

Data from some piezometers support the theory that unsaturated conditions exist within the Lavery till beneath the water table. West of the NDA, piezometers between 6.1 and 16.2 m in wells 82-3A, 82-3B, and 82-3C (see Fig. A.3.5-10) have never contained water. The area near this piezometer cluster is routinely traveled over and scraped by heavy equipment, resulting in a compacted surface. This may encourage runoff and reduced infiltration. Prudic and Randall (1979) noted dry piezometers between 5.5 and 14 m deep in holes L and Q (see Fig. A.3.5-10), west of Trench 14 in the SDA.

Neutron-moisture profiles of till near piezometer cluster 82-3 and in saturated till near piezometer cluster 82-1, south of the NDA, show a 0-10% moisture content in the non-water-yielding till, compared to 20-35% moisture in saturated till (Bergeron et al. 1987).

Most precipitation to the till around the burial areas is lost by evapotranspiration or runoff to streams via overland flow (Dana et al. 1979). Groundwater discharges to the land surface at three locations: a low-lying area between the SDA and NDA, west of borehole G (Fig. A.3.5-10); surface depressions east of the north trenches of the SDA; and the base of the slope incised by Frank's Creek. Discharge within these areas, calculated by computer simulations (Bergeron and Bugliosi 1988), amounted to 1.5 x 10^{-4} m/d. Flow in nearby streams, measured during base-flow periods in the spring, was generally less than 8.5 x 10^{-3} m^3/s. During summer, the discharge areas remained saturated even though the streams were not flowing, indicating possible groundwater seepage.

Infiltration rates used in best-fit model simulations by Bergeron and Bugliosi (1988) ranged from 1.4 cm/yr along smooth, sloping, or compacted surfaces, to 3.8 cm/yr near swampy areas.

Supplemental information (i.e., physical and hydraulic properties; aquifer parameters; groundwater flow characteristics) on the Lavery till is presented in WVDP-EIS-009 (Part 4).

Computer Simulations of Groundwater Flow

Groundwater flow near the SDA was analyzed by Prudic (1986) using a computer model to quantify factors controlling groundwater flow near the trenches. The model was used to: 1) simulate flow across the trenches; 2) simulate flow from the trenches to Frank's Creek; and 3) evaluate possible anisotropy in the till and variations in hydraulic conductivity.

In the best computer simulation, hydraulic conductivity of the uppermost layer of till, from the surface to the base of the weathered zone, was calibrated at 10 times higher than the unweathered till (the third layer). The second layer, unweathered till with oxidized fractures, had a conductivity 5 times higher than the unfractured unweathered till. To model the effect of overburden pressures and lack of fractures with depth, the fourth layer of deep till was assigned a conductivity of 15-30% less than the third till layer. This decrease correlated well with results of consolidometer tests of core samples, which showed decreases in conductivity when pressure was applied.

The computer simulations indicated that water seeping from the trenches would not intersect any of the nearby streams. However, if the water level in a trench rose above the level of the reworked till cover, it could seep out through the cover to the surface. Geohydrologic data indicate little possibility that the layer of bedded silt and sand just below Trench 8 extends as far as Frank's Creek, 75 m west of the trench. The simulations suggest that even if this layer was extensive, and the trench filled with water to the cover, water seeping outward would only migrate 18 m laterally before beginning to travel downward.

Bergeron and Bugliosi (1988) incorporated Prudic's (1986) model and used it to analyze the possible migration of radionuclides from the NDA burial pits into the till and to Erdman Brook. Simulations of a burial pit, assumed to be filled with water, indicated that water near the bottom of the pit would migrate laterally in the shallow, weathered till for 5 to 6 m before moving downward into the unweathered till, and water near the top of the pit would move laterally less than 20 m before moving downward into the unweathered till.

A subsequent simulation study was performed, which again investigated groundwater flow and radionuclide transport from NDA disposal pits (USNRC, 1991). The results suggested that lateral flow through the weathered till layer could be more significant than indicated by the previous modeling studies. However, a conclusive assessment of the actual magnitude of lateral flow was not made. The need for a more definitive study will be determined by decisions regarding future use of the NDA.

Till-Sand

The till-sand is a silty, gravelly sand layer locally-present within the Lavery till. It has not been specifically identified in any previous studies as a potential aquifer. It is thought to be either a pro-glacial sand pod or a lens of reworked kame deposit.

The till-sand is limited in areal extent, occurring mainly on the North Plateau in an east-west band approximately 150 to 350 m wide. It lies 10 to 13 m below the top of the till, and is from 3 to 10 m thick. Drilling in 1989-90 for monitoring well installations, penetrated the unit at several locations on the North Plateau. Supplemental information on the till-sand is presented in WVDP-EIS-009 (Part 4).

Design Considerations

The Lavery till is a good foundation material, with dry densities in excess of 100 lb/ft^3 and shear strengths greater than 1,000 lb/ft^2. While the till is highly impermeable, some jointing permits limited groundwater flow. It is, nonetheless, a good barrier to radionuclide migration. For conservatism, the hydrostatic surface is set at ground level for design purposes, though in reality the groundwater level is much deeper and variable. Additionally, the Lavery till is not prone to liquefaction (see TSD A.3.6-F).

A.3.5.1.5 Lacustrine/Kame Deposit

Lacustrine and kame delta deposits (or Kent recessional sequence) of post-Kent till age underlie the Lavery till on parts of both the North and South plateaus. The unit consists of laminated silt and clay grading upward into fine to coarse sand and silt, locally capped by gravel (Bergeron et al. 1987). It was deposited when pauses in the recession of the Kent glacier through a pro-glacial lake allowed the accumulation of kame deltas over lakebed silts and clays. This unit is underlain by at least two older clayey silt tills, the Kent till and the Olean till, which are in turn separated by other lacustrine deposits (LaFleur 1979). Additional geologic information on the lacustrine/kame deposit is presented in WVDP-EIS-004 (Parts 1 through 4).

Groundwater Flow

Water moving downward through the Lavery till eventually reaches the lacustrine sand and silt. Data from eight test holes near the burial areas indicate that the upper sandy part of the unit is not water-yielding. Neutron-moisture profiles from four boreholes south and east of the NDA suggest minor levels of saturation, indicating pressure heads less than or close to zero in this part (Bergeron et al. 1987). These unsaturated conditions are thought to be the result of very low recharge from the overlying till (Prudic 1986).

Piezometers in the lower silt and clay section of the unit are saturated, and suggest lateral groundwater flow, with a gradient of 0.023 to the northeast, towards Buttermilk Creek (Bergeron et al. 1987). Water levels in three piezometers finished in the saturated part of the unit have fluctuated less than 20 cm/yr (Prudic 1986). Figure A.3.5-11 shows an idealized vertical section of inferred distribution of saturated and unsaturated conditions within the sediments underneath the South Plateau.

Porosity determinations have been performed on three samples of the lacustrine unit in the vicinity of the NDA and SDA (Prudic 1986; WVNS 1985); the values ranged from

0.33 to 0.41, with a mean of 0.36. A laboratory test of constant head permeability yielded a vertical hydraulic conductivity of 1.3×10^{-8} cm/s.

Supplemental information is presented in WVDP-EIS-009 (Part 4) which describes physical and hydraulic properties, groundwater hydrology, soil chemistry, and aqueous geochemistry.

A.3.5.1.6 Groundwater Use Inventory

A survey of groundwater usage within 3 km of the WVDP was conducted in September 1982. The results of that survey are contained in Figure A.3.5.12 and Table A.3.5-8. The tabulated information indicates that the vast majority of the wells identified serve residences and farms; the maximum number of persons served per well is ten. A large percentage of the wells is located on the higher elevations east and west of the WNYNSC, along the principal north-south county roads. A second concentration of wells is located on the lowlands north of the WNYNSC in the vicinity of Bond Road and Thomas Corners Road. Between 10 and 15% of the wells are located outside the Buttermilk Creek drainage basin; the remainder are within the surface drainage basin and presumably tap the same groundwater systems that underlie the site.

Water supplies north of the WNYNSC and south of Cattaraugus Creek derive mainly from springs and shallow dug wells completed in Defiance outwash that overlies the Lavery till in this area. The distribution of springs and the general geologic relationships indicate that the groundwater system here is perched above the Lavery and that flow patterns are much the same as those that characterize the North Plateau at the WVDP. This hydrostratigraphic unit clearly is disconnected from the WVDP both hydraulically and topographically. Nonetheless, water supplies developed from bedrock wells in this same area downstream and downgradient of the WVDP might be hydraulically connected to water originating on-site via the surface water system and shale exposures in the lower reaches of Buttermilk Creek. In 1982, the nearest bedrock supply well (No. 36) was more than 1.5 km distant from those exposures.

Supply wells on the uplands bordering the WNYNSC, such as along Route 240 and Dutch Hill Road, typically are completed in bedrock. The tabulated data and the glacial geologic map (LaFleur 1979) indicate that a nominal 15 m of till overlie a fractured bedrock aquifer on the summit levels west of the site, and comparison of screen depths and static water levels indicate that the aquifer is confined. A similar situation exists on the uplands east of the WNYNSC, except that most of these wells intersect from 20 to 45 m of Kent till and ground moraine above their completion depths in shale bedrock. The data also suggest that pressure head in the bedrock aquifer in this area is greater than along Dutch Hill Road on the west. Groundwater supplies in both of these areas can be assumed to be isolated hydraulically from groundwater in bedrock at lower elevations beneath the WNYNSC and the WVDP.

The Lavery till and underlying lacustrine sequence presently are not drawn upon for groundwater supplies and there is no reason to anticipate that the Lavery, given its hydraulic properties, ever will be considered a source of groundwater. The lacustrine sequence, however, has many of the properties of an aquifer and might be considered as a source of groundwater in a subsistence farming scenario.

A.3.5.2 Site Characteristics

All water used at the plant, both for processing and domestic use, originates from two artificial reservoirs. These reservoirs were formed by two earthen dams which were constructed across two stream valleys (Dames & Moore 1974). The plant railroad spur runs across the top of both dams. The two reservoirs contain more than 555,525 m^3 of water (NFS 1973). Groundwater is not used at the plant for process or drinking water supplies. Figure A.3.5-13 identifies the groundwater recharge areas within the influence of the plant. These areas consist of:

1) The North Plateau alluvial fan, and
2) The Lavery till

Both are recharged by precipitation and meltwaters. The alluvial fan, because of its higher permeability, is recharged much more readily than the Lavery till.

Because of the low permeabilities of the site sediments, impacts of dewatering during construction activities will be limited to areas immediately proximate to the excavation.

Groundwater flow patterns within the alluvial fan and within the Lavery till have been presented in Section A.3.5.1. The locations of monitoring wells used to evaluate possible outleakage from the plant are shown in Figure A.3.5-6.

A.3.5.3 Contaminant Transport Analysis

If required and utilized, contaminant transport models for a specific facility would be contained in the individual facility SAR. However, since no bounding accidents have thus far been identified for the hydrologic pathway, safety analyses of such accidents have generally been highly simplified (and have been based on very conservative premises).

A report (Dames & Moore, January 1992) provides a discussion of background information for, and results of, the selection of groundwater flow, contaminant-transport, and geochemical models that may be applied to the West Valley Demonstration Project (WVDP) site as part of site-characterization activities. In this document, the following items are also discussed: (1) general site conditions, (2) model-selection criteria, (3) model data requirements and data availability, and (4) the advantages and disadvantages of recommended models. The document provides guidance for the selection of appropriate groundwater flow, contaminant-transport, and geochemical models for use at the WVDP site. Because of the wide variety of hydrogeologic conditions at the site, the selection process included models appropriate for simulation of saturated flow and transport, unsaturated flow and transport, chemical-equilibrium speciation, chemical reactions, and multi-phase flow. Basic environmental contaminant transport information collected for the WVDP and WNYNSC is summarized in WVDP-EIS-020.

A simulation study was undertaken, which investigated groundwater flow and radionuclide transport from NDA disposal pits (NUREG/CR-5794). Part of this investigation involved simulation of the migration of Sr-90, Cs-137, and Pu-239 from one of the fuel hull disposal pits. The simulations indicated that for wastes buried below the fractured till zone (i.e., in unweathered till), no significant migration would occur. However, under an assumed radionuclide leach rate, significant lateral migration was predicted for radionuclides present in the upper, fractured weathered till.

Another investigation was conducted to address elevated levels of gross beta activity (due primarily to Sr-90) that had been observed in groundwater samples taken from monitoring wells downgradient of the main plant (Dames & Moore, 1995). The activity was found to be migrating northeastward in the surficial sand and gravel unit and had traveled over 900 feet in no more than 30 years. Specific areas of the main plant were believed to be the primary sources of this contamination. In a model simulation, using measured activity increases of Sr-90 in on-site groundwater over time, a distribution coefficient (K_d) of 4.5 mL/g was derived for Sr-90.

In the summer of 1994, the WVDP implemented a subsurface probing program on the North Plateau (WVDP-220). Some of the accomplishments of this program included:

- Characterization of the lateral and vertical extent of the Sr-90 plume on the North Plateau;
- Identification of preferential flow paths for Sr-90 migration;
- Identification of potential source areas of radiological contamination; and
- Characterization of radioactivity in groundwater and soil beneath the Main Plant.

In the summer and fall of 1997, the WVDP implemented a second subsurface probing program on the North Plateau to further characterize the extent of contamination near the leading edge of the plume. Results of this characterization are contained in WVDP-298, *Geoprobe Investigation on the North Plateau at the West Valley Demonstration Project* (WVNS). A total of 29 locations provided soil and groundwater quality characterization data.

In the summer of 1998, the WVDP performed a third subsurface probing program within and immediately adjacent to the main plant to characterize contaminated groundwater and soil near the core zone of the north plateau plume. In addition, groundwater was also sampled near the leading edge of the western lobe of the north plateau plume. As part of this investigation, groundwater was collected from 20 locations, and soil samples were collected from 8 locations. The results of the 1998 probing characterization program are detailed in WVDP-346, *1998 Geoprobe Investigation in the Core Area of the North Plateau Groundwater Plume* (WVNS).

A.3.6 Geology and Seismology

The physiography, geologic history, stratigraphy, structure, and hydrology of the site are summarized in this section, and each facet of the geology of the WNYNSC and its environs is described in greater detail in TSD A.3.6-A.

Supplemental information on regional and site geology is presented in WVDP-EIS-004, Parts 1 and 2. For regional and site seismology, supplemental information may be found in WVDP-EIS-005.

A.3.6.1 Geologic and Seismologic Overview

The WNYNSC is located within the glaciated northern portion of the Appalachian Plateau Physiographic Province, a maturely dissected upland region underlain in western New York by shales and siltstones of Devonian age. The plateau region has been subjected to multiple glaciations that resulted in the deepening and oversteepening of many pre-glacial valleys and in the accumulation in those valleys of as much as 150 m of glacial drift. The WNYNSC is situated within one of these north-trending valleys.

The region around the WNYNSC has undergone a moderate amount of relatively minor seismic activity. The only historical earthquake of Modified Mercalli Intensity (MMI) >VII in western New York assigned to a discrete tectonic feature occurred near Attica on the Clarendon-Linden Structure; the epicenter of that event was 50 km northeast of the site. Several smaller shocks in the Buffalo-Hamilton (Ontario), area have been interpreted as related to stress concentrations and crustal readjustments associated with glacial rebound. Ground motion at the site in historical time, probably has not exceeded MMI IV (WVDP 1984).

The WVDP has undergone intense geologic investigation and characterization since the early 1960s. To date, in excess of 100 publications dealing with almost every aspect of the site geology, seismology, and hydrogeology have been generated. These studies can be categorized as follows:

Borehole Records - Site boring data were collected in the course of subsurface characterization studies, foundation investigations, and monitoring-well installation programs. As of May 1991, in excess of 500 boreholes had been drilled inside the fenced area. Hollow-stem augers were used in most instances, but several deeper on-site monitoring wells were installed using either hydraulic rotary or cable-tool drilling methods. Since 1994, the use of hydraulically-powered, percussion probing equipment have been used extensively in the collection of soil and groundwater samples. Representative graphic boring logs for various site areas are presented in TSD A.3.6-B; most of these records were generated by Dames & Moore. Other organizations involved in these studies include NYSGS, USGS, USNRC, NFS, and WVDP. Borehole records generated from 1960 through 1983 are contained in USGS Open File Report 83-682 (Bergeron 1985).

During a 1993 soils characterization program, an additional 50 soil borings were drilled across the site. Data and information pertaining to this program are presented in WVDP-EIS-008.

In the summer of 1994, the WVDP implemented a subsurface probing program on the North Plateau (WVDP-220). A total of 73 locations were sampled outside the Main Plant; a total of six locations were sampled beneath the Main Plant; one location was sampled in the FRS Building.

A record of drilling projects that occurred at the WVDP and WNYNSC is presented in Table A.3.6-1.

Geophysical Surveys - Three geophysical surveys have been conducted at the WNYNSC. The first survey was reported in 1973 in the NFS SAR. This was a shallow reflection type investigation and included surveys along 12 lines across various areas of the site. The second survey, conducted in December 1983, employed electromagnetic, resistivity, and magnetometric techniques in and around the NDA. Results of this survey are described in the Dames & Moore report of March 5, 1984. The third survey, conducted during 1989 at the SDA, employed electromagnetics, resistivity, magnetometry, and seismic refraction profiling. The results of this survey are summarized in TSD A.3.6-A.

Trenching - Several trench studies have been carried out by the NYSGS. These consisted of the trenching of tills at various locations east of the SDA and resulted in detailed descriptions and interpretation of till structural and sedimentary features. Results of these trench studies are contained in Dana et al. (1979 and 1980) and are summarized in TSD A.3.6-A. Trench studies conducted by Dames & Moore at the NDA are documented in TSD A.3.6-A.

A.3.6.1.1 Summary of Regional and Site Geology

The following subsections provide summary descriptions of regional and site geology. TSD A.3.6-A contains detailed information on these topics.

A.3.6.1.1.1 Regional Physiography

The site is located on the Glaciated Allegheny Plateau section of the Appalachian Plateau Physiographic Province. This region is bounded on the north by the Erie Ontario Lowlands, on the east by the Tughill Upland, on the south by the unglaciated Appalachian Plateau, and on the west by the Interior Lowlands.

The Glaciated Allegheny Plateau has been subjected to the erosional and depositional actions of repeated glaciations, resulting in accumulation of various glacial deposits over the area. Fluvial erosion and mass wasting currently are altering the glacial landscape.

Surface water leaves the WVDP via Frank's Creek which joins Buttermilk Creek on the WNYNSC. Buttermilk Creek flows northward to join Cattaraugus Creek at the boundary of the WNYNSC. Cattaraugus Creek flows generally to the west and enters Lake Erie near Silver Creek, New York.

Regional physiography and the physiography of the site vicinity, including surface drainage patterns, are discussed further in TSD A.3.6-A.

A.3.6.1.1.2 Regional Geologic History

The bedrock underlying the glacial cover was deposited from Precambrian time to early to middle Paleozoic time. The later periods of the Paleozoic Era (Mississippian, Pennsylvanian, and Permian) are not extensively distributed throughout the region. However, small outliers of Mississippian and Pennsylvanian age rocks are present near Olean, New York. Five or more Pleistocene glacial ice sheets advanced over the region, depositing the thick sequence of tills and glacial outwash that directly underlie the modern landforms of the site and its environs.

The geologic history of the region and that of the site vicinity are discussed in greater detail in TSD A.3.6-A.

A.3.6.1.1.3 Regional Stratigraphy

Precambrian crystalline rocks comprise the basement rocks of the region. The crystalline terrains are overlain by approximately 2,300 m of Paleozoic strata consisting predominantly of shales, siltstones, sandstones, carbonate rocks, and some evaporites. Bedrock stratification in the area is nearly flat and essentially undeformed, with an average dip of 6-8 m/km to the south. The overburden consists of glacial deposits that mantle the higher elevations and fill the preglacial valleys that had been eroded into bedrock. The thickness of glacial deposits at the site ranges from 1.5 m or less on the uplands to 150 m along the axis of the valley.

The bedrock stratigraphy of the site region is discussed more fully in TSD A.3.6-A. The shallow stratigraphy of the site vicinity and the WVDP are discussed in Section A.3.5, Subsurface Hydrology, and in TSD A.3.6-A.

A.3.6.1.1.4 Regional Structure

No fold or fault of any consequence is recognized within the site area. The closest major structural zone is the St. Lawrence Rift Valley System, located about 480 km to the northeast. The north-trending Clarendon-Linden Structure, located 50 km northeast of the site, is the only significant structural feature in the western New York region. The Paleozoic strata in the site region are essentially horizontal, as indicated in A.3.6.1.1.3. Regional structure is discussed at greater length in TSD A.3.6-A.

A.3.6.1.1.5 Regional Subsurface Hydrology

Discussions of regional hydrogeology and site hydrogeology are presented in Sections A.3.5.1 and A.3.5.2, respectively. Regional hydrogeology also is discussed at greater length in TSD A.3.6-A.

A.3.6.1.1.6 Engineering Geology Considerations

The area within 8 km of the site has been examined in the field for evidence of deformation relatable to seismic activity. Aerial photographs of the site and surrounding area at distances from the site of from 8 to 65 km also have been examined. Neither field studies nor aerial photos revealed any geomorphologic features to indicate recent seismic activity.

A.3.6.2 Vibratory Ground Motion

Characterization of the seismicity of the site and site region is presented in this section in order to develop seismic criteria and guidelines. A description and the results of the site investigations and laboratory testing are provided in Section 3.6.4.

A summary of the regional and site geologic framework is provided in Section 3.6.1.1. Detailed discussions are contained in TSD A.3.6-A.

A.3.6.2.1 Underlying Tectonic Structures

Tectonic structures of the site region are discussed in TSD A.3.6-A. No tectonic features are recognized that would result in conditions conducive to a significant geological event at the site.

A.3.6.2.2 Behavior During Prior Earthquakes

Evidence of seismically induced ground failure, such as liquefaction, slumping, and fissuring has not been observed on or near the site during intensive geologic exploration programs. This lack of evidence is consistent with the reported and estimated epicentral intensities of historic earthquakes in the site region and their projected intensities (i.e., MMI ≤IV) at the WVDP, as discussed in Section A.3.6.2.4.

Intensities of MMI (Modified Mercalli intensity) IV or less typically are associated with accelerations of less than 0.05 g (Coulter et al. 1973; Krinitsky and Chang 1977), and likely would not have produced detectable physical effects in the soil and rock materials encountered at the site.

A.3.6.2.3 Engineering Properties of Materials Underlying the Site

The engineering properties of on-site subsurface materials are discussed in Section A.3.6.4.2.

A.3.6.2.4 Earthquake History

Numerous analyses of seismicity within the WVDP site region have been performed both for project purposes and for requirements of nearby critical facilities by federal and state agencies, private consultants, and university researchers. This subsection summarizes the results of these studies.

From 1737 to 1999, there have been 119 recorded earthquakes within 480 km of the WVDP with epicentral intensities of MMI V to MMI VII; their geographic distribution is shown on Figure A.3.6-1. Of the 119 events shown, 25 occurred within 320 km of the WVDP. Dates, locations, intensities, and magnitudes (where available) of these events are listed on Table A.3.6-2 (Chiburis, 1981).

Assuming that MMI II is the limit of perceptible ground motion, all earthquakes listed in Table A.3.6-2 with epicenters within 210 km of the WVDP could have been felt at the WVDP. Based on the published eastern United States attenuation curve (Fig. A.3.6-2), six MMI V earthquakes could have been felt at the site since 1840, and all nine MMI VI events within 320 km of the site could have been felt at the site.

Figure A.3.6-2 also suggests that all MMI VII events that occurred within 480 km of the site could have been felt at the WVDP and that the 1871 and 1954 shocks could have been felt as MMI III at the site.

The only historic earthquakes within or near the site region known to have produced intensities higher than MMI III at the site were the 1929 Attica shock and the 1944 Cornwall-Massena shock. Both of these earthquakes produced an estimated MMI IV at the site.

The Cornwall-Massena shock (MMI VIII) occurred on September 5, 1944, at 12:39 a.m. The epicenter was 430 km east-northeast of the site, at 74.7°W, 45.0°N, midway between Cornwall, Ont., and Massena, N.Y. The shock was felt in an area of 450,000 sq km in the United States (see Fig. A.3.6-3). This earthquake was evaluated in 1983 by the Niagara Mohawk Power Corporation. Losses resulting from it amounted to two million dollars. At Massena, the shock destroyed or damaged 90% of the chimneys. Masonry, plumbing, and house foundations were damaged, windows were broken, and many structures were rendered unsafe for occupancy. Many wells in St. Lawrence County, N.Y., went dry, and water levels were affected in streams and wells as far away as Westchester County and Long Island, N.Y. Fourteen aftershocks were noted by November 1, 1944. The strongest, on September 9, 1944 at 7:25 p.m., was nearly equal to the intensity of the main shock. The WVDP site would have undergone shock intensities of IV or less.

The 1929 Attica earthquake occurred on August 12, at 6:25 a.m., about 48 km northeast of the WVDP. The epicenter was at 78.4°W, 42.9°N. The affected area of 130,000 sq km included parts of Canada. The shock was felt most strongly in the eastern part of the city of Attica and in the region immediately east of Attica (see Fig. A.3.6-4). In the region immediately to the south of the epicenter, there was less effect on structures, but changes in groundwater conditions were noted.

The shock was accompanied by sounds compared to thunder. In Attica, reportedly 251 house chimneys collapsed or were damaged, and cracked walls and fallen plaster were common. Objects were thrown from shelves, monuments in cemeteries were toppled, and a number of wells went dry. The degree of damage to structures generally could be related to the type of design and construction. For example, three churches and a school within one city block were damaged to significantly different degrees. The

Attica High School, a new, well-constructed, three-story building had damage limited to minor plaster cracking. Damage to the Westinghouse factory southeast of the city was greatest in the east-west wing of the T-shaped brick building due to the collapse of a brick chimney. On the basis of this damage, Dames & Moore (1974) assigned an epicentral intensity of VII and a magnitude m_b = 5.2 to the 1929 Attica event.

Shocks smaller than the 1929 Attica event have occurred frequently in the Attica area (December 1929, 1939, and 1955; July and August 1965; January 1966; and June 1967). The largest of these were the two most recent events, each reported as being MMI VI in the epicentral area. These shocks probably resulted in intensities of III or less at the WVDP.

The Attica shock of January 1, 1966 (MMI VI) occurred at 8:24 a.m., and foreshocks of similar intensity occurred at 5:30 a.m. and 6:30 a.m. The shocks were felt over 9,000 sq km of western New York, northwestern Pennsylvania, and southern Ontario, and the main shock was most strongly felt at Varysburg, about 13 km southwest of Attica. The Attica shock of June 13, 1967 (MMI VI) occurred at 2:09 p.m., and was felt over an area of about 8,000 sq km (3,000 sq mi) in western New York. Slight damage was sustained at Attica and at Alabama, NY, where the shock was felt by many people.

The Buffalo-Lockport earthquake of October 23, 1857, occurred at 3:15 p.m. The epicenter was at 78.6°W, 43.2°N, and the shock affected an area of 46,000 sq km. The epicentral intensity of VI was felt in an area 120 km long, from north-northeast to south-southwest, and 100 km wide. This earthquake was felt at Hamilton, Petersborough, and Port Hope in Ontario and at Rochester, NY, Warren, PA, and Dayton, OH. At Lockport, rumbling noises were heard for a full minute. The shock was felt by many people but caused no serious damage (Niagara Mohawk Power Corporation 1983).

In addition to the 1857 Buffalo-Lockport shock, smaller events occurred in the Buffalo, NY - Hamilton, Ontario, area in 1879, 1944, 1946, and 1962. The March 27, 1962 shock is typical. It occurred at 1:37 p.m., and the epicenter was located near Niagara Falls, NY. The event was accompanied by a loud noise and was felt by many people over a relatively small area. The shock was a maximum of MMI V.

Large distant shocks of record such as the Charleston, S.C., event of 1886, the New Madrid, Mo., events of 1811-12, and the more significant (MMI IX-X) events in the upper St. Lawrence Valley probably produced small effects at the WVDP. Using empirical relationships (Coulter et al. 1973) to correlate MMI with ground acceleration, and considering attenuation, it is concluded that ground acceleration at the WVDP has not exceeded 0.05 g during the last two centuries.

Surficial geologic materials at the site are mainly similar to those in the epicentral areas of the Attica and Buffalo area earthquakes. The only significant geologic difference between the WVDP and the Attica and Buffalo epicentral areas is the thickness of the Paleozoic rock sequence above the granitic basement. At the site area, the crystalline basement is about 600 m lower than it is near Attica and Buffalo (see Fig. A.3.6-5), but no observable differences in the propagation of energy from the Attica or Buffalo area earthquakes are attributable to this difference in depth to basement.

A.3.6.2.5 Correlation of Epicenter with Geologic Structures

The Clarendon-Linden Structure is the only seismogenic crustal feature known to exist in the site region (see Fig. A.3.6-5), and earthquakes in the Attica area generally have been associated with this structure (NMPC 1983; Dames & Moore 1973, 1974, 1983; Van Tyne 1975). Other earthquakes within the site region, including those on the Niagara Frontier, have not been definitely assigned to known geologic structures but have been associated with tectonic provinces. The Clarendon-Linden Structure is discussed in Sections A.3.6.2.6 and A.3.6.2.7. Tectonic provinces are identified below and discussed in TSD A.3.6-C.

A.3.6.2.5.1 Tectonic Provinces of the Site Region

Several studies conducted in the 1970s and early 1980s defined various tectonic provinces as potential seismic source zones. Hadley and Devine (1974) defined seismotectonic provinces based on their interpretation of regional tectonic structure and seismicity. Similar interpretations were presented by New York State Electric and Gas (1979) in a study for a proposed nuclear station at New Haven, N.Y., and by Niagara Mohawk Power Company (1983) in a study for the Nine Mile Point Nuclear Station. Additional seismic source zones have been proposed by the USGS (Algermissen et al. 1976) and various other authors. A study by Dames & Moore (1983) on the seismic exposure of the WVDP reviewed and evaluated various concepts of tectonic provinces and presented digitized models of the concepts. That review and analysis is summarized in TSD A.3.6-D.

A.3.6.2.6 Identification of Active Faults

In several investigations, the Clarendon-Linden Structure has been associated with seismicity near Attica, N.Y. (see Section A.3.6.2.5). The 1929 Attica earthquake (MMI-VII) was centered near a complex portion of the Clarendon-Linden Structure (see Section A.3.6.2.4 and Fig. A.3.6-5). An array of seismic stations operated by the Lamont-Doherty Geological Observatory of Columbia University and designed to accurately locate events in the Buffalo-Attica region has been monitoring earthquake activity in the Attica area since 1971. A number of small naturally occurring events with magnitudes generally less than m_b = 3.0 have been reported (Fletcher and Sykes 1977; Sbar and Sykes 1973). A swarm of microseismic events also occurred during the summer and fall of 1971. That activity correlated well in time and space to the injection of water under high pressure into a brine well (Van Tyne 1975) and was localized along the strike of the Clarendon-Linden Structure, indicating that the fluid injection triggered the release of tectonic stress that had accumulated on the fault. Much of the natural and induced activity has occurred within the triangular area bounded by the main Clarendon-Linden Structure and the southwestward-directed splay in the Attica-Dale area (Dames & Moore 1974).

Focal mechanism solutions of two earthquakes that occurred near Attica in 1966 (m_b = 4.6) and 1967 (m_b = 4.4) (Hermann 1978), and a composite focal mechanism solution of earthquake swarms near Attica (Fletcher and Sykes 1977) indicate a combination of right-lateral strike-slip and reverse faulting on planes parallel to the northerly trend of the Clarendon-Linden Structure. Hermann computed focal depths of 2 to 3 km for the 1966 and 1967 Attica events. The events analyzed by Fletcher and Sykes occurred at depths of less than 1 km and were thought to be related to hydraulic mining of salt at a depth of 0.5 km.

There has been no known surface movement along the trace of the structure as a result of earthquakes, but basement-involved faulting and the distribution of seismic activity indicate that the Clarendon-Linden Structure is active in the geologic sense.

A.3.6.2.7 Description of Capable Faults

In the absence of surface offset, the Clarendon-Linden Structure cannot be considered "capable" in the strict sense of the 10 CFR 100 Appendix A definition. However, evidence at hand indicates that the structure is certainly capable of generating earthquakes. Consequently, this analysis makes the conservative assumption that the Clarendon-Linden Structure is "capable" and as such, should be considered in defining the maximum earthquake for the WVDP.

The Clarendon-Linden Structure extends about 90 km southward from Lake Ontario to Bliss, NY, 37 km east-northeast of the WVDP. The Clarendon-Linden Structure was initially described (Chadwick 1920) as a north-trending normal fault extending from the Niagara escarpment near Clarendon, NY, on the north to Linden, NY, on the south, a distance of some 40 km. Chadwick found surficial displacement of the Onondaga and Niagara escarpments, with the western side displaced to the north relative to the eastern side, and in the vicinity of Linden he observed stratigraphic offset to indicate down-on-the-west displacement. Chadwick, therefore, concluded that the feature was a fault, downthrown on the west. Subsequently, Chadwick (1932) redefined the feature as a monocline at the Linden end and a fault at the Clarendon end, and termed the entire structure the Clarendon-Linden Displacement.

Since 1932, numerous studies intended to characterize the development, geometry, and seismogenic potential of the Clarendon-Linden Structure have resulted in an extensive literature on this feature. These efforts have been traced and summarized in previous Safety Analysis Reports, and have been reviewed and summarized for the present SAR in TSD A.3.6-A, under the heading Regional Structure.

A.3.6.2.7.1 Current Interpretation of the Clarendon-Linden Structure

The Clarendon-Linden Structure is presently considered to be a complex steeply dipping fault zone comprising at least three and as many as six steeply dipping en echelon fault planes. Displacement is either reverse or normal on individual faults and net displacement is down on the west. Displacement is clearly expressed in that part of the section beneath the Salina salt zone and in the Grenville basement, but is obscure, if present, in the overlying Devonian sequence. Seismic activity seems to have centered historically on the Attica area, probably due to the intersection there of the southwestward-trending Attica splay and the main fault zone (see Fig. A.3.6-6). Alternatively, an east-west structural trend related to historical seismicity on the Niagara Frontier might account for localization of seismic activity at Attica.

The Clarendon-Linden Structure presently is thought to extend northward into southern Ontario, Canada, and southward into central Allegheny County, N.Y., where it has been tentatively mapped as intersecting the outermost known structures of the Appalachian fold belt.

A.3.6.2.7.2 Relation to Regional Tectonics

Crustal stress on a continental scale has been described by Haimson (1977), Plumb and Cox (1987), Evans (1989), and Zoback and Zoback (1980, 1989). Figure A.3.6-7 shows the generalized stress provinces of the United States as defined by Zoback and Zoback (1989). The WVDP is located in the mid-plate province. Results of these studies show a consistent ENE-WSW trending compressive stress in the northeastern region of this province. The areal extent of this trend in a variety of lithologies at shallow depths, and the consistency with the orientation proposed by plate tectonic models, suggests that the maximum principal horizontal stress is the result of contemporary tectonic processes (Sbar and Sykes 1973). Evans (1989) states that the observed stress is indicative of stress field conditions at greater seismogenic depths in those cases where a major structural detachment is absent.

Some areas locally anomalous to this trend have been suggested. Well hydrofracture measurements in the Devonian section of Western New York suggests that the maximum stress orientation is aligned with the predominantly E-W structural trend, (Evans 1989). Maximum compressive stress in the deeper Silurian section has also been shown to be oriented approximately E-W (Evans 1989; Fletcher and Sykes 1977). The stress orientation of Fletcher and Sykes was determined from composite focal mechanism solutions for earthquakes associated with the Clarendon-Linden Structure, giving a thrusting mechanism. This is consistent with the ENE/E compressive trend in the mid-continent, but apparently skewed towards an alignment with the local structure in western New York. A comparison of the stress orientation in Paleozoic rocks versus that of the basement has not shown the difference to be statistically significant (Evans 1989).

No direct measurement of stress in basement rocks is available for the western New York area. Earthquake focal mechanism solutions for events ranging in depth from 2.5 to 12 km consistently show strike-slip motion on near-vertical fault planes with NE or ENE trending axes of maximum compressive stress. A hydrofracture stress measurement taken on the northern shore of Lake Ontario corroborates the stress orientation determined by focal mechanism solutions (See Figure A.3.6-8). The orientation of the observed horizontal stress field is a relatively recent phenomena, at most Mesozoic in age. While the magnitude of the stresses may have changed over intervening geologic time, it is likely that the orientation has remained relatively constant.

The origin of the stress field is related directly to forces responsible for the last opening of the Atlantic Ocean. Computations of intraplate synthetic stress fields based on mathematical modeling of plate motions indicate that the present stress field within lithospheric plates, including eastern North America, is primarily generated as a response to the driving mechanisms of plate tectonics. The relative motion of a plate with respect to the asthenosphere (100 km - 350 km in depth) results in a viscous drag at the base of the plate. When considered in combination with the driving force at the spreading center and the pulling forces at the convergence zone, these factors constitute a system of forces acting on the lithosphere which induce the global intraplate stress field. This stress field would be characterized by a nearly horizontal major principal stress oriented approximately parallel to the spreading direction. In the case of the North American plate, the stress vector would trend approximately northeast-southwest, coincident with the observed direction (Zoback and Zoback 1989; McWhorter et al. 1986). The uniform presence of this stress field in rocks of different ages and structural settings indicates that residual or remnant tectonic stresses, those remaining in the bedrock from past tectonic episodes, is not a significant component of the existing stress field.

In addition, there does not appear to be any direct correlation between the areal distribution of the stress regime and those areas subjected to Quaternary glaciation except in some areas adjacent to the margin of maximum ice advance where crustal downwarping would have been the greatest.

The site, and the Clarendon-Linden Structure, lie within the mid-plate stress province (Zoback and Zoback 1989) characterized by NE-SW compressive stress. The geometry of the fault with respect to the inferred regional stress field results in a potential for reactivation which is both favorable and unfavorable. The strike of the fault would imply that reactivation is possible under the applied stress, but the dip of the component faults are relatively steep for reverse type faulting to occur. Strike-slip faulting would be expected in the regional stress field. Focal mechanism solutions of the 1966 and 1967 Attica events, determined by Herrmann (1978), show either approximately N-S right-slip, with a component of down-to-the-east thrusting, or E-W left-slip. Because of the elongation of the hypocentral areas, as a result of the 1971 fluid injection-induced earthquakes parallel to the N-S Clarendon-Linden Structure, the right-slip solutions appear to represent the actual fault plane. Although these focal mechanisms are consistent with the movement expected given the regional stress field and observed subsurface offset of the Clarendon-Linden Structure, it is not clear how they relate to ongoing vertical glacial rebound. Review of precision survey lines (Dames & Moore 1978) indicates that the site area is tilting southward at about 2 mm/year. Given the pattern of tilting, an up-to-the-east, largely normal motion on the Clarendon-Linden Structure would be expected if it is a result of glacial rebound. Based on available data, it appears that deviatoric stress from rebound must be small in relation to the NE-SW horizontal compressive stress.

The Clarendon-Linden Structure is intersected by two cross-cutting features. Diment et al. (1980) have proposed a northwesterly trending geophysical lineament based on a few gravity and magnetic highs, and on the termination, offset, or flexure, of some gravity and magnetic trends. The southwest trending Attica splay and the lineament of Diment et al. (1980) both intersect the main N-S trend of the Clarendon-Linden Structure in the vicinity of Attica where historical seismicity has been concentrated. A study by Hildenbrand et al. (1982) has shown a circular gravity anomaly near Attica which suggests a deep perturbation.

A.3.6.2.8 Maximum Earthquake

The assessment of seismic hazard to DOE non-reactor nuclear facilities has commonly drawn on the techniques and terminology borrowed from the commercial nuclear power industry. This practice is reflected in the use of the superseded terms Maximum

Earthquake, Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE). These terms are defined in 10 CFR 100 Appendix A and referenced in NRC Regulatory Guide 3.26.

The maximum earthquake is a deterministic assessment based on the greatest intensity or magnitude historic earthquakes that have been correlated with tectonic structures close to the site or tectonic provinces in which the site is located. The design vibratory ground motion at the site, specified as the SSE and OBE, is determined from the maximum earthquake.

Three maximum earthquakes have been considered:

- the maximum event associated with a tectonic structure (the Clarendon-Linden Structure);
- the maximum event within the site tectonic province not assigned to a specific structure; and
- the maximum event exterior to the site tectonic province.

The Clarendon-Linden Structure, the seismic source zone closest to the site, is the dominant contributor to the seismic hazard at the site.

The Safe Shutdown Earthquake (SSE) is that earthquake which produces the maximum vibratory ground motion for which certain structures, systems and components are designed to remain functional. This level of ground motion is generally that expected from either the largest historic earthquake within the tectonic province in which the site is located, or that determined from an assessment of the maximum earthquake potential of the closest tectonic structure or capable fault. The SSE has been superseded by the Design Basis Earthquake (DBE).

The Operating Basis Earthquake (OBE) was developed as a design basis for safety related structures, systems and components at a code allowable level. In current DOE design criteria only a single earthquake, the DBE, is used.

A.3.6.2.8.1 Clarendon-Linden Structure Maximum Earthquake

The 1929 Attica earthquake is the maximum historic earthquake associated with the Clarendon-Linden Structure. This earthquake had an epicentral intensity of MM VII, as discussed in Section A.3.6.2.4, and an estimated magnitude of m_b = 5.2 (Dames & Moore 1974).

The approach used in the analyses for the proposed expansion of the NFS facility (Dames & Moore 1970, 1971) was to assume that the maximum earthquake would be one intensity unit (or one half magnitude) greater than the maximum historic earthquake. At that time, the 1929 Attica earthquake was considered to be an MMI VII-VIII event. That event was projected to the nearest location of the Clarendon-Linden Structure to the site (37 km). Using then-current attenuation relationships, Dames & Moore (1971) estimated that such an event would produce 0.12 g peak horizontal ground acceleration at the WVDP. That value was recommended as the SSE acceleration in the NFS Safety Analysis Report (1973).

Subsequent analyses have shown that the 1929 Attica event was more likely an intensity VII earthquake corresponding to a magnitude of m_b = 5.2. If the maximum earthquake is assumed to be one intensity unit greater than the maximum historic earthquake, then the maximum earthquake for the Clarendon-Linden Structure would be an intensity VIII event with a magnitude of 5.7 to 5.8.

Attenuation of the MMI VII Attica earthquake was at least 1.5 intensity units over 40 km (see Figure A.3.6-2). In the direction of the site, the attenuation was approximately 2.5 intensity units over the distance from the epicenter to the site. Attenuation of this magnitude is typical of shallow earthquakes in the mesoseismal area. If the minimum attenuation of the 1929 Attica earthquake is used (see Figure A.3.6-2), an epicentral intensity of VIII on the Clarendon-Linden Structure would be attenuated to an intensity of VI-VII at the site, 37 km west of the fault zone. This intensity (i.e., MMI VI-VII) corresponds to a peak horizontal acceleration of approximately 0.12 g for average foundation conditions (Coulter et al. 1973). This acceleration value is in agreement with an estimate of 0.1 g sustained maximum horizontal acceleration (three cycles), based on attenuation of an m_b = 5.75 event at a distance of 47 km, using Nuttli's (1979) relationship for the eastern United

States. Other appropriate attenuation relationships suggest similar site ground accelerations:

Housner (1965)	0.13 g
Schnabel and Seed (1973)	0.13 g
Algermissen and Perkins (1976)	0.10 g
Nuttli and Herrmann (1981)	0.12 g
Dames & Moore (1971)	0.12 g
Nuttli, Newmark-Hall (1986)	0.14 g
McGuire et al. (1988)	0.10 g

A.3.6.2.9 Design Basis Earthquake

This section provides a summary of the seismic hazard analyses of the WVDP site going back to the original design of the reprocessing facility in the early 1960's. Further details are provided in TSD A.3.6-E.

A.3.6.2.9.1 Original Design Earthquake

At the time of the NFS plant construction (1964), no specific seismic standards had been established for nuclear fuel reprocessing facilities. In lieu of these standards, the seismic zone maps of the 1961 Uniform Building Code (UBC) were used and the facility designed to the requirements of the 1961 UBC for Seismic Zone 3.

A.3.6.2.9.2 NFS Upgrade Maximum Earthquake

In the early 1970's NFS planned to expand the reprocessing operation and sought an operating license from the NRC under 10 CFR 50. Following the criteria outlined in 10 CFR 50, analyses were made to define the Maximum Earthquake, the SSE (determined to be 0.12 g) and the OBE. However before the license was approved, NFS withdrew from the reprocessing business and no designs were completed using this criteria.

A.3.6.2.9.3 WVDP Design Basis Earthquake

The WVDP Design Basis Earthquake (DBE) was established in 1983 using a probabilistic assessment. The WVDP adopted a DBE having a horizontal peak ground acceleration

(PGA) of 0.10 g. The probabilistic assessment (Dames & Moore 1983c) of the seismic hazard to the site was consistent with then-current analyses for a typical nuclear power plant in the eastern United States. Using the site median seismic hazard curve (Figure A.3.6-10), the annual probability of exceeding the DBE peak ground acceleration of 0.10 g is 5. x 10^{-4} /year.

A.3.6.2.9.4 Design Basis Earthquake Response Spectra

The WVDP Design Basis Earthquake (DBE) established a peak ground acceleration (PGA) of 0.10 g horizontally and 0.067 g vertically and is quantified in engineering terms using the US Nuclear Regulatory Commission (NRC) Regulatory Guide 1.60 response spectra (Figure A.3.6-11). The use of this spectra is conservative as the NRC spectra is a mean plus one sigma spectra, yet UCRL 15910 allows the use of a median spectra. The NRC spectra is also likely to be more conservative than a site specific response spectra that could be developed.

A.3.6.2.9.5 Re-evaluation of Design Basis Earthquake

DOE guidance (e.g. DOE Order 5480.28) required a review of the state-of-the-art of natural phenomena hazard (NPH) assessment methodology and of site-specific information every 10 years and a recommendation made on the need for updating the existing NPH assessments based on the identification of a significant change.

The ground motion hazard at the WVDP was evaluated (Dames & Moore January, 1995) based on information in publications by the Electric Power Research Institute (EPRI) and by Lawrence Livermore National Laboratory (LLNL) pertaining to seismic hazard analyses of nuclear power plant sites in the central and eastern United States. In particular, the data in these publications relevant to the seismic hazard at the closest nuclear power plant (Ginna) to the WVDP site were reviewed. Using these publications, the results of a 1992 study by Dames & Moore that applied the EPRI hazard analysis methodology, and the guidance of DOE Standard 1024, the PGA at the 1 x 10^{-3} and 5 x 10^{-4} annual probabilities were estimated to be 0.053 g and 0.078 g, respectively. By DOE guidance, the minimum PGA required is 0.10 g.

The 1 x 10^{-3} annual probability associated with the ground-motion hazard was required under DOE Order 6430.1A as specified in UCRL-15910 (Kennedy et al., 1990); this probability pertains to Use Categories of DOE facilities designed as "Moderate Hazard". The WVDP is categorized as a Moderate Hazard facility. The 5×10^{-4} annual probability is recommended in the recent DOE-STD-1020-94 for Performance Category 3, which corresponds to the Moderate Hazard category in UCRL-15910.

A.3.6.3 Surface Faulting

Neither geologic nor geophysical studies have revealed evidence of faulting at the site. A summary of faulting on a regional and site basis is presented in Section A.3.6.1.1.4 and the topic is discussed at greater length in TSD A.3.6-A.

A.3.6.3.1 Geologic Conditions at the Site

Details of the stratigraphy, structure, and geologic history of the site are presented in TSD A.3.6-A. Lithologic, stratigraphic, and structural geologic conditions at the WVDP and surrounding areas also are discussed in TSD A.3.6-A.

A.3.6.3.2 Evidence of Fault Offset

Detailed geologic mapping and subsurface investigations conducted at and near the WVDP have revealed no evidence to suggest that the Paleozoic bedrock is faulted. The Site Structure portion of TSD A.3.6-A contains a discussion of glacial "pop-ups" and other shallow-seated structures that are known to occur in the site region.

A.3.6.3.3 Identification of Capable Faults

Capable faults as defined in Appendix A of 10 CFR 50 are not recognized in the site vicinity. No faults have been identified within 8 km of the site, and no historic earthquakes have been focused within 24 km of the site. The nearest documented fault is associated with the Clarendon-Linden Structure, about 37 km east of the site. The Clarendon-Linden Structure and further details on regional faulting and earthquakes are discussed in Section A.3.6.2 and in TSD A.3.6-A

A.3.6.4 Stability of Subsurface Materials

This section discusses geologic features and processes that could have an impact on the integrity and longevity of on-site structures and facilities and summarizes the results of field and laboratory tests conducted to determine the engineering properties of the geologic media at the site. The geology of the WVDP, including its physiography, stratigraphy, and structure, is described in TSD A.3.6.A; features and processes with implications for plant safety are discussed briefly in Section 3.6.4.1; and engineering properties are presented in Section 3.6.4.2.

The discussion of features and processes is based on the results of regional and on-site drilling programs, regional aeromagnetic and Bouguer gravity surveys, surface geophysical surveys conducted on-site, geologic field mapping, and photogrammetric analyses of the region and the site area. All known seismic-tectonic elements and trends in the region are indicated in Figure A.3.6-12. Most of the engineering data were generated from samples recovered during numerous drilling programs conducted at the WVDP since 1963. A chronology of drilling activities at the site is provided in Table A.3.6.1. Geologic logs for most of the boreholes listed are provided in either TSD A.3.6-B or USGS Open-File Report 83-682 (Bergeron 1985).

A.3.6.4.1 Geologic Features

Potential for Land Subsidence

Subsidence is the settlement of the earth's surface with little or no horizontal motion. Subsidence typically occurs when solids or fluids such as salt or groundwater are removed by natural or artificial processes. Lack of support may then lead to collapse of the overlying sediments and the formation of depressions (i.e., sinkholes) at the land surface. This process is not likely to occur at the WVDP because the shallowest rock unit susceptible to solution by groundwater, the Onondaga Limestone, occurs at depths greater than 600 m at the site and because the overlying few hundred meters of shale and siltstone are typically chemically stable and do not contain economically significant mineral resources.

Mass movement (i.e., landsliding) is the principal agent of landform modification in the Buttermilk Creek drainage basin. An historical account of mass movement and active landsliding within the site area are presented in Section A.3.6.5 and in TSD A.3.6-A.

Neither bedrock nor surficial deposits are considered to be regional aquifers and neither possesses characteristics to suggest the presence of economic mineral deposits. The shale bedrock has poor primary permeability and produces very limited quantities of water from shallow-seated joints and fractures. The glacial deposits are discontinuous and therefore not suitable for large-scale withdrawal of groundwater. The possibility of subsidence as a result of fluid withdrawal is considered remote. The distribution of and demands upon groundwater in the site area are discussed in TSD A.3.6-A under Regional Groundwater, and in Section A.3.5 of this volume.

Deformational Zones

Two photogrammetric analyses have been conducted to determine the presence in the Buttermilk Creek drainage basin and beyond of lineaments that might indicate persistent discontinuities in bedrock. The results of these analyses are presented in TSD A.3.6-A under Site Structure and Regional Structure. Geologic mapping within the Buttermilk Creek drainage basin and geophysical surveys conducted on the WVDP have provided no evidence to indicate the presence of either warping or faulting in either bedrock or overburden.

Weathered Zones

Weathered zones at the WVDP include: 1) the uppermost three meters of the Lavery till where that unit is exposed, as it is in the southern sector of the site; and 2) a zone of broken and saprolitized shale ranging to 2 m or more in thickness that occurs at the top of bedrock.

The uppermost Lavery till is characterized by several sets of intersecting fractures, both horizontally and near-vertically disposed, that impart distinctive hydrologic and engineering characteristics to the zone. Similarly, uppermost bedrock is jointed and fractured to the extent that it, too, has hydrologic and engineering characteristics much different than the underlying shale sequence. Additionally, each of the zones has been weakened by chemical decomposition.

The weathered and fractured till is described in detail in TSD A.3.6-A under Site Structure and Geochemical Characterization, and its engineering properties are described in Section A.3.6.4.2. As the uppermost unit across much of the WVDP, its thickness distribution is well documented.

Bedrock disintegration and decomposition probably occurred mainly prior to Pleistocene time and glacial advance very likely removed much of the weak rock. The distribution and thickness variation of this zone remains largely unknown because of the presence in most places of glacial overburden. Throughout the site area, however, shallowest bedrock is assumed to be relatively weak and, in its hydrologic properties, relatively transmissive. The significance of this zone is discussed in Section A.3.5, and in TSD A.3.6-A under Regional Hydrostratigraphy.

In Situ Stress

In situ stress measurements made in recent years in the Eastern United States, include two measurements taken near Niagara Falls and Rochester. Both of these indicate that the maximum in situ compressive stress in the region is on the order of 6,900 kiloPascals (kPa). Although similar determinations were not made at the site, in situ stress in bedrock at the WVDP probably is quite similar to the listed values. Based on the available stress data and site geologic information, the unrelieved residual stress at the WVDP is too small to compromise plant structures. The regional stress field is indicated in Figure A.3.6-7.

Soil/Rock Stability

A complete description of the geomechanical properties of the geologic media in the building areas is presented in Section A.3.6.4.2. As documented in TSD A.3.6-F, the soils are not prone to liquefaction under ground motions developed by the Design Basis Earthquake.

A.3.6.4.2 Properties of Underlying Materials

Supplemental information on physical properties of underlying materials can be found in WVDP-EIS-004, Part 3.

A.3.6.4.2.1 Laboratory Testing

The results of geotechnical tests performed in conjunction with subsurface studies conducted at the WVDP through 1983 are summarized below and are presented fully in Tables A.3.6-3 through A.3.6-5; the borehole logs are contained in TSD A.3.6-B. The locations of the referenced boreholes are illustrated on the plot plans (Figures A.3.6-13 through A.3.6-15).

A.3.6.4.2.2 Index Properties

Moisture and density were routinely measured for all soil samples submitted for laboratory analysis. Determinations also were made for additional selected samples not otherwise tested for purposes of correlating parameters. All tests were run in accordance with ASTM test designation D2-216. The results of these tests are shown in Table A.3.6-3.

Atterberg Limit Determinations

Soil samples were tested to evaluate their plasticity characteristics - liquid limit, plastic limit, and plasticity index - in accordance with ASTM test designation D-2216. The results of these tests were used primarily for purposes of classification and correlation. The Atterberg limits are presented in Table A.3.6-3.

Of the 36 tests performed, 29 (80%) resulted in a classification of the fraction passing the Number 40 sieve as Cl - inorganic clays of low to medium plasticity. The remaining seven tests resulted in classifications of CL-ML or ML, indicating somewhat siltier materials. These classifications are consistent with determinations made visually in the field and entered on the field logs. For many of the samples, proportions of coarser grain-size classes—sand and gravel—were determined by particle-size analyses (see below).

Specific Gravity

Tests to determine specific gravity of soils were performed on ten samples in accordance with ASTM test designation D-854. The results are presented in Table

A.3.6-3. Specific gravity values obtained range from 2.65 to 2.75 and had an arithmetic mean of 2.71.

Particle Size Analyses

Particle size analyses were performed on representative samples of site soils in accordance with ASTM test designation D-422-63. The results (provided in TSD A.3.6-G) have been synthesized in Figures A.3.6-16 through A.3.6-22. These reveal the pronounced textural uniformity of the Lavery till, that the till is characteristically a gravelly mud (gM), and that the alluvial and fluvial deposits on and near the plant site are muddy gravels (mG) and muddy sandy gravels (msG).

Strength Tests

Direct Shear Tests. Direct shear tests were performed on eight samples using the method described in TSD A.3.6-H. The test results (Table A.3.6-3) indicate dense soils and high angles of internal friction where gravels predominate.

Unconfined Compression Tests. Four unconfined compression tests were run on samples of unweathered clayey soils taken at depths of 6 to 14 meters and on one sample of a silty soil taken near the surface (1.5 m). The procedure is described in TSD A.3.6-H. The results (Table A.3.6-5) correlate well with density in that both sets of data indicate that the tills are stiff to very stiff materials.

Triaxial Compression Tests. The results of fourteen triaxial compression tests performed on samples of slightly gravelly clayey soils (GCS) are presented in Table A.3.6-5.

Consolidation Tests

Consolidation tests were performed on six samples of clayey soils found in the plant area. The test method is provided in TSD A.3.6-H. Samples were selected from various depths to provide a profile of compressibility characteristics. The results are presented in TSD A.3.6-I. An evaluation of the data indicates that preconsolidation pressures resulting from glacial loading are in excess of 479 kPa.

Hydraulic Conductivity Tests

The vertical hydraulic conductivity (K_v) of representative undisturbed foundation soils at the site was determined by constant head and falling head tests. In addition, constant head tests were performed on samples prepared in the laboratory by compacting these samples at the optimum moisture content determined from compaction tests. The results of the laboratory tests are summarized in Table A.3.6-6.

In addition to the foregoing tests, the USGS and the New York State Geological Survey have performed a number of laboratory and in situ hydraulic conductivity tests in the vicinity of the SDA. The results of these tests are presented in Section A.3.5 and in TSD A.3.5-C.

A.3.6.4.3 Plot Plan

The locations of most of the borings drilled for the various geotechnical studies are shown on the Plot Plan (Figures A.3.6-13 to A.3.6-15, and A.3.6-16b). The nine borings shown in Figure A.3.6-16b are located near the Bulk Storage Warehouse, in the southeastern section of the WNYNSC. Figures A.3.6-16a to A.3.6-22b present borehole locations and corresponding ternary plots of sample particle size distributions. Three subsurface sections have been developed for the plant area (Fig. A.3.6-23 through A.3.6-25). The locations of these sections are indicated on Figure A.3.6-13.

An additional seven (7) borings were drilled in the vicinity of the main plant during 1991 to support utility room and sewage treatment expansions (Dames & Moore, 1991b and 1991a).

A.3.6.4.4 Soil and Rock Characteristics

Supplemental information on soil and rock characteristics can be found in WVDP-EIS-004, Part 3, as well as WVDP-EIS-009, Part 4.

A.3.6.4.4.1 Static Soil Characteristics

The foundation soil for the reprocessing plant is the Lavery till - a dense, compact, stable, impervious material. It will maintain a satisfactory condition when subjected to design static loading during the economic life of the plant. This evaluation is based on the summarizations entered below.

General

The average field moisture content is 18% and the average specific gravity is 2.70. The overall liquid limit is 28, the plastic limit is 17, and the plasticity index is 11. The in situ dry density generally ranges from 1.78 g/cc to 2.03 g/cc, with extremes of and 1.27 and 2.18 g/cc. The estimated field relative density is between 40% and 100%. The Unified Soil Classification for most of the material is either CL or ML.

Strength

The laboratory static shear strength of the clayey soil ranges from 35.9 kPa to 213.2 kPa. Based on the isotropically consolidated undrained test results, an undrained strength envelope was developed (Figure A.3.6-26). The field standard penetration blow counts (N) ranged from 7 to refusal, with most blow count values falling between 20 and 60. The relative density of the cohesionless alluvial soil on the North Plateau was evaluated by means of these standard penetration tests. The results of the standard penetration resistance plotted against relative density as a function of overburden depth are presented on Figure A.3.6-27. Based on the correlation between standard penetration resistance and relative density developed by Gibbs and Holtz (1957), the relative density for the upper layer of gravelly soils ranges from 45 to 90% and typically exceeds 70%. For the lower layer of gravelly soil, the relative density is on the order of 90% or more. The material therefore can be considered as stiff to hard with occasional medium stiff layers. The dynamic test data also indicate that the material has very high dynamic strength.

Compressibility

As determined from consolidation tests, the compression ratio of the clayey soil is about 0.07, except at the surface of the dam site, where it is 0.21. The compression ratio (estimated from the empirical formula) ranges from 0.05 to 0.16. The compressibility of the underlying clayey soil therefore can be considered small and most settlement should occur during construction and within one year following the emplacement of structural loads.

Hydraulic Conductivity

The in situ hydraulic conductivity of the clayey material is 1.37 x 10^{-8} cm/sec. The average hydraulic conductivity is 3.9 x 10^{-8} cm/sec when the same material is compacted at optimum moisture content. This material therefore can be considered relatively impervious.

A.3.6.4.4.2 Dynamic Soil Characteristics

A seismic survey conducted in 1963 by the NYSGS revealed that the overburden compressional wave velocities ranged from 1,646 m/sec to 1,920 m/sec. The lower velocities were measured in the deeper portion of the valley along its axis, while the higher velocities were measured along the valley flanks where the site is located. No shear wave information is available.

In 1971, Dames & Moore performed dynamic laboratory tests on samples of site soils in order to analyze the soil-structure interaction (Dames & Moore, 1971a). A sample of the soil was subjected to a steady-state torsional, sinusoidal, forcing function. The frequency of the applied force was varied until the resonant frequency of the soil system was obtained. From these data, the velocity of shear wave propagation and the modulus of rigidity (shear modulus) were computed. Using an empirical value for the dynamic Poisson's ratio, values for the modulus of elasticity and the vertical spring constant and vertical subgrade modulus were estimated. Dames & Moore recommended the following parameters for use in foundation studies at the plant site:

Silty gravel:

Modulus of Elasticity	$E = 6 \times 10^6$ pounds per square foot (psf)
Modulus of Rigidity (Shear Modulus)	$G = 2 \times 10^6$ psf
Vertical Spring Constant	$k_y = 5 \times 10^6 \sqrt{BL}$ lb/ft
Vertical Subgrade Modulus	$S_y = \frac{5 \times 10^6}{\sqrt{BL}}$ lb/ft^3
Poisson's Ratio	$\mu = 0.4$

Clayey till:

Modulus of Elasticity	$E = 11 \times 10^5$ psf
Modulus of Rigidity (Shear Modulus)	$G = 4 \times 10^5$ psf
Vertical Spring Constant	$k_{zx} = 2$ to $5 \times 10^6 \sqrt{BL}$ lb/ft
Poisson's Ratio	$\mu = 0.4$

A geotechnical investigation (Dames & Moore, 1992a) was performed during 1991-92 to assess dynamic soil properties for the High Level Waste Transfer System (HLWTS) at the WVDP. The dynamic soil properties were to be used in a soil-structure interaction (SSI) analysis as well as seismic wave propagation studies for the trenches, pits, and piping that constitute the HLWTS. Other components that interact with the system include the buried vaults and tanks 8D-1 through 8D-4 and the vitrification facility.

A.3.6.4.5 Excavations and Backfill

Plans and drawings of the excavation and backfill requirements for specific facilities are presented in the facility modules. Drawings for existing facilities are not available in all instances, since such records were not consistently generated and archived.

Structural fill and backfill for Project facilities consist of a 1:1 blend of New York State Department of Transportation Number 1 and Number 2 crushed stone. Pipe bedding consists of clean concrete sand graded as follows:

SIEVE SIZE	PERCENT PASSING
0.953 CM (3/8 INCH)	100
No. 4	95 - 100
No. 8	80 - 100
No. 16	50 - 85

Under prevailing backfill requirements, contractors must remove all debris from the excavation and the backfill must be free of debris and frozen soil. Fill is placed in level layers not exceeding 8 inches in thickness and is compacted to 95% of optimum density, obtained by the modified AASHO method. In situ density is verified by field testing.

A.3.6.4.6 Groundwater Conditions

The groundwater regime at and in the vicinity of the WVDP is discussed in general terms in Section A.3.5, Subsurface Hydrology. Reference is made in Section A.3.5 to hydrologic studies and compilations of hydrologic data in TSD A.3.6-A.

Facility-specific design water levels for analyses of lateral earth pressure and hydrostatic uplift are defined with reference to the groundwater level database contained in Section A.3.5.

A.3.6.4.7 Response of Soil and Rock to Dynamic Loading

Because each Project facility has a different stratigraphic column, a generic site-wide analysis is neither feasible nor indicated. For facilities with design requirements over and above the requirements of the Uniform Building Code, an appropriate geomechanical model is used to analyze the response of soil and rock to dynamic loading. These analyses are presented in the appropriate SAR module.

A.3.6.4.8 Liquefaction Potential

Earthquake-induced soil liquefaction may have potentially damaging effects on the integrity of critical facilities. Soil liquefaction is the transformation of a soil from a solid state to a liquified state as a result of increased pore pressure and the consequential decrease in effective stress. Liquefaction typically occurs in loose, well-sorted, granular soils in combination with a high water table.

The geologic substrate at the WVDP is comprised of, in order of decreasing stratigraphic position:

- A fluvial-alluvial complex consisting of gravels, muddy gravels, and muddy sandy gravels;
- A dense and compact clayey glacial till; and
- A sequence of thinly bedded and fairly well sorted glaciolacustrine sands, silts and clays.

Fluvial-Alluvial Complex

The fluvial-alluvial sequence underlies the North Plateau and the majority of the Project structures. Owing to its age, depth of burial, mode of emplacement, textural properties, and hydrogeometry, the fluvial-alluvial sequence would be more likely to experience liquefaction than other on-site units.

An analysis of the potential for seismically induced liquefaction in the fluvial-alluvial sequence is reported in TSD A.3.6-F. Twenty-eight sample locations were characterized using the methods developed by Seed et al. (1983) and by Liao et al. (1988). These methods compare the blow counts (N-values) generated when driving the sampling tubes into the soil to empirically derived field performance curves. The methods assess the potential for (or probability of) liquefaction given a magnitude m_b = 5.25 event at the site. This magnitude event corresponds to the smallest magnitude earthquake for which the methods have been developed. (It may be that earthquakes of smaller magnitude would not provide the cyclic character necessary to elevate pore pressures to values to cause liquefaction). A magnitude m_b = 5.25 event at the site corresponds to a peak horizontal ground acceleration of 0.15 g - an unlikely event at the WVDP site.

When evaluated by the Seed et al. criteria, only one of the 28 samples was shown to have a moderate probability of liquefaction - given the magnitude m_b = 5.25 event at the site. Using the criteria of Liao et al., seven samples would have a moderate probability (10-30%) of liquefaction, and the remaining 21 samples would have a low probability (< 10%).

Considering the unlikely occurrence of a magnitude m_b = 5.25 event at the site with the moderate probability of liquefaction, earthquake-induced soil liquefaction is extremely unlikely.

Clayey Glacial Till

The clayey (Lavery) till underlies the entire WVDP, including the North Plateau, where it occurs beneath the fluvial-alluvial sequence. The cohesive texture, density, depth of burial, and the blow count (N) values, which are influenced by these properties, indicate that this unit is not susceptible to liquefaction.

Glaciolacustrine Sequence

The liquefaction potential of the glaciolacustrine sequence to seismically induced accelerations is expected to be relatively minor, as the depth at which this unit is found diminishes the potential for liquefaction.

Structural Integrity

On the North Plateau, most of the main plant complex is founded at or slightly below grade. The Fuel Storage Pool (FSP), Cask Unloading Pool (CUP), and several other process cells are founded below grade at elevations as low as 1,368 feet NGVD. All of these structures are founded on groups of steel H-piles driven several tens of feet into the underlying Lavery till and do not bear on the alluvial materials. They therefore would not be affected by liquefaction of the alluvium. The vault containing HLW tanks 8D-1 and 8D-2 is founded in the Lavery till at 1,362 feet NGVD, about 30 feet below the base of the alluvium. Thus, the integrity of tanks 8D-1 and 8D-2 would not be affected by liquefaction of the alluvium. On the South Plateau, the host formation for waste disposal is the Lavery till.

A.3.6.4.9 Techniques to Improve Subsurface Conditions

The site foundation soil capacity has been evaluated (D&M 1963a, 1963b, 1970a, 1971a, 1971b, 1975, 1985a, 1986, 1988, 1990, 1991, and 1991) and found to be adequate to support facility structures. Most of the structures are supported on spread foundations although the very heavy concrete cell structures of the former nuclear fuel reprocessing facility are supported on piles. The design of facility foundations is covered in appropriate design criteria documents. No subsurface improvements are required for the construction of Project facilities.

A.3.6.5 Slope Stability

Landslides provide an active mechanism to headward erosion for altering the landform in Buttermilk Creek Valley, which include the WVDP site. Landslides typically occur on slopes that have a relief of more than 3 m (10 feet). Thus, all currently eroding surfaces except the upland flats have potential for landslide development. Landslides range from 1 m (3 feet) to 20 m (65 feet) in height. Landsliding has been recognized since the mid-1970s along the small streams bordering the burial areas and these streams are of immediate concern to site integrity. Although these streams and their tributary gullies are likely to be the first to negatively impact the closed facilities and burial areas, Buttermilk Creek may also be a long-term factor.

Stratigraphy affects both landslide location and development. Landsliding takes place in the Buttermilk Creek Valley, where the Lavery till unit is dissected and the underlying lower sand and gravel layers (i.e., Kent recessional deposits) are exposed. This lower sand and gravel unit, which is unconsolidated and fails under any erosive action, is removed by stream erosion where meanders in the stream touch the valley wall. This leaves the overlying till unsupported, and collapse follows, bringing down large blocks of the valley wall.

Landslides on the small WVDP streams (Frank's Creek, Quarry Creek, Erdman Brook, and associated gullies) tend to occur as the channel cuts downward through the Lavery till, increasing the steepness of the stream banks. The steep banks, coupled with an increasing overburden load (from the growing forest), result in a series of short slide blocks. The blocks tend to be less than four feet high and occur along the slope from the edge of the plateau to the edge of the stream channel.

Creep occurs on the slopes of Buttermilk Creek Valley and its tributaries, but is a relatively benign condition that usually takes place at relatively slow rates compared to landsliding. A slope may have surface layers a few centimeters thick that move a few centimeters per year. If the surface layers become highly charged with water, the surface may liquify and then move downslope as mudflows. These mudflows occur most frequently in conjunction with landsliding.

Downslope movement of till in the Buttermilk Creek Valley by landslides, slumping, and earthflow appears to be a continuous process measured at an average rate of 1.5 m/yr (5 ft/yr) (Boothroyd et al., 1982). The yearly amount of material delivered to Buttermilk Creek is volumetrically small except when sudden failure by block gliding deposits a large mass onto bars and into the channel. The average volume of material delivered to Buttermilk Creek has been estimated to be 150 m^3/yr (5,250 ft^3/yr).

Previous information derived from the landslide mapping, monitoring, and identified slope domains indicates that an area most susceptible to failure would have a surface slope exceeding 8°; slope material composed of the same silt and clay as the till deposits or alluvial fan material; an active stream channel impinging along the foot of slope; and little or no vegetative cover or heavy overburden. The first site facilities likely to be affected by stream-induced landsliding are lagoons 2 and 3. Except for gully development, the slopes of the burial areas are generally close to a stable angle. As the streams wash the floodplain soils away from those areas, downcutting will recommence and the slopes will eventually become unstable.

The surface slope domains of the WVDP site are shown on Figure A.3.6-28. The slope domains were chosen by inspection of topographic contour density and information from the landslide analysis (Albanese et al. 1984). Five slope domains were identified as follows:

- Slope Domain 1. This domain is characterized by slopes of less than 1° where there are active fluvial channel, bar, and terrace systems or where the topography has been modified by landscaping or filling operations (such as the SDA). The surface topography is flat and it is underlain by fluvial sand and gravel, silt and clay of the Lavery till, or artificial fill of varying composition. Vegetation is moderate and typically consists of various grasses. This domain is not susceptible to landsliding unless immediately adjacent to Slope Domain 4 or if a slope exceeding the critical angle (8°) is created.

- Slope Domain 2. This domain is characterized by slopes from 1 to 2.9° in the Lavery till or distal portions of the North Plateau alluvial fan. The surface topography is hummocky, with poor to moderate drainage, commonly with swamps and ponded water. It is underlain by silt and clay of the till or silty sand of the fan. It is moderately vegetated by swamp grass and shrubs. This domain is generally stable unless modified or immediately adjacent to Slope Domain 4.

- Slope Domain 3. This domain is characterized by slopes from 3 to 8° which are typically composed of the relatively inactive surfaces. The surface topography is gentle, with moderate to good drainage, and is underlain by either sand and gravel or silt and clay that is generally well-vegetated by grasses and shrubs. This domain is stable, although it is prone to landsliding if adjacent to Slope Domain 4.

- Slope Domain 4. This domain is characterized by surface slopes which exceed 8°. The surface topography is steep and irregular, expressing landslide scars, slump blocks, and flow masses. It is adjacent to active drainages and is most often underlain by silt and clay of the Lavery till. It is poorly to moderately vegetated by forest growth, or unvegetated. Landslides occur exclusively within this domain. It is highly susceptible to failure, particularly when unvegetated and impinged upon by active stream channels.

- Slope Domain 5. This domain is characterized by slopes greater than 8° which occur along the lower shoulders or flanks of hills, away from well-organized, active fluvial systems. The surface topography is gentle with well-developed drainage. It is underlain by silt and clay (typically of the Kent till) and is moderately to well-vegetated by grasses, shrubs, and trees. This domain is not prone to failure unless the critical angle is exceeded by cut-and-fill operations or oversteepening.

In defining slope domains, Albanese et al. (1983) tended to place all areas in which the general slope exceeded 8 degrees into slope domains 4 and 5. The current studies at the State-Licensed Disposal Area (SDA) by Dames & Moore (June 1992) using field observations and updated topographic maps, indicated that movement (i.e., block sliding and slumping) will generally occur on slopes with an angle greater than 21 degrees and will continue until a slope angle of approximately 21 degrees is achieved.

The most recent studies of slope stability, mass wasting, and erosion are presented in WVDP-EIS-009, Part 1 and Part 3. Included in these studies are: numerical/computer analyses of selected slopes, maps showing landslide locations, and evaluations of stream valley growth.

A.3.6.6 Geochemical Characterization of Site Soils

Site and site-area soils have been described in terms of the elements as determined spectrographically, in terms of the oxides of major elements as determined by atomic adsorption and wet chemical methods, and in terms of mineral species, soil pH, and cation-exchange capacity. Bench tests also were performed to evaluate the sorptive capacity of site soils for Cs-137 and Sr-85, and the natural radioactivity of the soil was evaluated. A limited number of analyses were performed to determine the fraction organic content of the glacial tills.

Additional studies relating to geochemical characterization of on-site soils along with their results are presented in: Dames & Moore (1995b), Dames & Moore (1995a), and Aloysius and Fuhrmann (1994).

A.3.6.6.1 Spectrographic Analyses

Ten soil samples taken from four boreholes were analyzed spectrographically by the Geochemistry and Petrology Branch, USGS in 1962; borehole locations are shown in Figure A.3.6-29. The distribution of sampling points and the date at which the samples were taken indicate that the data (Table A.3.6-7) comprise valid baseline geochemical information for the site.

A.3.6.6.2 Major Element Analyses

Major element analyses were performed by the USGS on fifteen samples taken from eight boreholes (Table A.3.6-8) and by the NYSGS Geochemistry Laboratory on borehole samples and eight additional samples taken from excavations in the vicinity of the SDA.

The NYSGS data (Table A.3.6-9) are presented in three sets to represent: 1) weathered Lavery till, 2) unweathered Lavery till, and 3) other units, including sand lenses within the Lavery, lacustrine sediment, and the older (Kent?) till.

Borehole locations are shown on Figure A.3.6-30 and the NYSGS excavations are indicated on Figure A.3.6-19b. The sample identification numbers in Table A.3.6-9 are explained at the end of the table, where it should be noted that "NFS drill holes" 4, 6, and 7 refer to 61DH4, 61DH6, and 61DH7 as shown on the map (Fig. A.3.6-30) and as listed in the borehole log compendium (Bergeron 1985).

Major element analyses revealed little remarkable in compositional differences among the units. Additionally, till composition is remarkably uniform, regardless of degree of weathering, as determined visually, and the composition of the glacial deposits closely approximates that of nearby bedrock. The weathered aspect of the Lavery in the near subsurface is relatable to chlorite decomposition and concomitant precipitation of ferric hydroxides within the unit. Other variations noted by the NYSGS between weathered and unweathered Lavery till include dissolution of carbonates and enrichment in silica and alumina during weathering of the till (Dana et al. 1979).

A.3.6.6.3 Mineralogy

Clay and silt fractions from eight samples were analyzed by x-ray diffraction (Dana et al. 1979). The analysts employed a fluorite standard and expressed their results as peak-area and peak-height ratios involving prominent fluorite reflections. Additional ratios were employed to evaluate illite crystallinity and the chlorite-vermiculite and chlorite-illite relationships. Results of the study, while not quantitative, afforded a basis for expressing variation among samples. The principal observations reported were that weathering of the Lavery till is attended by a decrease in the crystallinity of illite, and increases in the illite-chlorite and vermiculite-chlorite ratios. In the aggregate, these changes enhance the cation exchange capacity of the Lavery till. The analytical results are listed in Table A.3.6-10 and the sampling locations are described in Table A.3.6-9. All samples were taken in excavations at the waste burial site (see Fig. A.3.6-31).

The Lavery till and the subjacent lacustrine sequence were characterized in terms of their mineralogy by LaFleur (1979). LaFleur analyzed ten samples from eight boreholes using X-ray diffraction techniques. The results are provided in Table A.3.6-11. Borehole locations are indicated on Figure A.3.6-30, and the borehole logs are contained in Bergeron (1985). Composition as expressed mineralogically is generally consistent with the major element analyses discussed in A.3.6.6.2. The illite-chlorite ratios of weathered and unweathered till are similarly related, expansible clay species are not present, and the relatively higher plagioclase content of the lacustrine units is consistent with the relatively higher Na_2O content of these units as determined in the major element analysis.

A limited mineralogical characterization of site area glacial till is presented in a report by Albanese et al. (1984). Four samples were taken from exposures in the Connoisarauley Creek drainage basin, to the west of the site, and a single sample was taken from on-site borehole 80-10-1A, at a depth of 17 feet. The samples and sampling locations are described as follows:

1) CCRA - weathered Lavery till from the bank of Connoisarauley Creek in the west-central Ashford Hollow Quadrangle, at an elevation of 364 m (1,195 ft);

2) CCRB - unweathered Lavery till from the same locality as CCRA;

3) CR-Till - unweathered Lavery till from a roadcut on Connoisarauley Road in the west-central Ashford Hollow Quadrangle about 0.8 km (0.5 mi) south of CCRA and CCRB, at an elevation of 395 m (1,295 ft);

4) 80-10-IA - unweathered Lavery till from drill hole 80-10 (see Figure A.3.6-31), at an elevation of 422 m (1,382 ft), 5 m (17 ft) below the surface;

5) SR-1 - Kent till from a roadcut on Snake Run Road in the southwest part of the Ashford Hollow Quadrangle, at an elevation of 518 m (1,700 ft).

Gravel, sand, silt, and clay fractions were analyzed using megascopic, petrographic, x-ray diffraction, and wet-chemical techniques. Results were compiled as histograms to indicate relationships between mineralogy and grain size (Figs. A.3.6-32, 33, and 34). The wet-chemical and diffraction data describing the silt and clay fractions are presented in Table A.3.6-12 and Table A.3.6-13. The grain-size distributions are summarized as follows:

	% Gravel	% Sand	% Silt	% Clay
	-1φ	-4φ	8φ	
SR-1 (Kent till)	13.5	29.5	37.5	19.5
CCRA (Lavery, wx)	05.7	11.4	41.1	41.8
CCRB (Lavery, u-wx)	05.5	12.4	36.0	46.1
CR-Till (Lavery, u-wx)	11.1	10.3	32.5	46.1
80-10-1A (Lavery, u-wx)	10.0	23.0	38.6	28.4

On the basis of these data, the texture of the on-site Lavery (80-10-1A) more closely resembles the Kent till than it does the off-site Lavery. CCRA, CCRB, and CR-Till appear to be silty clays, whereas SR-1 and 80-10-1A are sandy clayey silts.

The characteristic mineral assemblage for this group of samples comprises quartz, potassic feldspar, plagioclase, calcite, dolomite, illite, chlorite, and sedimentary and high-grade metamorphic rock fragments; kaolinite and vermiculite were not identified in these samples. A detailed discussion of the methods employed and results obtained is available in Albanese et al. (1983).

A.3.6.6.4 Cation Exchange Capacity

The cation exchange capacity (CEC) of forty-three soil samples extracted from twenty-four boreholes was determined by the USGS and included in the NFS SAR (1973). The data are listed in Table A.3.6-14. Borehole locations are shown on Figure A.3.6-29.

Table A.3.6-14 also includes the pH of each sample and a description, excerpted from the borehole log, of the interval from which the soil sample was taken. The borehole logs can be found in Bergeron (1985).

The analytical method involved saturation of the samples with NH_4^+ ions (using NH_4Cl) and determining the amount retained by the soil components. Governing factors include the mineral species present, sediment grain size, and the pH of both the soil and the exchange environment. The method is described in the following excerpt from the NFS SAR (1973):

> The pH was determined on 1:10 soil-water mixtures of each sample. One-gram samples, crushed to pass a sixty mesh sieve, were leached overnight (sixteen hours) in 1N neutral NH_4Cl. The sample was separated from the leachate by centrifugation, and washed free of excess NH_4Cl with ethyl alcohol. The exchange capacity was then determined by ammonia distillation.

Values listed for pH ranged from 5.43 to 8.99 and averaged 8.21. Of the 43 values, 41 are greater than 7.0 and 37 are greater than 8.0, indicating that site-area soils characteristically are decidedly alkaline. This soil characteristic is extremely significant for its potential to minimize outward migration of actinides in acidic solutions.

CEC values range from 3.5 to 18.8 meq/100 grams of soil and average 10.3 meq/100 grams of soil for the entire suite of samples. Arranging the data according to geological unit and weathering aspect might provide a more useful summary, as follows:

	No.of Samples	Range (meq/100g)	Average (meq/100g)
All Samples	43	3.5 - 18.8	10.3
Lavery till, slightly weathered to weathered	11	5.1 - 18.8	11.4
Lavery till, unweathered	14	8.1 - 17.9	12.5
Kent till, weathered	2	11.3 - 17.0	14.2
Kent till, unweathered	2	6.9 - 12.6	9.8

	No. of Samples	Range (meq/100g)	Average (meq/100g)
All Samples	43	3.5 - 18.8	10.3
Lavery till, slightly weathered to weathered	11	5.1 - 18.8	11.4
fluvial terrace deposits (Wfg); alluvium (Haf); sand lenses in Lavery till; lacustrine unit (Wlb)	9	3.8 - 16.8	7.1

As formatted, the data fail to reveal variation relatable to depth and degree of weathering. However, samples designated "Lavery till, slightly weathered to weathered" were selected conservatively, which might have skewed the listed average values and obscured the positive correlation between exchange capacity and degree of weathering perceived by the NYSGS.

An additional fourteen CEC values were generated by the Rutgers Soil Testing Laboratory for Dames & Moore in 1983. The samples were taken in Shelby tubes at various depths in boreholes 83-1-E, 83-2-E, and 83-3-E, immediately west of the waste disposal areas (Fig. A.3.6-31). The analytical method and the analytical results are provided in Table A.3.6-15. In this group of data, eleven samples of unweathered Lavery till have CECs ranging from 1.87 to 7.64 meq/100g, averaging 4.90 meq/100g.

The wide disparity between the values listed in Table A.3.6-14 and Table A.3.6-15 is difficult to explain. Inasmuch as typical unweathered Lavery till, for example, is described as having twice the CEC in the Table A.3.6-14 data as it does in the Table A.3.6-15 data, the discrepancy probably is related to either obscure but actual variation in the till or to differences in the analytical techniques employed. Review of the CEC values obtained in the 1973 study suggests that the exchange capacity of the Lavery in the vicinity of boreholes 83-1-E, 2-E, and 3-E is lower than average, and that both sets of data are tenable. Fraction organic content of each of the fourteen samples also was determined and found to range from 0.96 to 2.48 percent and average 1.88 percent (Table A.3.6-15). These values are considered fairly high for glacial till and the indicated vertical variation in organic content would seem to preclude any correlation with modern processes including carry-down through till fracture systems.

A second study conducted in the same general area (Dames & Moore 1983) determined the CEC and organic content of seven samples taken from boreholes 82-1-D and 82-3-D at the NDA (Fig. A.3.6-31). Interval descriptions are taken from geologic logs contained in Bergeron (1985). The CEC values (Table A.3.6-15) range from 3.41 to 6.57 meq/100g, and average 4.58 meq/100g.

A.3.6.6.5 Distribution Coefficients

The distribution coefficient (partition coefficient, [K_d]), commonly expressed in ml/g, indicates and can be used to predict attenuation of a solute by the geologic matrix in a soil-groundwater system. The K_d commonly is determined experimentally by contacting known volumes of solution of known concentration or, in the case of radionuclides, known activity, with measured amounts of disaggregated matrix for prescribed periods of time. Contact time is extended until the concentration or activity of the liquid phase stabilizes, at which point a state of equilibrium between sorption and desorption is inferred. The K_d is defined as the ratio of the concentration (or activity) of a species sorbed on the soil, divided by its concentration (or activity) in solution under steady-state conditions. The distribution coefficient is calculated as follows:

$$K_d = \frac{(Fm)(Vs)}{(Fs)(Wm)}$$

where:

K_d = distribution coefficient (mL/g),

Fs = fraction of total concentration or activity in solution at the end of testing. Fs is found by dividing the final concentration (or activity) of the species in solution (after steady-state conditions are reached between the solution and soil) by its initial concentration in solution, prior to interacting with the soil,

Fm = fraction of concentration (or activity) sorbed onto the soil (Fm = 1 - Fs),

Wm = weight of soil or solid residue (g), and

Vs = total volume of solution (mL) allowed to react with Wm

The K_d is an empirical parameter and the mechanisms and relationships responsible for the sorption observed, which might include ion exchange and electrostatic bonding, normally are not determined in the process.

Distribution coefficients, as implied above, are determined for and apply to soil-groundwater systems in equilibrium. The same K_d values do not apply in the case of a phase solvent other than water in contact with the geologic matrix. The K_d does imply contact time consistent with intergranular groundwater flow and has little relevance in situations such as fracture flow or overland flow, where kinetic effects are pronounced.

The requirement for K_d values in studies intended to characterize solute transport through a geologic substrate are expressed by the relation:

$$\text{velocity of solute} = \frac{\text{velocity of groundwater}}{Rf} = \frac{\text{velocity of groundwater}}{1 + P/n \ (K_d)}$$

where P is the average bulk density of the geologic matrix, n is its porosity, and Rf is the retardance or retardation factor. As matrix density and porosity are determinable values and groundwater velocities normally are established prior to solute-transport simulation, distribution coefficients for all solutes of concern permit velocity values (or travel times) for each solute to be determined.

K_d values might be presented as average values or ranges of values and might be represented as applicable to a given class of geologic matrix (sands, clays) or to a specific substrate such as the Lavery till. The most reliable and useful values derive from sorption experiments employing site-specific media and contact times long enough to permit the system to stabilize. The K_d values available for modeling solute transport at the WVDP include default and site-specific values.

Default K_d values for 48 elements, including all of those for which site-specific values have been generated (Cs, Sr, Ru, Co, I), were provided by Sheppard and Thibault (1990). Table A.3.6-16 is based on their work and a literature review. The K_d values are presented as geometric means for four soil types—sand, loam, clay, and organic soil. The effects on solid-liquid partitioning of soil texture, organic carbon content, competing ions, pH, soil solution ratio, solution concentration, and atomic number are discussed. Sheppard and Thibault did not report data derived from anoxic systems.

Distribution coefficients for 22 nuclides were used in the 1986 WVDP Environmental Assessment (USDOE 1986). K_d values were listed for four geochemical environments—overland flow, the waste mass in the disposal trenches, the Lavery till, and the lacustrine unit (Table A.3.6-17). The values listed for Cs, Sr, Am, and Eu were extrapolated from site-specific data generated at Brookhaven National Laboratory (Pietrzak et al. 1981); the remaining values were extrapolated from typical values for sand and clay contained in the literature (Staley et al. 1979).

Unweathered Lavery till collected in 1975 at a depth of 35 feet in borehole A2 at the SDA was tested for its sorption characteristics in the presence of leachate collected in 1977 from sumps and well points in Trench 5 at the SDA (see Fig. A.3.6-13). These experiments were conducted at Brookhaven National Laboratory using equipment and procedures designed to generate site-specific K_d values for Cs, Sr, and Co in both oxic and anoxic environments.

A description of the equipment and procedures employed in the Brookhaven study, and preliminary results and conclusions, were reported in Columbo and Weiss (1979) and subsequently expanded by Pietrzak et al. (1981). The latter report includes K_d values for Eu and Am as well as Cs, Sr, and Co, and discusses the observed effects of each of several variables on the sorption characteristics of the till. Columbo and Weiss concluded that the unweathered Lavery till is a "strong absorber of radionuclides."

Of the variables, trench water composition and soil disaggregation techniques were found to significantly affect the sorption of the radionuclides (Table A.3.6-18). The results also indicate that sorption of these species could increase markedly due to dilution and oxygenation as the organic ion-laden leachate migrates into and mixes with the ambient groundwater.

Distribution coefficients for Cs-137, Sr-85, Ru-106, Co-60, and I-129 have been calculated from sorption data provided by Duckworth et al. (1974). Sorption values reported as percentages for Cs, Sr, Ru, and Co were generated for 37 samples of weathered and unweathered Lavery till taken from ten boreholes at the SDA at depths of 4 to 51 feet (Fig. A.3.6-35, Table A.3.6-19). Sorption of Cs and Sr was determined by contacting 10 g of soil and 250 ml of water containing 100 ppm NaCl adjusted to pH 8. Sorption of Ru and Co were determined by contacting 10 g of soil and 250 ml of water containing 430 ppm NaCl at pH 7. In each case, sorption of the radionuclide was recorded after 4 hours and again after 16 hours of contact.

Iodine sorption was determined for ten samples of weathered and unweathered till taken from boreholes 1, 4, and 7. Conditions for the tests involving I-129 were not reported, but are assumed to have been the same as those involving the other radionuclides—250 ml of solution and 10 g of soil. It is further assumed that chloride was not introduced to the system in the iodine experiments. The iodine sorption data are listed in Table A.3.6-20 and presented as a normal probability plot in Figure A.3.6-36.

Distribution coefficients recently calculated from the sorption data are contained in Table A.3.6-20 and are summarized in Table A.3.6-21. The lithologic descriptions and the moisture content of the samples are on file at the Dames & Moore site office.

The SDA data reveal that Co-60 is almost completely sorbed by both weathered and unweathered Lavery till and that Co exhibits no selectivity for either material. The authors suggest that Fe, Ni, and Mn will be sorbed to a similar extent. The results indicate a similar degree of sorption for Cs and Sr, as was indicated in the Oak Ridge experiments, and the same relationship in the case of Sr between weathered and unweathered Lavery till. Ru-106 sorption values are much higher than those derived in the Oak Ridge experiments, a disparity that was attributed to the presence in the Oak Ridge National Laboratory (ORNL) test solution of a high ratio of non-sorbable to sorbable Ru; the ORNL test solution was taken from seepage pits (leach beds) at Oak Ridge. Chelation or complexation of the Ru in the ORNL solution is a plausible explanation for the low sorption.

Variation in K_d values as a function of depth and a clear delineation of the range of values occupied by each chemical species are shown in Figure A.3.6-37. Normal probability plots of the data contained in Table A.3.6-20 are shown in Figure A.3.6-38. The probability plot for Sr (Fig. A.3.6-38B) clearly reveals the higher sorptive capacity of the weathered till for this element, while Figure A.3.6-38A suggests that Cs also is more thoroughly attenuated by the weathered till than by the unweathered till. More comprehensive analysis of all available site-specific sorption data and their potential relationships to geotechnical and groundwater chemical data is in progress.

The site-specific K_d data contained in Table A.3.6-20 were compared to the generic data contained in Table A.3.6-16 to evaluate the overall applicability of the default K_d values to the Lavery till. Specifically, the range and geometric mean (GM) for the 16-hour tests involving Cs, Sr, Ru, Co, and I were compared to the ranges and geometric means for the same elements as determined by Sheppard and Thibault. Among the generic values, only those pertaining to loam and clay substrates were considered. The comparison (Table A.3.6-22) reveals that:

- the range of cesium K_d values determined for the Lavery till at the SDA lies well within the range extracted from the literature, and the GM of the Lavery values is almost the same as that of 54 values for loam soils described in the literature.

- the range of site-specific values for strontium is within the range representing 43 loam soils described in the literature. The GM of the Lavery values is quite similar to the corresponding values for both loam soils and clay soils.

- the geometric mean of the site-specific K_d values for cobalt is five times greater than the GM of 23 values for loam soils and ten times greater than the GM of 15 clay soils described in the literature; the range of site-specific values for cobalt, however, is within the combined range of values for the 38 fine-grained soils represented in Table A.3.6-22.

- the site-specific data for iodine are entirely consistent with those contained in the literature, as indicated in the GM's for Lavery till, loam soil, and clay soil, respectively.

Eight soil samples from six boreholes drilled in 1961 were submitted to ORNL for batch-test determinations of their sorptive capacity for specific radionuclides. The borehole locations and sampling depths were selected to provide site-wide coverage at shallow to intermediate depths within the Lavery and to provide a basis for comparing the retentivity of the weathered and unweathered till. Borehole locations are shown in Figure A.3.6-29 and the sampled intervals, analytical results, and conditions of the experiments are provided in Tables A.3.6-23A through A.3.6-23F.

The data on cesium sorption using Oak Ridge tap water (Table A.3.6-23A) show that the till has a high affinity for this element and that introduction of potassium ions reduces the sorption of Cs to one-sixth of the original tap water value (Table A.3.6-23B). The results are consistent with an ion-exchange mechanism for Cs and competition for exchange sites in clay mineral lattices presented by K ions. In the absence of K ions, Cs was seen to be almost totally sorbed.

Movement of strontium is a primary concern in that soils normally do not exhibit high selectivity for this element. Tests were made using Oak Ridge tap water, demineralized water with 15 ppm calcium, and New York State well water. The tabulated results (Tables A.3.6-23C through A.3.6-23E) reveal that Sr sorption after 24 hours of contact was essentially the same in all three experiments and for all but one of the eight till samples tested (DH-4 at 15.0'-16.5'). A series of Sr sorption tests subsequently conducted using demineralized water containing 150 ppm calcium resulted in Sr K_d values of about one-fourth of those obtained using Oak Ridge tap water. This significant depression of the distribution coefficient for strontium probably is the result of competition for sorption sites presented by Ca ions.

The K_d values determined in the ORNL experiments indicate that sorption of Cs by the burial till will be from one to two orders of magnitude greater than the sorption of Sr. This same relationship is apparent in several of the data sets described in this section, including the generic data.

A few tests were run using a ruthenium tracer, but the results were not considered particularly meaningful because they were conducted using seep ruthenium (ruthenium which had percolated through the Oak Ridge soil) and from which the sorbable and filterable portions had been removed. Tests conducted at Oak Ridge using waste ruthenium (not seep ruthenium) have shown that this element precedes strontium, and one can also expect this relationship to hold at New York. The ruthenium test data area listed in Table A.3.6-23F.

The samples taken for K_d determinations comprised three of weathered till and five of fresh till; all were taken from the upper one-half of the Lavery. Unweathered Lavery corresponds in all five instances to "moist or wet gray plastic silt," while weathered Lavery corresponds to "moist yellow, brown, or reddish-brown silt." Variation in sorption after twenty-four hours as related to weathering aspect is as follows:

Lavery till, weathered	3 values	K_d Cs-137	4900-8020
Lavery till, unweathered	5 values	K_d Cs-137	3350-4500
Lavery till, weathered	3 values	K_d Cs-137, in presence of K	700-1840
Lavery till, unweathered	5 values	K_d Cs-137, in presence of K	300-805
Lavery till, weathered	3 values	K_d Sr-85	32-74
Lavery till, unweathered	5 values	K_d Sr-85	19-52
Lavery till, weathered	3 values	K_d Sr-85, in presence of Ca	33-77
Lavery till, unweathered	5 values	K_d Sr-85, in presence of Ca	22-53

Aside from the negative effects on K_d of the introduction of potassium to the cesium experiment and calcium to the strontium experiment, the principal relationship revealed above is a persistent substantial difference in K_d between weathered and unweathered till. The sorptive capacity of the till, at least for cationic solution species, clearly is enhanced by weathering processes.

Recent investigation of strontium behavior in the sand and gravel unit confirmed that sorption increased significantly with increasing pH (Dames & Moore 1995). The uptake of strontium is also believed to be strongly associated with iron oxide or hydroxide minerals or coatings on the surfaces of other mineral grains. Limited testing further indicated that the majority of strontium was associated with particles larger than 2 microns, suggesting that colloid-facilitated transport is not a primary transport process. The results of column testing, to evaluate dynamic geochemical behavior, indicated a K_d value for strontium on the order of 4.5 ml/g which is significantly lower than the results obtained from batch testing.

A.3.6.6.6 Radiometric Analyses

The weathered and unweathered Lavery till and incorporated masses of lacustrine sediment were characterized in terms of their inherent radioactivity by the USGS in 1975. The results of this analysis are discussed by Dana et al. (1979) and the data are provided in Tables A.3.6-24 and A.3.6-25. Borehole locations are shown on Figure A.3.6-30 and the geologic logs for the boring are contained in Bergeron (1985).

The potassium values listed in Table A.3.6-25 were found to agree well with the K_2O values determined through chemical analysis (Tables A.3.6-8 and A.3.6-9), while those for thorium and equivalent uranium concentrations agreed quite closely with average concentrations of U and Th in gray shales, as reported in the literature (Clark et al. 1966).

Additional information pertaining to radiometric analyses of both on-site and off-site soils, with respect to the WVDP boundaries, can be found in: WVDP-EIS-007, WVDP-EIS-008, and WVDP-220.

A.3.7 Ecological Characterization of the WNYNSC

The WNYNSC is located in the Town of Ashford, Cattaraugus County, N.Y., about 56 km (35 miles) south of Buffalo. From an ecological point of view, the WNYNSC is composed of two zones: approximately 220 acres associated with the Project of plant area (the WVDP Site Security Area) within the 3,345 acres, which serves as an exclusion or buffer zone around the WVDP site (see Figures A.3.1-2a, A.3.1-2b, A.3.1-3a, and A.3.1-3b). Most of the WVDP area has been cleared for existing facilities, although wooded tracts are found along drainage streams. The buffer zone contains a mixture of previously cleared agricultural areas, which are now in various stages of ecological succession. The site has a rolling and irregular topography and is intersected by several streams. The stream banks are somewhat steeper in the buffer zone, along Buttermilk Creek, than in the WVDP area. The generally acidic and poorly drained soils of the site influence the occurrence, distribution, and relative abundance of the plant species and their associated fauna. Construction of residences has not been allowed within the WNYNSC site since 1961.

The purpose of the ecological studies has been to characterize the site sufficiently to allow assessment of ecological impacts from the performance of the WVDP. Data collected during an annual cycle (October 1990 to September 1991) at the site were used along with data from previous site studies to characterize important terrestrial and aquatic ecosystem components of both the plant site and the WNYNSC as a whole. The ecological studies updated information that had been used in the development of a 1982 Environmental Impact Statement (EIS) on the site. Historically, vegetation, mammals, birds, reptiles, and amphibians have been investigated in the WNYNSC. Insect studies were not conducted as part of the 1990-91 study because they had not been included in previous studies and because the current field sampling procedures are qualitative in nature and would not permit meaningful analysis of the insect populations. Moreover, detailed quantitative sampling of insects is not considered appropriate to the present level of effort of the ecological investigations.

The ecological resources of the WNYNSC are described in detail in WVDP-EIS-010, *Ecological Resources of the Western New York Nuclear Service Center* (WVNS December 21, 1992). This report also is identified as Environmental Information Document Volume XI.

Standard biological sampling procedures were used during 1982-83 and 1990-91 surveys. These procedures are discussed in Appendix A to the previously referenced Environmental Information Document (EID). Common and scientific (Latin) names of all species presented in the EID are provided in Appendix B. Appendix C of the EID contains the wetlands investigation and designation of a 550 acre area of the WNYNSC that also includes the WVDP site.

The results of historical and recent field investigations, review of publications, and consultation with authorities on the area are summarized in Section A.3.7.1, Terrestrial Ecology, and Section A.3.7.2, Aquatic Ecology.

A.3.7.1 Terrestrial Ecology

A.3.7.1.1 Summary

The WNYNSC lies within the northern hardwood forest region. Its climax community forests are characterized by the dominance of sugar maple, beech, and Eastern hemlock. At present, the site is about equally divided between forestland and abandoned farm fields. Plant communities found on-site have been categorized into five cover types: mixed hardwood forest, pine-spruce community, successional creek bank communities, late oldfield successional areas, and fields-meadows. The plant communities found on-site are characteristic of Western New York. The relatively undisturbed nature of large portions of the WNYNSC has allowed for natural succession of previous agricultural areas within its boundaries. Because neither the setting nor the former agriculture land use are unique, the forest communities that will eventually develop in the abandoned fields will be similar to others in the region.

The small wetlands that exist within the WNYNSC consist of forested wetlands in isolated areas where groundwater seepages are found, persistent emergent wetlands at the headwaters of on-site ponds and reservoirs, and a shrub-scrub wetland found at the headwaters of the southernmost reservoir. Similarly sized and larger wetlands are found within a 16-km (10-mile) radius of the WNYNSC (Andrle 1982). Appendix C of the EID contains the wetlands study and delineation of a 550 acre area that includes the entire WVDP site and areas of the WNYNSC for which site operations activities are ongoing or may be needed.

The 1982-83 field studies revealed no plant species in the study area on either the State or Federal protected plant lists (Mitchell 1982). Field studies conducted by several groups since 1973 have also failed to record any such species. Field studies were conducted in the spring of 1992 to re-examine the WNYNSC with respect to the current State and Federal protected plant lists. No federally threatened or endangered species were identified. One each of New York State endangered and threatened plant species were found within the WNYNSC.

The US Department of the Interior, Fish and Wildlife Service, maintains a file of habitat locations designated as critical to the survival of federally listed endangered or threatened species. Based on a review of the most recent listings and contact with the U.S. Fish and Wildlife Service Cortland, N.Y., field office (June 1997), no such habitats occur in or around the site.

Critical habitats are also designated by the NYSDEC, Bureau of Wildlife. The state-designated critical habitats are areas found to be of significance to game and other important wildlife species. Such areas could include seasonally important wintering areas and breeding grounds. A 4,000-acre area encompassing the entire WNYNSC site has been classified as critical habitat due to its extensive use as a whitetail deer wintering area. The area has been designated because softwood shelter availability is rated intermediate, and food availability is rated good (NYSDEC 1974). Five other areas within a 10-mile radius of the site are similarly designated.

NYSDEC also recognizes riparian areas on Cattaraugus Creek as Habitat Significant for Wildlife (NYSDEC 1990). The delineated area reaches from Hake's Bridge on Cattaraugus Creek at Route 240 to the confluence with the South Branch of Cattaraugus Creek.

In October 1987, the New York State Department of State's Coastal Zone Program designated the Cattaraugus Creek from Lake Erie's Sunset Bay to a point 458 m (1500 feet) upstream of the US Route 20 bridge as a Significant Coastal Fish and Wildlife Habitat. Cattaraugus Creek is one of the largest New York State tributaries to Lake Erie providing habitat for lake-based fisheries in the Great Lakes Plain ecological region. It is one of the most popular recreational fishing areas in Western New York. The Creek from Sunset Bay to the Springville dam is the top salmonid spawning stream among the Lake Erie tributaries.

Threatened or Endangered Wildlife Species

The USDOI and the NYSDEC maintain lists of threatened and endangered species of wildlife that are protected under the Endangered Species Act (ESA) of 1973 and the Fish and Wildlife Coordination Act (FWCA) of 1958. Based on population range maps, threatened or endangered species with potential for occurring at the WNYNSC include:

Birds

- Common tern - state threatened

- Bald eagle - federal threatened and state endangered (proposed for removal from the Federal Endangered Species list and recommended for state threatened status)
- Loggerhead shrike - state endangered
- Northern harrier - state threatened
- Osprey - state threatened (recommended for state special concern status)
- Peregine falcon - federal and state endangered
- Piping plover - federal and state endangered
- Red-shouldered hawk - state threatened (recommended for state special concern status)
- Spruce grouse - state threatened recently (recommended for state endangered status)

Mammals

- Indiana bat - federal and state endangered

Herptiles

- Eastern massasauga - state endangered
- Timber rattlesnake - state threatened

Historical records and field studies through the end of 1991 failed to reveal any federal threatened or endangered species occurring or utilizing the WNYNSC. However, field investigations in 1990-1991 recorded one species (Northern harrier) on the NY list of threatened species and six state species of special concern (Cooper's Hawk, upland sandpiper, common raven, Eastern bluebird (recommended for unlisted status), Henslow's sparrow (recommended for threatened status), and vesper sparrow). Special concern species are species under consideration for potential inclusion as endangered or threatened. Typically, species of special concern are those whose populations are declining, often in association with critical habitat loss. All the noted species were observed in areas of the WNYNSC outside the WVDP. Moreover, none of these threatened or species of special concern depend on areas within the WVDP for any aspect of their life cycle. Eight birds, two mammals, and six herptiles on the special concern list may potentially occur at the WNYNSC. Four of the listed birds (common loon, Northern raven, common nighthawk, and Eastern bluebird (recommended for unlisted status) have been recorded at the WNYNSC. While suitable habitat for some of these species exists on-site, their presence at the WNYNSC (except in the case of the Eastern bluebird) is not due to the presence of critical habitat within the WNYNSC. The Eastern bluebird habitat has been artificially created by a substantial bluebird nesting box program. This program has proved very successful. During 1990, approximately 85 birds were fledged from boxes on the WNYNSC.

NFS records indicated that in the early 1970s the WNYNSC was not on a normal migratory flyway nor was it used as a normal resting area for migratory waterfowl (Nuclear Fuel Services, Inc., 1973a). Since then, the site's southernmost reservoir and smaller wetlands have become more important to migratory waterfowl. During the 1990-91 survey a total of 215 Canada geese, fifteen mallards, fifteen wood ducks, three hooded mergansers, two black ducks, and sixty-five tundra swans were observed within the WNYNSC. However, the on-site areas offer no unique habitat as similar habitat areas exist nearby, including Lime Lake 8 km (5 miles) east, Farmersville Pond and Marsh 16 km (9.9 miles) east, and Cuba Lake and Marsh 32 km (20 miles) southeast (Andrle 1982).

Common game species found on the site and in the region include whitetail deer, Eastern cottontail, red fox, ruffed grouse, turkey, and others.

Moore (1982) also notes a potentially stressful situation that may occur on-site as a result of an overpopulation of whitetail deer within the Site Security Area. In an attempt to manage the overpopulation of deer within the WNYNSC with a goal of reducing the number of deer/vehicle collisions on roads around the WNYNSC, NYSERDA has allowed controlled hunting (during the deer hunting season) within the WNYNSC premises, but not within the West Valley Demonstration Project. The deer take from 1994 to 1998 is listed as shown below:

1994	5 deer
1995	38 deer
1996	149 deer (WVNS, 1996)
1997	113 deer
1998	57 deer (Attridge, T., 1999)

In 1994, five deer were taken. In 1995, thirty-eight deer were taken. In 1996, one hundred and forty-nine deer were taken (WVNS, 1996). In 1997, one hundred and thirteen deer were harvested. Contamination of on-site deer has also been documented. Studies reported by the EPA in 1974 indicated that deer taken from the WNYNSC had slightly elevated levels of cesium-134, cesium-137, and zinc-65. Strontium-90 levels did not differ significantly from deer taken from off-site locations. The EPA report also indicated that deer accumulate radionuclides while grazing on-site. Based on this information, the maximum whole-body dose commitment to an individual from ingestion of venison in 1970 was estimated to have been 14 millirem (USEPA 1977). However, during the most recent four years for which data are available (1992 - 1995), samples of venison from deer taken near the site were not statistically higher in radioactivity than samples from control deer taken far from the site.

WVDP-289, the *WVDP Deer Management Program Plan* (WVNS) was implemented between October 1997 and March 1998. This action resulted in the removal of all the deer within the WVDP premises.

A.3.7.2 Aquatic Ecology

A.3.7.2.1 Summary

The aquatic environment at the WNYNSC consists of several creeks, two small reservoirs, and several beaver ponds. The creeks originating on or flowing through the site are of particular interest to the WVDP because some of them receive effluent discharges from the WVDP and/or potential releases from waste disposal areas. Aquatic ecology data may also be useful in performing pathway-to-man analyses of radionuclide transport through the environment. A report by Kelleher (1969) indicates that the aquatic pathway at the WNYNSC is a more significant pathway to man than either the atmospheric or the terrestrial pathway. The aquatic ecosystems within Erdman Brook, Frank's Creek, Quarry Creek, Buttermilk Creek, and Cattaraugus Creek were sampled in August 1982, May 1983, July 1991, and August 1991. Results of these sampling efforts indicate species diversity typical of small creeks in Western New York. Commonly found species included creek chub, common shiner, Eastern blacknosed dace, Northern hogsucker, common white sucker, fathead minnow, and sand shiner.

Examination of state and federal lists of threatened and endangered species and range maps, performance of field sampling and a literature survey, and interviews with local experts provided no indication that any threatened or endangered aquatic flora or fauna exist in the reservoirs, ponds, or streams on the WNYNSC or in its vicinity. NYSDEC has delineated an Eastern sand darter area on Cattaraugus Creek near Perrysburg, N.Y. This area is protected to preserve the state-listed endangered. The Eastern sand darter species was recently recommended for state-listed threatened species status. Due to dilution of effluents by Cattaraugus Creek, any operational discharges from the West Valley site would have insignificant incremental impact on this area.

A.3.7.3 Design Considerations

The seasonal field surveys (Section A.3.7) within the Security Area during 1990-91 indicated that the following birds and mammals were present:

BIRDS

Ruffed Grouse

American Robin

Killdeer

Cedar Waxwing

Spotted Sandpiper

Solitary Sandpiper

Starling

Red-Eyed Vireo

Rock Dove

Common Yellowthroat

Great Crested Flycatcher

House Sparrow

Least Flycatcher

Red-Winged Blackbird

Bank Swallow

Brown-Headed Cowbird

Barn Swallow

Indigo Bunting

Blue Jay

Dark-Eyed Junco

Common Crow

American Goldfinch

Black-Capped Chickadee

Chipping Sparrow

Song Sparrow

White-Breasted Nuthatch

House Wren

House Finch

Gray Catbird

MAMMALS

Muskrat	Eastern Cottontail
Raccoon	Woodchuck
Striped Skunk	Whitetailed Deer*
Deer Mouse	Meadow Vole

*All deer within the 220 acre security area were removed during October 1997 and March 1998.

Within the site Security Area, animals whose habits might have potential impacts on design requirements may be generally classified into four major groups: 1) wading birds, 2) insectivorous birds, 3) birds that nest on or in buildings, 4) and burrowing mammals.

Wading birds (e.g., killdeer, spotted sandpiper, and solitary sandpiper) regularly visit small ponds and creeks to forage for aquatic insects. The on-site Low-Level Waste Treatment Facility (LLWTF) includes two unlined lagoons that provide suitable feeding habitat for these wading birds. Any construction activities that involve water retention should therefore consider designs that minimize the creation of water edge habitat. For example, lining any retention basins greatly reduces the aquatic insect populations therein.

Insectivorous birds (e.g., bank swallow, barn swallow, and tree swallow) will forage on insects that may have reproduced in contaminated areas. By consuming contaminated insects, these birds could be a pathway for the uncontrolled spread of radioactivity. Any projects in contaminated areas should consider designs that do not create habitat suitable for insect reproduction, or should exclude them all together.

Buildings should be designed to exclude or deter nesting birds (e.g., barn swallow, cliff swallow, rock dove, starling, house sparrow, and house finch). This would minimize their contact with contaminated areas and reduce the potential for spreading contamination.

The last group of animals whose habits present potential impacts and should be considered is burrowing mammals (e.g., woodchuck and eastern cottontail). Woodchucks and rabbits merit consideration because they den in extensive burrows. Woodchuck dens typically have two or more openings and may be 120-150 cm deep and 8-9.5 meters long.

Eastern cottontail dens are characteristically not as deep or long and generally are located only in heavy brush, strips of forest, and edges of swamps. As such, although a burrowing mammal, the cottontail has very little impact on facilities.

On the other hand, although woodchucks naturally inhabit open woods, they are well adapted to a suburban environment. Although standard building codes are generally sufficient to preclude damage by woodchuck dens, the WVDP has initiated an Animal Control Program to monitor den locations and when necessary remove these animals from the security area. Typical animal species encountered include birds flying into buildings under renovation or construction, woodchucks burrowing under or chewing on the underside of temporary on-site trailers and mice and voles invading interior spaces. Traps are set. Upon the trapping or location of an animal, Radiation Protection technicians survey and log the live animal or carcass prior to its removal. Birds and animals found to be clean are released. Carcasses are stored pending burial in the on-site animal disposal area. Carcasses found to contain radioactivity are taken to the Environmental Lab, for counting, and then are stored in the XCR (Extraction Chemical Room) pending disposal. The Environmental Lab uses the Laboratory Information Management System (LIMS) to maintain sample information on animals that it processes.

A.3.8 Summary of Site Characteristics Impacting Safety Considerations

The following factors involve safety considerations and are accounted for by design criteria, including operating procedures, presented in Section A.4.

Site Characteristics (Factors) Impacting Design	Consequence on Structures	Section Where Design Criteria Are Addressed
Snowfall	The principal design consequence of snowfall is additional loading on structures (particularly roofs)	(A.4.2.6)
Wind	The principal design consequence of winds is additional loading on structures.	(A.4.2.1)
Temperature	The principal design consequence with regard to temperatures is the requirement for freeze protection.	(A.4.2.10)
Precipitation	The principal design consequence with regard to precipitation relates to sizing of drainage structures.	(A.4.2.3)
Tornado	The principal design consequence with regard to tornados relates to perforation of confinement or collapse of structures	(A.4.2.2)
Earthquake	The principal design consequence with regard to earthquakes relates to the collapse of structures	(A.4.2.5)
Near Surface Groundwater	The principal design consequence with regard to near surface groundwater is hydrostatic loading on foundations and the potential for buoyant uplift of structures.	(A.4.2.9)

REFERENCES FOR SECTION A.3.0

Albanese, J.R., et al. 1982. *Geologic and Hydrologic Research at the Western New York Nuclear Service Center, West Valley, New York: Progress Report, August 1979 - July 1981. U.S. Nuclear Regulatory Commission Report NUREG/CR-2381.*

Albanese, J.R., S.L. Anderson, L.A. Dunne, and B.A. Weir. 1983. *Geology and Hydrologic Research at the Western New York Nuclear Service Center, West Valley, New York, Annual Report August 1981-July 1982.* U.S. Nuclear Regulatory Commission. NUREG/CR-3207.

Albanese, J.R., S.L. Anderson, R.H. Fakundiny, S.M. Potter, W.B. Rogers, and L.F. Whitbeck. 1984. *Geologic and Hydrologic Research at the Western New York Nuclear Service Center, West Valley, New York, Final Report.* U.S. Nuclear Regulatory Commission. NUREG/CR-3782.

Algermissen, S.T., and Perkins, D.M. 1976. *A Probalistic Estimate of Rock Acceleration in Rock in the Contiguous United States U.S.G.S.* Open File Report 76-416.

Aloysius, D.L. and M. Fuhrmann. 1994. *Geochemical Testing and Characterization of Glacial Deposits, West Valley Demonstration Project, West Valley, New York.* Report prepared for U.S. Department of Energy, West Valley Project Office and West Valley Nuclear Services Co., Inc.

American National Standards Institute. *General Safety Standard for Installations Using Nonmedical X-Ray and Sealed Gamma-Ray Sources Energies up to 10 MeV.* ANSI N543-74.

________________. 1980. *Guidance for Defining Safety-Related Features of Nuclear Fuel Cycle Facilities.* ANSI N46.1.

________________. 1992. *American National Standard for Respiratory Protection.* ANSI Z88.2-1992.

REFERENCES FOR SECTION A.3.0

(Continued)

Andrle, R. August 1982. *Personal Communication.* Curator of Vertebrate Zoology, Buffalo Museum of Science, Buffalo, N.Y.

Attridge, T. June 1999. Personal Communication NYSERDA. Number of Deer Harvested on WNYNSC during 1998 hunting season.

Ayer, J.E., A.T. Clark, P. Loysen, M.Y. Ballinger, J. Mishima, P.C. Owczarski, W.S. Gregory, B.D. Nichols. May 1988. *Nuclear Fuel Cycle Facility Accident Analysis Handbook.* U.S. Nuclear Regulatory Commission. NUREG-1320.

Bailey, H.H. 1975. *Geologic Logs of Cores from the NFS-NYSASDA Drilling Project at West Valley, New York.* Unpublished NYSGS report.

Baker, A. Radford, April 9, 1993. Letter 0262:93:01, A. Radford Baker to B.A. Mazurowski, *Information Regarding Calspan's Ashford Experimental Operations.*

Bergeron, M.P. 1985. *Records of Wells, Test Borings, and Some Measured Geologic Sections Near the Western New York Nuclear Service Center, Cattaraugus County, New York.* U.S. Geological Survey Open-File Report 83-682.

Bergeron, M.P., W.M. Kappel, and R.M. Yager. 1987. *Geohydrologic Conditions at the Nuclear Fuels Reprocessing Plant and Waste Management Facilities at the Western New York Nuclear Service Center, Cattaraugus County, New York.* U.S. Geological Survey Water Resources Investigations Report 85-4145.

Bergeron, M.P., and E.F. Bugliosi. 1988. *Groundwater flow near two radioactive-waste disposal areas at the West Valley Nuclear Services Center, Cattaraugus County, New York.* Results of Flow Simulation, U.S. Geological Survey Water. Resources Investigations Report 86-4351.

Bernreuter, D.L., J.B. Savey, R.W. Mensing, and J.C. Chen. 1989. *Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains*: Lawrence

REFERENCES FOR SECTION A.3.0

(Continued)

Livermore National Laboratory report to U.S. Nuclear Regulatory Commission, NUREG/CR - 5250, UCID - 2151, Vols. 1 and 2.

_______________. 1984. *Seismic Hazard Characterization of the Eastern United States: Methodology and Interim Results for Ten Sites.* Livermore, California. Lawrence Livermore National Laboratory. NUREG/CR-3756.

Boothroyd, J.C., B.S. Timson, L.A. Dunne. 1982. *Geomorphic Processes and Evolution of Buttermilk Valley and Selected Tributaries, West Valley, New York.* U.S. Nuclear Regulatory Commission Technical Report. NUREG/CR-2862.

Boothroyd, J.C., B.S. Timson, R.H. Dana, Jr. 1979. *Geomorphic and Erosion Studies at the Western New York Nuclear Service Center, West Valley, New York.* U.S. Nuclear Regulatory Commission. NUREG/CR-0795, NYSGS/79/2406.

Buffalo News. August 8, 1997. "UB Scientists to Test Pollutants at Ex-military Site in Ashford."

Cattaraugus Area Tourist Bureau, 1976, 1977, 1981. Annual Reports, Salamanca, N.Y.

Cattaraugus County Cooperative Extension. *Dairy Statistics, Cattaraugus County 1974 and 1980.* Ellicottville, N.Y.

Cattaraugus County Industrial Development Agency. February 1981. *Cattaraugus County Industrial Directory.* Little Valley, N.Y.

Cattaraugus County Planning Board. June 1977a. *Cattaraugus County Land Use Plan.* Little Valley, N.Y.

_______________. June 1977b. *Mass Transit Development Plan.* Little Valley, N.Y.

REFERENCES FOR SECTION A.3.0

(Continued)

Cattaraugus County Planning Board Staff. March 1979. *The Place! A Justification for the Location of a Regional Tourist Information Center in Cattaraugus County.* Little Valley, N.Y.

Chadwick, G.H. 1920. *Large Fault in Western New York.* Geological Society of American Bulletin, 31: 117-120.

Chadwick, G.H. 1932. *Linden Monocline, a Correction.* Geological Society of America Abstract, 43: 143.

Chadwick, G.H., 1933. *Preliminary List of Titles and Abstracts of Papers to be Offered at 46th Annual Meeting, in Geological Society of America, 46th Annual Meeting, Chicago, Ill.* Proceedings, pp. 19, 82, 83, 84.

Chiburis, E.F. 1981. *Seismicity, Recurrence Rates, and Regionalization of the Northeastern United States and Adjacent Southeastern Canada.* Weston, Massachusetts. Weston Observatory of Boston College, NUREG/CR-2309.

Christiansen, J.H., et al. September , 1986. *Meteorological Monitoring and Airborne Radionuclide Dispersion Modeling at the West Valley Demonstration Project.* DOE/NE/44139-24.

Clark, S.P., et al. 1966. *Abundances of Uranium, Thorium and Potassium. Handbook of Physical Constants.* Edited by S. P. Clark, Geological Society America Me. 97.

Columbo, P. and Weiss, A.J. 1979. *Evaluation of Isotope Migration--Land Burial.* Progress Report No.9. NUREG/CR-0707.

Cooper, H.H., Jr., J.D. Bredehoeft, and S.S. Papadopulos. 1967. *Response of a Finite-Diameter Well to an Instantaneous Charge of Water.* Water Resources Research, v. 3, pp. 262-269.

REFERENCES FOR SECTION A.3.0

(Continued)

Coulter, H.W., Waldren, H.H., and Devine, J.F. 1973. *Seismic and Geologic Siting Considerations for Nuclear Power Facilities.* Fifth World Conference on Earthquake Engineering Paper No. 302, Rome, Italy.

Daly, Peter. July 3, 1995. *Personal Communication.* Erie County Emergency Services Department, Buffalo, New York.

Dames & Moore. 1963a. *Site Investigation, Proposed Spent Nuclear Fuel Processing Plant near Springville, New York:* Report to Nuclear Services, Inc.

________________. 1963b. *Site Investigation, Proposed Plutonium Fuel Plant, West Valley, New York: Prepared for Nuclear Fuel Services, Inc.*

________________. 1970a. Report: *Site and Foundation Investigation, Proposed Iodine Recovery Building, West Valley, New York.*

________________. 1970b. Report: *Site Environmental Studies, Seismo-Tectonics, Proposed Expansion, Nuclear Fuel Reprocessing Facility.*

________________. 1971a. Report: *Soils and Foundation Investigation, Proposed High-Level Waste Facility, West Valley, New York.* Prepared for Nuclear Fuel Services, Inc.

________________. 1971b. Report: *Evaluation of Subsurface Conditions, Nuclear Fuel Reprocessing Facility Site, West Valley, New York.*

________________. 1973. Safety Analysis Report, Section 5: *NFS' Reprocessing Plant, West Valley, New York.* Nuclear Fuel Services, Inc.

________________. 1974. *Hydrologic Investigation of Flooding Potential and Lake Water Supply System, Nuclear Fuel Services, Inc., Western New York Nuclear Service Center at West Valley, New York.*

REFERENCES FOR SECTION A.3.0

(Continued)

______________. 1975. *Foundation and Hydrology Studies - Emergency Water Supply for Cooling at the Spent Fuel Processing Plant, West Valley.*

______________. 1975. *Soil and Foundation Investigation, Existing Facilities and Proposed High Level Waste Facilities, Spent Fuel Processing Plant, West Valley, New York.* Field Report to Nuclear Fuel Services, Inc.

______________. 1978. *Evaluation of Alternatives for the Future of Facilities at the Western New York Nuclear Service Center.*

______________. October 4, 1982. DEMOG2 Computer Program Run: *West Valley Population Projections.* Cranford, N.J.

______________. 1983a. *Laboratory Test Program No.1, Disposal Area, West Valley, New York.* Job No. 10805-108-23.

______________. 1983b. *Laboratory Test Program No.2, NRC Disposal Area, West Valley, New York.* Job No. 10805-108-23.

______________. 1983c. *Seismic Hazard Analysis—West Valley Demonstration Project.*

______________. March 5, 1984. *Investigation of Kerosene-Tributyl Phosphate Migration, NRC-Licensed Burial Area, Western New York Nuclear Service Center, West Valley, New York.*

______________. 1985a. *STS Building, Augered Cast-in-Place Pile Design: Report for West Valley Nuclear Services Company, Inc.*

______________. 1985b. *Dewatering Design Report: Tank 8D-1: For West Valley Nuclear Services Company, Inc.*

REFERENCES FOR SECTION A.3.0

(Continued)

________________. 1986. *Soil Boring Summary Report.*

________________. 1988. *Report: Subsurface Investigation, Vitrification Facility, West Valley Demonstration Project.*

________________. 1990. *Report: Subsurface Investigation, Vitrification High-Level Waste Treatment Facility, Melter Disassembly Building.*

________________. October, 1991. *Subsurface Investigation Sewage Treatment Plant Expansion.* West Valley Demonstration Project.

________________. December, 1991. *Subsurface Investigation Utility Room Expansion.* West Valley Demonstration Project.

________________. 1992. *Seismic Hazard Analysis - West Valley Demonstration Project.*

________________. January 1992. *Report: Selection of Groundwater Flow and Contaminant-Transport Models for the Western New York Service Center and the West Valley Demonstration Project, West Valley, New York*

________________. June 1992. *Stability Evaluations of Slopes Adjoining the New York State-Licensed Disposal Area (SDA), Western New York Nuclear Service Center (WNYNSC) West Valley, New York.*

________________. August 24, 1992. *Geotechnical Investigation, High-Level Waste Transfer System, West Valley Demonstration Project, West Valley, New York.*

________________. 1993. *Subsurface Investigation, Office Complex Building #2 Complex.* West Valley Demonstration Project.

________________. December, 1993. *Hydrogeologic Investigation: Evaluation of Water Accumulation in Trenches 13 and 14 State Licensed Disposal Area (SDA) Western New*

REFERENCES FOR SECTION A.3.0

(Continued)

York Nuclear Service Center (WNYNSC) West Valley, New York. (Dames & Moore report prepared for New York State Energy, Research, and Development Authority).

_______________. January 1995. *Evaluation of Ground Motion Hazard at the West Valley Demonstration Project (WVDP) Site,for West Valley Nuclear Services Company, Inc.*

_______________. March 21, 1996. *Annual Meteorological Data Report, January 1, 1995 - December 31, 1995, West Valley Demonstration Project, West Valley, New York.*

_______________. 1995a. *Investigation of Strontium Behavior in the Surficial Sand and Gravel-Groundwater System, West Valley Demonstration Project, West Valley, New York.* Report prepared for U.S. Department of Energy, West Valley Project Office and West Valley Nuclear Services Co., Inc.

_______________. 1995b. *Testing and Characterization of Glacial Deposits: Geochemical and Radionuclide Adsorption Data, West Valley Demonstration Project, West Valley, New York.*

_______________. July, 1995. *Analysis of Hydraulic Conductivity Tests Conducted on Selected Wells at the WVDP.*

_______________. July, 1996. *Analysis of Hydraulic Conductivity Tests Conducted on Selected Wells at the WVDP.*

Dana, R.H., S.A. Molello, R.H. Fickies, and R.H. Fakundiny. 1979. *Study of Groundwater Flow at a Low-Level Radioactive Waste Burial Site at West Valley, New York.* New York State Geological Survey Open File Report NYSGS/79-2409.

Dana, R.H., et al. 1979. *Geologic Study of the Burial Medium at a Low-Level Radioactive Waste Burial Site at West Valley, New York: N.Y.S. Geological Survey.* Report Prepared for U.S. Environmental Protection Agency. NYSGS Open-File 79-2411.

REFERENCES FOR SECTION A.3.0

(Continued)

Dana, R.H., V.S. Ragan, S.A. Molello, H.H. Bailey, R.H. Fickies, R.H. Fakundiny, V.G. Hoffman. 1980. *General Investigation of Radionuclide Retention in Migration Pathways at the West Valley, New York, Low-Level Burial Site.* Final Report, October 1978-February 1980. NUREG/CR-1565. U.S. Nuclear Regulatory Commission.

Davis, K. April 19, 1974. *On NFS Reprocessing Plant, West Valley New York: Geologist's Trip Report.* Memo from Davis, NYSDEC Office of Environmental Analysis to Thomas Cashman, NYSDEC Bureau of Radiation.

deLaguna, W. 1972. *Hydraulic Fracturing Test at West Valley, New York.* Oak Ridge National Laboratory. ORNL-4827.

Development Analysis and Planning Associates, Ltd. February 1982. *Southtowns Planning and Economic Analysis Study 1982.* For the Erie County Department of Environment and Planning.

Diment, W.H., O.H. Muller, and P.M. Lavin. 1980. *Basement Tectonics of New York and Pennsylvania as Revealed by Gravity and Magnetic Studies.* Proceedings, the Caledonides in the USA, Virginia Polytechnic Institute and State University, Department of Geological Sciences, Blacksburg, pp. 221-227.

Domino, Arthur. July 9, 1992. *Personal Communication.* Calspan Corporation, Buffalo, New York.

Duckworth, J.P., M.J. Jump, and B.E. Knight. 1974. *Low-level Radioactive Waste Management Research Project--Final Report.* Nuclear Fuel Service, Inc., West Valley, New York.

EG&G Rocky Flats Publication. *Risk Assessment Guide.*

REFERENCES FOR SECTION A.3.0

(Continued)

Elder, J.C., et al. *A Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities.* LA-10294-MS, 1-86, Los Alamos National Laboratory.

Electric Power Research Institute. July 1986. *Seismic Hazard Methodology for the Central and Eastern United States*: Electric Power Research Institute Report NP-4726, Vols. 5 - 10.

________________. April 1989. *Probabilistic Seismic Hazard Evaluation at Nuclear Plant Sites in the Central and Eastern United States: Resolution of the Charleston Earthquake Issue*: Electric Power Research Institute Report NP 6395-D.

Empire Soils Investigation, Inc. 1975. *Site Investigation Report for Nuclear Fuel Services, Inc. Exploratory Borings for Emergency Water Reservoir, West Valley, New York.*

Environmental Protection Agency. *PRESTO-EPA: A Low-Level Radioactive Waste Environmental Transport and Risk Assessment Code - Methodology and User's Manual.* EPA 520/5-83-004.

________________. 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion.* EPA-520/1-88-020, Federal Guidance Report No. 11.

Evans, K.F. 1989. Appalachian Stress Study - 3: *Regional Scale Stress Variations and Their Relation to Structure and Contemporary Tectonics.* Journal of Geophysical Research, Vol. 94, No. B12, pp. 17619-17645.

Fletcher, J.B., and L.R. Sykes. 1977. *Earthquakes Related to Hydraulic Mining and Natural Seismic Activity in Western New York State.* Journal of Geophysical Research, Vol. 82.

REFERENCES FOR SECTION A.3.0

(Continued)

Foster, G.R. 1988. *Modeling Soil Erosion and Sediment Yield.* In Soil Erosion Research, ed. R. Lal. Ankeny, Iowa. Soil and Water Conservation Society.

Giardina, P.A. et. al., 1977. *Summary Report on the Low-Level Radioactive Waste Burial Site,* West Valley, New York (1963-1975). U.S. Environmental Protection Agency Report 902/4-77-010.

Gibbs, H.J. and Holtz, W.G. 1957. *Research on Determining the Density of Sand by Spoon Penetration Test.* Proceedings, 4th International Conference on Soil Mechanics and Foundation Engineering, Vol. I, pp. 35-39.

Gilbert, T.L., et al. June 1989. *A Manual for Implementing Residual Radioactive Material Guidelines.* Argonne National Laboratory, DOE/CH/8901, ANL/ES-160.

Grenberg, Michael R. and Donald Krueckeberg. 1973. *Long-Range Population Projections for Minor Civil Divisions: Computer Programs and User's Manual.* Brunswick, N.J.: Rutgers University Center for Urban Policy Research.

Gureghian, A. B. and Jansen, G. May 1983. *LAYFLO: A One-Dimensional Semianalytical Model for the Migration of a Three-Member Decay Chain in a Multilayered Geologic Medium.* ONWI-466 Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio.

Hadley, J.B., and J.F. Devine. 1974. *Seismotectonic Map of the Eastern United States.* U.S. Geol. Surv. Map MF-620, Washington, DC.

Haimson, B.C. 1977. *Crustal stress in the Continental United States as Derived from Hydrofracturing Tests, in The Earth's Crust: Its Nature and Physical Properties.* Geophys. Monogr. Ser., Vol. 20, edited by J.C. Hancock, AGU, Washington, D.C., pp. 576-592.

Hatfield, Tom. January 24, 1983. *Personal Communication.* Kissing Bridge Ski Area.

REFERENCES FOR SECTION A.3.0

(Continued)

Herrmann, R.B. 1978. *A Seismological Study of Two, Attica, New York Earthquakes.* Bull. Seism. Soc. of Amer., Vol. 68, No. 3, p. 641-651.

Hildenbrand, T.G., M.F. Kane, and J.D. Hendricks. 1982. *Magnetic Basement in the Upper Mississippi Embayment - A Preliminary Report.* In McKweon, F.A. and L.C. Pakiser(eds.), Investigations of the New Madrid, Missouri, earthquake region. U.S. Geological Survey, Professional Paper 1236e, pp. 39-53.

Housner, G.W. 1965. *Intensity of Earthquake Ground Shaking Near the Causitive Fault.* Proceedings, Third World Conference on Earthquake Engineering, New Zealand, Vol. I, No. 3, pp. 94-111.

Hoggan, D.H. 1989. *Computer Assisted Floodplain Hydrology and Hydraulics.* New York: McGraw-Hill.

International Commission on Radiological Protection (ICRP). 1974. *Report of the Task Group on Reference Man.* ICRP Report 23, October 1974.

International Commission on Radiological Protection (ICRP). 1979. *Limits for Intake of Radionuclides by Workers.* ICRP Publication 30, Part 2, 1980.

_______________. July 1979. *Limits for Intake of Radionuclides by Workers.* ICRP Publication 30 Part 1.

Iwasaki, T. 1986. *Soil Liquefaction Studies in Japan: State-of-the-Art.* Soil Dynamics and Earthquake Engineering, Vol. 5, No. 1.

Kappel, W.M., and W.E. Harding. 1987. *Surface Water Hydrology of the Western New York Nuclear Service Center Cattaraugus County, New York.* U.S. Geological Survey Water Resources Investigation Report 85-4309.

REFERENCES FOR SECTION A.3.0

(Continued)

Kelleher, W.J. 1969. *Environmental Surveillance Around a Nuclear Fuel Reprocessing Installation, 1965-1967.* Radiological Health Data and Reports, pp. 10:8:329-339.

Kennedy, R.P. et al. 1990. *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards:* LLNL Report UCRL-15910, June.

Kool, J.B., and Yu-Shu Wu. 1991. *Groundwater Flow and Transport Modeling of the NRC Licensed Waste Disposal Facility in West Valley, New York.* Hydrogeologic, Inc., Herndon, VA.

Krinitzsky, E.L. and F.K. Chang. December 7, 1977. *State-of-the-Art for Assessing Earthquake Hazards in the United States, Specifying Peak Motions for Design Earthquakes.* Misc. Paper S-73-1, Report 7, U.S. Army Engineers Waterways Exp. Station, CE, Vicksburg.

LaFleur, R.G. 1979. *Glacial Geology and Stratigraphy of Western New York Nuclear Service Center and Vicinity, Cattaraugus and Erie Counties, New York.* U.S. Geological Survey Open-File Report 79-989.

LaFleur, R.G. 1983. *Downcutting by Cattaraugus Creek and Tributaries - History and Prognosis.* Troy, New York: Rensselaer Polytechnic Institute.

Lal, R. 1988. *Erodibility and Erosivity, In Soil Erosion Research Methods.* ed. R. Lal. Ankeny, Iowa. Soil and Water Conservation Society.

Lanigan, Paul J. January 26, 1993. Letter 0262:93:11, P. J. Lanigan to T. J. Rowland, *Request for Information About Calspan's Ashford Operations.*

LaSala, A.M. 1968. *Groundwater Resources of the Erie-Niagara Basin.* New York State Conservation Department Basin Planning Report ENB-3.

REFERENCES FOR SECTION A.3.0

(Continued)

Lawrence Livermore National Laboratory. May 24, 1977. *Seismic Analysis of the Nuclear Fuel Service Reprocessing Plant at West Valley, N.Y.* UCRL-52266. Prepared for U.S. Department of Energy.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. *Fluvial Processes in Geomorphology.* San Francisco: W.H. Freeman and Company.

Liao, S.S.C., and R.V. Whitman. 1986. *Overburden Correction Factors for SPT in Sand.* Journal of Geotechnical Engineering, Vol. 112, No. 3.

Liao, SSC, D. Veneziano, and R. V. Whitman. April 1988. *Regression Models for Evaluating Liquefaction probability.* Journal of Geotechnical Engineering, Vol. 114, No. 4, pp. 389-411.

Los Alamos National Laboratory. March 1978. *Seismic Investigation of the Nuclear Fuel Services, Inc.* Reprocessing Plant at West Valley, New York. LA-7087-MS.

LUNR User Service. 1968. *New York State Land Use and Natural Resources Inventory, 7.5 Minute Quadrangle Map Overlays: Ashford Hollow, Springville, Collins Center, Sardinia, West Valley.* Ithaca, N.Y., Cornell University.

Mahalovic, John. July 9, 1992. *Personal Communication.* Erie County Emergency Services Department, Buffalo, New York.

Maryland Dept. of Natural Resources. 1984. *Standards and Specifications for Infiltration Practices.* Annapolis, Maryland.

McDonald, M.G., and Harbaugh, A.W. 1984. *A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model.* U.S. Geological Survey Open-File Report 83-875, p. 521.

REFERENCES FOR SECTION A.3.0

(Continued)

McGuire, R.K., and J.F. Schneider, editors. 1988. Proceedings: *Earthquake Ground-Motion Estimation in Eastern North America*. Prepared by Risk Engineering, Inc. Palo Alto, California, Electric Power Research Institute, EPRI NP-5875.

McWhorter, J.G., C. Fairhurst, R. Heemann, L. McGinnis, and R. Rodriguez. 1986. *Seismic Hazard Methodology for the Central United States, Volume 6: Tectonic Interpretations by Dames & Moore.* Plo Alto, California, Electric Power Research Institute, EPRI NP-4726.

Miller, Richard D. Written Communication. November 3, 1982. *The Regional Municipality of Niagara (Canada) Regional Population Forecast and Distribution.* St. Catharine's, Ontario, Canada.

Mitchell, Dr. Richard. August 1982. Personal Communication. State Botanist, NYSDEC.

Moore, T. July 1982. *Personal Communication.* Manager Bureau of Wildlife, NYSDEC, Region 9, Olean, N.Y.

Newmark, N.M. 1967. *Design Criteria for Nuclear Reactors Subjected to Earthquake Hazards.* Presented at the Earthquake Reactor Conference of the International Atomic Energy Commission, Tokyo, Japan.

New York Agricultural Statistics Service. July 1997. *New York Agricultural Statistics 1996-1997.* New York State Department of Agriculture and Markets, Division of Statistics, Albany, N.Y.

_______________. July 1998. *New York Agricultural Statistics 1997-1998.* New York State Department of Agriculture and Markets, Division of Statistics, Albany, N.Y.

New York Crop Reporting Service. April 1982. *Corn, Wheat and Oats, County Estimates.* Albany, N.Y., New York Dept. of Agriculture and Markets.

REFERENCES FOR SECTION A.3.0

(Continued)

________________. June 8, 1982. *New York Crop and Livestock Report.* Albany, N.Y., New York Dept. of Agriculture and Markets.

________________. May 1981. *Corn, Wheat and Oats, County Estimates 1975-1980.* Albany, N.Y., New York Department of Agricultural and Markets.

New York State Department of Commerce. 1980. *I Love New York Skiing and Winter Sports.* Albany, N.Y.

________________. 1982. *I Love New York Camping.* Albany, N.Y.

________________. 1982. Population Projections for New York Counties and Minor Civil Divisions (unpublished). Albany, N.Y.

New York State Department of Environmental Conservation. 1980. Significant Habitat Overlays, Buffalo Quad, Habitat Inventory Unit, Wildlife Recovery Center, Delmar, N.Y.

________________. 1974. *Deer Wintering Area Evaluation Form and Critical Habitat Maps.*

________________. 1983. *1983 Annual Report.* Bureau of Fisheries Lake Erie Unit to the Great Lakes Fishery Commission's Lake Erie Committee. Albany, N.Y.

________________. 1984. *1984 Annual Report.* Bureau of Fisheries Lake Erie Unit to the Great Lakes Fishery Commission's Lake Erie Committee. Albany, N.Y.

________________. 1990. Roblee, Ken. October 1990. Personal Communication. NYSDEC Division of Fish and Wildlife. Buffalo, N.Y.

________________. 1991. *1991 Annual Report.* Bureau of Fisheries Lake Erie Unit to the Lake Erie Committee and the Great Lakes Fishery Commission. Albany, N.Y.

REFERENCES FOR SECTION A.3.0

(Continued)

______________. 1995. *1995 Annual Report.* Bureau of Fisheries, Lake Erie Unit to the Lake Erie Committee and the Great Lakes Fishery Committee and Great Lakes Fishery Commission. Albany, N.Y.

______________. 1998. *1998 Annual Report.* Bureau of Fisheries, Lake Erie Unit to the Lake Erie Committee and the Great Lakes Fishery Committee and Great Lakes Fishery Commission. Albany, N.Y.

______________. 1999. *1999 Annual Report.* Bureau of Fisheries, Lake Erie Unit to the Lake Erie Committee and the Great Lakes Fishery Committee and Great Lakes Fishery Commission. Albany, N.Y.

New York State Department of State Coastal Zone Management Program. 1987. Coastal Fish & Wildlife Habitat Rating Form. Cattaraugus Creek. October 15. Albany, New York.

New York State Department of Transportation. 1980. *Four Sheet New York State Map, Scale 1:250,000, West Sheet.* Albany, N.Y.

______________. *Traffic Volume Report.* Albany, New York.

______________. *Planimetric Quadrangle Maps, Scale 1:24,000:* Ashford Hollow, Springville, Collins Center, West Valley, Sardinia, Arcade, Delevan, Cattaraugus, Ellicottville, Ashford.

New York State Electric and Gas Corporation. 1979. *Geologic Investigation, Demster Structural Zone;* Appendix 2.5A, of Preliminary Safety Analysis Report, New Haven Units 1 and 2, Docket Nos. STN50-596 and STN50-597.

New York State Reporting Service. June 1981. *New York Agricultural Statistics 1980.* Albany, New York Dept. of Agriculture and Markets.

REFERENCES FOR SECTION A.3.0

(Continued)

Niagara Mohawk Power Corporation. 1983. *Final Safety Analysis Report:* Section 2.5-12; v. 3 & 4, Nine Mile Point-Unit 2.

Nicholson, T.J., and R.D. Hurt. 1985. *Information on the Confinement Capability of the Facility Disposal Area of West Valley, New York.* NUREG/1164.

Nuclear Fuel Services, Inc. 1973a. *Safety Analysis Report: NFS Reprocessing Plant, West Valley, New York:* Docket No. 50-201.

________________. 1973b. *Safety Analysis, Spent Fuel Reprocessing Plant, West Valley, New York, Vol. 1.* Report to the U.S. Nuclear Regulatory Commission.

Nuttli, O.W. 1979. *The Relation of Sustained Maximum Ground Acceleration and Velocity to Earthquake Intensity and Magnitude:* Report 16, Misc. Paper S-73-1, U.S. Army Eng. Waterways Exp. Station, Vicksburg, Va.

________________. 1981. *Consequences of Earthquakes in the Mississippi Valley.* Preprint 81-519, Amer. Soc. Civil Eng., Meeting St. Louis.

________________. 1986. Letter J.B. Savy dated September 19, 1986. Quoted in McGuire, R.K., G.R. Toro, and M.W., McCann 1989. EQHAZARD Primer. Prepared by Risk Engineering, Inc. Palo Alto, California, Electric Power Research Institute, EPRI NP-6452-D.

________________. 1974. Deer Wintering Area Evaluation Form and Critical Habitat Maps. Unpublished File Data.

Oak Ridge National Laboratory. June 1979. *AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides.* ORNL-5532.

REFERENCES FOR SECTION A.3.0

(Continued)

________________. November 1990. *CAP-88, Clean Air Act Assessment Package.* RSIC Computer Code Collection. Publication CCC-542.

________________. June 1987. *PRESTO-II: Code System for Low-Level Waste Environmental Transport and Risk Assessment.* CCC-504 Radiation Shielding Information Center.

O'Brien and Gere. January 1980. *Western Four County Comprehensive Sewerage Study.* WPC-CS-210.

Onishi, Y., S.B. Yabusaki, C.T. Kincaid, R.L. Skaggs, and W.H. Walters. 1982. *Sediment and Radionuclide Transport in Rivers.* NUREG/CR-2425.

Pacific Northwest Laboratory. November, 1982. PAVAN: *An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials form Nuclear Power Stations.* NUREG/CR-2858, PNL-4413.

Pietrzak, R.F., K.S. Czyscinski, and A.J. Weiss. 1981. *Sorption Measurements Performed under Site-Specific Conditions--Maxey Flats, Kentucky, and West Valley, New York, Disposal Sites.* Nuclear and Chemical Waste Management, vol. 2, pp. 279-285.

Plumb, R. and J. Cox. 1987. *Stress Directions in Eastern North America Determined to 4.5 km from Borehole Elongation Measurements.* Journal of Geophysical Research, Vol. 92, pp. 4805-4816.

Prudic, D.E. 1981. *Computer Simulation of Groundwater Flow at a Commercial Radioactive Waste Landfill near West Valley, Cattaraugus County, New York.* In Little, C.A., and L.E. Stratton, (eds.): *Modeling and Low-Level Waste Management - An Interagency Workshop: Oak Ridge, Tenn.* Oak Ridge National Laboratory, pp. 215-248.

________________. 1982. *Hydraulic Conductivity of a Fine-Grained Till, Cattaraugus County, New York.* Ground Water, v. 20, no. 2, pp. 194-204.

REFERENCES FOR SECTION A.3.0

(Continued)

________________. 1986. *Ground-Water Hydrologic and Subsurface Migration of Radionuclides at a Commercial Radioactive Waste Burial Site, West Valley, Cattaraugus County, New York.* U.S. Geological Survey Professional Paper 1325.

Prudic D.E., and A.D. Randall. 1977. *Groundwater Hydrology and Subsurface Migration of Radioisotopes at a Low-Level, Solid Radioactive Waste Disposal Site, West Valley, New York.* USGS Open File Report 77-566.

Rauls, W.J., D.L. Brakensick, and K.E. Saxton. 1982. *Estimation of Soil Properties.* Transactions of the American Society of Agricultural Engineers, Volume 25, No. 5, pp 1316-1320.

Roberts, C.J., and Y.C. Yuan. January 7, 1985. *Comparison of Off-site Dose Predictions from Generic and Site-Specific Dispersions Models -- A Case Study from the West Valley Demonstration Project.* Health Physics Symposium, Colorado Springs, Colo.

Rogan, V. et al. 1979. *Studies of Surface Water Transport of Radionuclides at the Low-level Radioactive Waste Burial Site at West Valley, New York.* 1976-1977. New York State Geological Survey. State Museum.

Rose, Sister Marion. August 19, 1982. Personal Communication. St. Aloysius School.

Rothfuss, Hilde. July 28, 1982. Written Communication. Springville-Griffith Institute Central School District.

Rowland, T. J. February 4, 1993. Letter EAM:026:93-0262:93:11 (DW:93:0195) T. J. Rowland to W. G. Poulson, *West Valley Nuclear Services Co., Inc. (WVNS), SAR-001, Project Overview and General Information.*

Ryan, Robert J. July 27, 1982. Written Communication. New York Division of Milk Control, Albany, N.Y.

REFERENCES FOR SECTION A.3.0

(Continued)

Ryder, Terry. July 28, 1982. Personal Communication. Assurance Procedures for Meteorological Program.

Rykken, L.E. June 2, 1986. *High-Level Waste Characterization at West Valley.* DOE/NE/44139-14.

Salamanca Office of Promotion and Development. July 1980. *Tourism Development in Salamanca.* Salamanca, N.Y.

Sbar, M.L. and L.R. Sykes. 1973. *Contemporary Compressive Stress and Seismicity in Eastern North America: An Example of Intra-Plate Tectonics.* Geol. Soc. Amer. Bull., Vol. 84, No. 6, p 1861-1882.

Schnabel, P. and H.B. Seed. 1973. *Acceleration in Rocks for Earthquakes in the Western United States: Bulletin of Seismological Society of America.* v. 63, p. 501-516.

Seed, H.B., I.M. Idriss, and I. Arango. 1983. *Evaluation of Liquefaction Potential Using Field Performance Data.* Journal of Geotechnical Engineering, ASCE, Vol. 109, No. 3.

Sheppard, M.I., and D.H. Thibault. 1990. *Default Soil Solid/Liquid Partition.*

Shuster, Loretta. August 19, 1982. Personal Communication. West Valley Central School.

Smith, Stuart, F. September, 1981. *Dairy Management, Business Summary, New York, 1980.* Ithaca, N.Y., Cornell University Department of Agricultural Economics.

Soil Conservation Service. 1983. *Technical Release 20 - Computer Program for Project Formulation Hydrology.* Version 3.40. Washington, D.C.

REFERENCES FOR SECTION A.3.0

(Continued)

_______________. 1985. *Technical Release 60 - Dam Breech Discharge Criteria.*

_______________. 1986. *Technical Release 55 - Urban Hydrology for Small Watersheds.* 2nd Edition. Washington, D.C.

Staley, G.B., G.P. Turi, and D.L. Screiber. 1979. *Radionuclide Migration from Low-Level Waste:* Generic Overview in M.W. Carter et. al., Management of Low Level Radiological Waste, vol. 2, New York, Pergamon Press.

Steenhuis, T.S., R.E. Muck, and M.F. Walter. December 1983. *Prediction of Water Budgets With or Without a Hardpan, in Proceedings from Conference on Advances in Infiltration.* American Society of Agricultural Engineers, Monograph Series, pp. 1-13.

Stewart, H.G., Jr. 1962a. Letter of April 3, 1962, to J.D. Anderson, New York State Office of Atomic Development. U.S. Geological Survey.

_______________. 1962b. Letter of July 10, 1962 to J.D. Anderson. U.S. Geological Survey.

Sun, R.J. 1982. *Selection and Investigation of Sites for the Disposal of Radioactive Wastes in Hydraulically Induced Subsurface Fractures.* USGS Professional Paper 1215.

Sun, R.J. and C.E. Mongan. 1974. *Hydraulic Fracturing in Shale at West Valley, New York: A Study of Bedding Plane Fractions Induced in Shale for Waste Disposal.* USGS Open File Report 74-365. West Valley Nuclear Services Company, Inc., 1985. West Valley Demonstration Project, Safety Analysis Report.

U.S. Army Corps of Engineers. 1974. *Flood Hydrograph Package.* HEC-1, No. 723-010.

REFERENCES FOR SECTION A.3.0

(Continued)

________________. 1982. *HEC-2 Water Surface Profiles Users Manual. Computer Program.* Updated February 1989. Davis, California.

U.S. Bureau of the Census. 1951. *U.S. Census of Population: 1950 Number of Inhabitants, Final Report, Pennsylvania and New York.* U.S. Dept. of Commerce.

________________. 1970. *County Subdivisions, Towns, Indian Reservations, and Places (Map) for New York and Pennsylvania.* U.S. Dept, of Commerce.

________________. August, 1971. *U.S. Census of Population: 1970 Number of Inhabitants, Final Report PC(1)-A40 Pennsylvania and PC(1)-A34 New York.* U.S. Dept. of Commerce.

________________. March, 1979. Current Population Reports, Series P-25, No. 796. *Illustrative Projections of State Populations by Age, Race, and Sex: 1975 to 2000.* U.S. Dept. of Commerce.

________________. March, 1981. 1980 Census of Population and Housing, PHC-80-V-34, New York. *Final Population and Housing Unit Counts.* U.S. Dept. of Commerce.

________________. March, 1981. 1980 Census of Population and Housing, PHC-80-V-40, Pennsylvania. *Final Population and Housing Unit Counts.* U.S. Dept. of Commerce.

________________. 1995. *1992 Census of Agriculture Vol. 2, Part 5. Zip Code Tabulation of Selected Items.* U.S. Dept. of Commerce.

U.S. Department of Energy. 1982a. *Final Environmental Impact Statement, Long-term Management of Liquid High-level Radioactive Wastes Stored at the Western New York Nuclear Service Center, West Valley.* DOE/EIS-0081.

REFERENCES FOR SECTION A.3.0

(Continued)

______________. 1982b. *Final Environmental Impact Statement, Long-Term Management of Liquid High-Level Radioactive Wastes Stored at the Western New York Nuclear Service Center, West Valley.* DOE/FEIS-0081.

______________. 1986. *Environmental Assessment for Disposal of Project Low-level Waste.* DOE/EA-0295.

______________. May 1987. *West Valley Demonstration Project, Implementation of the Kerosene Plan.* DOE/NE/44139-38.

______________. July 1988a. *Internal Dose Conversion Factors for Calculation of Dose to the Public.* DOE/EH-0071.

______________. July 1988b. *External Dose-Rate Conversion Factors for Calculation of Dose to the Public.* DOE/EH-0070.

______________. July 20, 1989. DOE Order 6430.1A: *General Design Criteria.*

______________. June 1990. *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards.* UCRL-15910. Washington, D.C.

______________. March 27, 1990. DOE Order 5480.1B: *Environmental, Safety & Health Program for DOE Operations.*

______________. June 5, 1990. DOE Order 5400.5: *Radiation Protection of the Public and the Environment.*

______________. 1991. *Guidance for the Evaluation of Seismic Hazard, Systematic Evaluation Program.* Washington, D.C.

REFERENCES FOR SECTION A.3.0

(Continued)

________________. 1992. *Guidelines for Use of Probabilistic Seismic Hazard Curves at Department of Energy Sites:* U.S. Department of Energy, DOE-STD-1024-92, December.

________________. December 1992. *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports.* DOE-STD-1027-92.

________________. 1994. *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities:* U.S. Department of Energy, DOE-STD-1020-XX, Draft, February.

________________. *A Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable (ALARA).* DOE/EV/1830-T5.

U.S. Department of Energy Idaho Field Office. October 18, 1991. Supplemental Directive to DOE Order 5481.1B: *Safety Analysis and Review System.*

U.S. Department of Interior. July 2, 1982. *Fish and Wildlife Service list of Endangered and Threatened Wildlife and Plants.* Environmental Reporter.

________________. June 19, 1997. Fish and Wildlife Service. Letter from Sherry W. Morgan (DOI) to T.J. Rowland (DOE).

U.S. Environmental Protection Agency. 1977. *Summary Report on the Low-level Radioactive Waste Burial Site, West Valley, N.Y., 1963-1975. Coefficients, K_ds for Four Major Soil Types: A Compendium.* Health Physics, Vol. 59, No. 4, pp. 471-482.

U.S. Geological Survey. *Topographic Quadrangle Maps, Scale 1:24,000: Ashford Hollow, Springville, Collins Center, West Valley, Sardinia, Arcade, Delevan, Cattaraugus, Ellicottville, Ashford.*

REFERENCES FOR SECTION A.3.0

(Continued)

U.S. Nuclear Regulatory Commission. *Domestic Licensing of Production and Utilization Facilities,* 10 CFR 50.

________________. *General Design Criteria for Nuclear Power Plants,* 10 CFR 50.

________________. *Seismic and Geologic Siting Criteria for Nuclear Power Plants,* 10 CFR 100.

________________. 1973. *Regulatory Guide 8.5: Immediate Evacuation Signal.*

________________. 1975. *Regulatory Guide 3.26: Standard Format and Content of Safety Analysis Reports for Fuel Reprocessing Plants.*

________________. 1976. *Regulatory Guide 8.15: Acceptable Program for Respiratory Protection.*

________________. 1977. *Regulatory Guide 1.59: Design Basis Floods for Nuclear Power Plants.*

________________. October, 1977. *Regulatory Guide 1.109: Calculation of Annual Doses to Man form Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 60, Appendix I.*

________________. 1978. *Development of Criteria for Seismic Review of Selected Nuclear Power Plants.* NUREG/CR-0098.

________________. August 1979. *Regulatory Guide 1.145: Atmospheric Dispersion Models for Potential Accident Waste Disposal Facility.* NUREG-1199, Rev. 1.

________________. 1991. *Ground-Water Flow and Transport Modeling of the NRC-Licensed Waste Disposal Facility, West Valley, New York.* NUREG/CR-5794.

REFERENCES FOR SECTION A.3.0

(Continued)

VanTyne, A. 1975. *Subsurface Investigation of the Clarendon-Linden Structure, Western New York.* New York State Museum and Science Service Open-File Report.

Vasiliauskas, George. August 19, 1982. Personal Communication. Bertrand Chaffee Hospital.

Walters, W.H., R.M. Ecker, and Y. Onishi. 1982. *Sediment and Radionuclide Transport in Reviers: Field Sampling Summary Report for Cattaraugus and Buttermilk Creeks, New York.* NUREG/CR-1030.

Weiss, A.J., and Peter Columbo. 1980. *Evaluation of Isotope Migration - Land Burial; Water Chemistry at Commercially Operated Low-Level Radioactive Waste Disposal Sites.* Upton, N.Y., Brookhaven National Laboratory, BNL-NUREG-51143.

West Valley Nuclear Services Co. 1974. Supplement to Safety Analysis Report. *NFS Reprocessing.* Docket No. 50-201.

_______________. May 1984. *Environmental Evaluation for Disposal of Project Low-Level Waste.*

_______________. 1985a. *Environmental Assessment for Disposal of Project Low-Level Waste.*

_______________. 1985b. *Investigation of Kerosene-TBP Movement from the NRC Licensed Disposal Area, Western New York Nuclear Services Center.*

_______________. December 28, 1989. *Characterization of Solvent Leakage and Migration, NRC Licensed Disposal Area, Western New York Nuclear Service Center, West Valley, New York.* WVNS-EIS-996.

_______________. May 1991. *Site Environmental Report for Calendar Year 1990.*

REFERENCES FOR SECTION A.3.0

(Continued)

______________. October 1992. *Environmental Information Document, Volume IX, Socioeconomics of the Area Surrounding the Western New York Nuclear Service Center.* WVDP-EIS-012.

______________. December 21, 1992. *Environmental Information Document, Volume XI, Ecological Resources of the Western New York Nuclear Service Center.* WVDP-EIS-010.

______________. December 23, 1992. *Environmental Information Document, Volume II, Seismology.* WVDP-EIS-005.

______________. January 1993. *Environmental Information Document, Volume III, Hydrology.* WVDP-EIS-009.

______________. January 8, 1993a. *Environmental Information Document, Volume VIII, Air Resources.* WVDP-EIS-015.

______________. January 8, 1993b. *Environmental Information Document, Volume VIII, Part 1: Air Quality.* WVDP-EIS-015.

______________. January 8, 1993c. *Environmental Information Document, Volume VIII, Part 2: Meteorology.* WVDP-EIS-015.

______________. January 8, 1993d. *Environmental Information Document, Volume VIII, Part 3: Climatology.* WVDP-EIS-015.

______________. January 29, 1993a. *Environmental Information Document, Volume III, Part 1: Geomorphology of Stream Valleys.* WVDP-EIS-009.

______________. January 29, 1993b. *Environmental Information Document, Volume III, Part 2: Surface Water Hydrology.* WVDP-EIS-009.

REFERENCES FOR SECTION A.3.0

(Continued)

________________. February 11, 1993. *Environmental Information Document, Volume VI, Site Radiological Surveys.* WVDP-EIS-007.

________________. April 1, 1993a. *Environmental Information Document, Volume I, Geology, Part 1: Regional Geology.* WVDP-EIS-004.

________________. April 1, 1993b. *Environmental Information Document, Volume I, Geology, Part 2: Site Geology.* WVDP-EIS-004.

________________. April 1, 1993c. *Environmental Information Document, Volume I, Geology, Part 3: Geomechanical Analysis.* WVDP-EIS-004.

________________. April 1, 1993d. *Environmental Information Document, Volume I, Geology, Part 4: Geochemical Characterization.* WVDP-EIS-004.

________________. April 1, 1993e. *Environmental Information Document, Volume XII, Pathway Assessment.* WVDP-EIS-020.

________________. December 12, 1993. *Environmental Information Document, Volume III, Part 3: Erosion and Mass Wasting Processes.* WVDP-EIS-009.

________________. December 19, 1993a. *Environmental Information Document, Volume III, Part 4: Groundwater Hydrology and Geochemistry.* WVDP-EIS-009.

________________. December 19, 1993b. *Environmental Information Document, Volume III, Part 5: Unsaturated Zone Hydrology.* WVDP-EIS-009.

________________. September 15, 1994. *Environmental Information Document, Volume IV: Soils Characterization.* WVDP-EIS-008.

________________. December 13, 1996. Volume 4, #70 Perspective. *Our Ten Percent.* Tom Attridge (NYSERDA).

REFERENCES FOR SECTION A.3.0

(Continued)

________________. Safety Analysis Report *WVNS-SAR-001: Project Overview and General Information.* (latest revision)

________________. Safety Analysis Report *WVNS-SAR-004: Supernatant Treatment System.* (latest revision)

________________. Safety Analysis Report *WVNS-SAR-005: Liquid Waste Treatment System.* (latest revision)

________________. *WVDP-010: Radiological Controls Manual.* (latest revision)

________________. *WVDP-220: Subsurface Probing Investigation on the North Plateau at the West Valley Demonstration Project.* (latest revision)

________________. WVDP-289: *WVDP Deer Management Program Plan.* (latest revision)

________________. WVDP-298: *Geoprobe Investigation on the North Plateau at the West Valley Demonstration Project.* (latest revision)

________________. WVDP-346: *1998 Geoprobe Investigation in the Core Area of the North Plateau Groundwater Plume.* (latest revision)

West Valley Nuclear Services, Co., Inc. and Dames & Moore. April, 1997. *Evaluation of 1st Quarter 1997 Groundwater Monitoring Data.*

White, J.E. and Eckerman, K.F. November 1982. *User's Manual LPGS: A Computer Program for Calculating Radiation Exposure Resulting from Accidental Radioactive Releases to the Hydrosphere.* Oak Ridge National Laboratory, Oak Ridge, Tenn.

Whitney, P.R. 1977. *Chemical Mineralogical Investigation of Surficial Materials from the West Valley Demonstration Project.*

REFERENCES FOR SECTION A.3.0

(Concluded)

Yager, R.M. 1987. *Simulation of Groundwater Flow near the Nuclear Fuel Reprocessing Facility at the Western New York Nuclear Service Center, Cattaraugus County N.Y.* U.S. Geological Survey Water Resources Investigations Report 85-4308.

Yeh , G.T. 1981. *Analytical Transient One-, Two-, and Three Dimensional Simulation of Waste Transport in an Aquifer System.* Oak Ridge National Laboratory, Oak Ridge, Tenn. ORNL-5602.

________________. 1983. FEMWATER-1: *A Finite Element Model of Waste Transport Through Saturated-Unsaturated Porous Media.* First Revision, Oak Ridge National Laboratory, Oak Ridge Tenn.

Zoback, J.L. and M. Zoback. 1980. *State of Stress in Coterminous United States.* Journal of Geophysical Research, 85:641-651.

Zoback, M.L. and M.D. Zoback. 1989. *Tectonic Stress Field of the Continental United States.* In L.C. Pakiser and W.D. Mooney, eds. *Geophysical Framework of the Continental United States.* Geological Society of America Memoir 172, pp. 523-539.

TABLE A.3.1-1

LOCATIONS AND POPULATIONS OF TOWNS AND VILLAGES PARTIALLY OR TOTALLY WITHIN 16 KILOMETERS OF THE SITE

TOWN/ VILLAGE[1]	DISTANCE/ DIRECTION (KM)	POPULATION				1960-1970 % CHANGE	1970-1980 % CHANGE	1980-1990 % CHANGE
		1960	1970	1980	1990			
Ashford (T)		1,490	1,577	1,922	2,162	5.8	21.9	12.5
Concord (T)	4.8N	6,452	7,573	8,171	8,387	17.4	7.9	2.6
Springville (V)[2]	5.6N	3,852	4,350	4,285	4,310	12.9	-1.5	0.6
Sardinia (T)	6.4NNE	2,145	2,505	2,792	2,667	16.8	11.5	-4.5
Yorkshire (T)	5.6 NNE	2,012	2,627	3,620	3,905	30.6	37.8	7.9
Delevan (V)[3]	14.4 ENE	777	994	1,113	1,214	27.9	12.0	9.1
Machias (T)	6.4 ESE	1,390	1,749	2,058	2,338	25.8	17.7	13.6
Franklinville (T)	12.5 SSE	3,090	2,847	3,102	2,968	-7.9	9.0	-4.3
Ellicottville (T)	7.7 S	1,968	1,779	1,677	1,607	-9.6	-5.7	-4.2
Mansfield (T)	12.0 SSW	632	605	784	724	-4.3	29.6	-7.7
East Otto (T)	4.8 SW	701	910	942	1,003	29.8	3.5	6.5
Otto (T)	12.0 WSW	715	731	828	777	2.2	13.3	-6.2
Collins (T)	12.0 WNW	6,984	6,400	5,037	6,020	-8.4	-21.3	19.5
North Collins (T)	14.4 NW	3,805	4,090	3,791	3,502	7.5	-7.3	-7.6
TOTAL ALL TOWNS		32,084	33,393	34,724	36,060	4.1	4.0	3.8

[1] (T) indicates town and (V) indicates village.
[2] Springville village population is included in the town of Concord.
[3] Delevan village population is included on the town of Yorkshire.
Source: U.S. Department of Commerce, 1990 Census of Population and Housing, August 1991.

TABLE A.3.1-2

POPULATIONS OF SELECTED MUNICIPALITIES, COUNTIES, AND STATES WITHIN 80 KILOMETERS OF THE SITE (1960-1990)

MUNICIPALITY/ COUNTY/STATE[1]	POPULATION				% CHANGE 1960-1990
	1960	1970	1980	1990	
NEW YORK (S)	16,782,304	18,241,391	17,558,072	17,990,455	+7.2
Cattaraugus (C)	80,187	81,666	85,697	84,234	+5.0
Erie (C)	1,064,688	1,113,491	1,015,472	968,532	-9.0
Hamburg (M)	41,288	47,644	53,270	53,735	+30.1
Orchard Park (M)	15,876	19,978	24,359	24,632	+55.2
Buffalo (M)	532,759	462,768	357,870	328,123	-38.4
Allegany (C)	43,978	46,458	51,742	50,470	+14.8
Wyoming (C)	34,793	37,688	39,895	42,507	+22.2
Chautauqua (C)	145,377	147,305	146,925	141,895	-2.4
Livingston (C)	44,053	54,041	57,006	62,372	+41.6
Genesee (C)	53,994	58,722	59,400	60,060	+11.2
Niagara (C)	242,269	235,720	227,101	220,756	-8.9
Steuben (C)	97,691	99,546	99,135	99,088	+1.4
PENNSYLVANIA (S)	11,319,366	11,800,766	11,866,728	11,881,643	+5.0
Warren (C)	45,582	47,682	47,449	45,050	-1.2
McKean (C)	54,517	51,915	50,635	47,131	-13.5
Potter (C)	16,483	16,395	17,726	16,717	+1.4

[1] (M) indicates municipality, (C) indicates county, and (S) indicates state.

Source: U.S. Bureau of Census, years cited, census of population

TABLE A.3.1-3

**1996 RESIDENT POPULATION ESTIMATES
BY SECTOR WITHIN 5 KILOMETERS OF THE SITE***

Sector	Under 5 years old	6 - 18 years old	Over 18 years old	Total Residents	Total Houses
N	4	16	44	64	24
NNE	5	23	66	94	42
NE	0	10	25	35	14
ENE	6	11	34	51	21
E	17	44	93	154	63
ESE	4	12	52	68	29
SE	7	13	48	68	31
SSE	2	8	29	39	20
S	1	1	12	14	12
SSW	2	11	34	47	18
SW	1	15	44	60	27
WSW	5	5	22	32	16
W	6	18	65	89	43
WNW	11	17	82	110	47
NW	2	21	74	97	39
NNW	3	4	20	27	17
Total	76	229	744	1049	463

* Table reflects raw data provided by survey respondents without correction for those households for which a response could not be obtained.

TABLE A.3.1-4

**1990 CENSUS POPULATION BY SECTOR
WITHIN 10 KILOMETERS OF THE SITE***

	KILOMETERS							
SECTOR	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-10	0-10 TOTAL
N	0	0	0	21	17	29	3,612	3,679
NNE	0	0	0	22	42	31	285	380
NE	0	0	7	16	0	13	184	220
ENE	0	0	2	32	0	18	93	145
E	0	0	0	21	74	64	143	302
ESE	0	0	0	1	42	7	152	202
SE	0	0	0	8	21	51	493	573
SSE	0	0	0	0	25	19	248	292
S	0	0	0	4	8	7	180	199
SSW	0	0	0	7	18	21	172	218
SW	0	0	0	7	0	48	216	271
WSW	0	0	0	9	10	9	123	151
W	0	0	5	26	31	18	88	168
WNW	0	0	24	39	12	36	110	221
NW	0	0	0	77	21	2	117	217
NNW	0	0	6	3	10	11	1,924	1,954
TOTAL	0	0	44	293	331	384	8,140	9,192
CUM. TOTAL	0	0	44	337	668	1,052	9,192	

* Does not include 1992 local survey

TABLE A.3.1-5

1990 CENSUS POPULATION BY SECTOR INCLUDING 1992 SURVEY* ESTIMATES WITHIN 10 KILOMETERS OF THE SITE

	KILOMETERS							
SECTOR	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-10	0-10 TOTAL
N	0	0	0	*22	17	29	3,612	3,680
NNE	0	0	0	22	*45	31	285	383
NE	0	0	7	*17	0	*16	184	224
ENE	0	0	2	32	0	18	93	145
E	0	0	0	*24	*77	*73	143	317
ESE	0	0	0	1	*43	*10	152	206
SE	0	0	0	8	21	*54	493	576
SSE	0	0	0	0	25	19	248	292
S	0	0	0	*7	8	*8	180	203
SSW	0	0	0	7	18	21	172	218
SW	0	0	0	*10	0	*54	216	280
WSW	0	0	0	9	10	*12	123	154
W	0	0	*8	26	*38	*27	88	187
WNW	0	0	*26	*43	*14	36	110	229
NW	0	0	*2	*75	21	2	117	217
NNW	0	0	6	*6	10	*16	1,924	1,962
TOTAL	0	0	51	309	347	426	8,140	9,273
CUM. TOTAL	0	0	51	360	707	1,133	9,273	

* Estimated residents including additional non-contacted households.

TABLE A.3.1-6

1990 CENSUS POPULATION BY SECTOR WITHIN 80 KILOMETERS OF THE SITE

		KILOMETERS						
SECTOR	0-10 TOTAL	10-20	20-30	30-40	40-50	50-60	60-80	0-80 TOTAL
N	3,678	1,636	4,401	23,904	75,906	115,217	58,249	282,991
NNE	368	742	3,918	3,212	5,518	9,843	35,429	59,030
NE	243	1,566	1,845	2,154	3,774	11,225	14,675	35,482
ENE	142	4,032	3,014	2,004	2,240	4,857	4,738	21,027
E	238	1,174	1,318	2,633	2,861	1,001	4,830	14,055
ESE	219	1,356	551	1,383	2,069	4,931	17,636	28,145
SE	565	461	2,866	1,982	4,171	4,472	8,004	22,521
SSE	293	368	649	2,322	26,540	6,360	9,335	45,867
S	199	992	1,501	6,628	1,705	16,981	7,009	35,015
SSW	214	452	2,020	2,558	730	1,203	17,278	24,455
SW	264	752	2,059	2,649	4,027	9,788	56,482	76,021
WSW	167	438	724	2,349	2,580	4,585	14,334	25,177
W	142	421	6,208	1,923	4,248	29,572	9,361	51,875
WNW	194	1,182	3,633	6,599	7,483	17	0	19,108
NW	230	1,021	5,187	17,392	1,237	0	0	*25,067
NNW	1,990	1,218	8,155	53,753	106,278	298,206	103,844	*573,444
TOTAL	9,146	17,811	48,049	133,445	251,367	518,258	361,204	1,339,280
CUM. TOTAL	9,146	26,957	75,006	208,451	459,818	978,076	1,339,280	

* Does not include Canadian statistics 55-80 km in these sectors

TABLE A.3.1-7

1995 CENSUS POPULATION PROJECTIONS BY SECTOR WITHIN 10 KILOMETERS OF THE SITE

	KILOMETERS							
SECTOR	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-10	0-10 TOTAL
N	0	0	0	21	17	29	3,612	3,679
NNE	0	0	0	22	42	31	285	380
NE	0	0	7	16	0	13	184	220
ENE	0	0	2	32	0	18	93	145
E	0	0	0	21	75	65	143	304
ESE	0	0	0	1	42	7	153	203
SE	0	0	0	8	21	52	496	577
SSE	0	0	0	0	25	19	249	293
S	0	0	0	4	8	7	180	199
SSW	0	0	0	7	18	21	172	218
SW	0	0	0	7	0	48	216	271
WSW	0	0	0	9	10	9	123	151
W	0	0	5	26	31	18	88	168
WNW	0	0	24	39	12	36	110	221
NW	0	0	0	78	21	2	117	218
NNW	0	0	6	3	10	11	1,924	1,954
TOTAL	0	0	44	294	332	386	8,145	9,201
CUM. TOTAL	0	0	44	338	670	1,056	9,201	

TABLE A.3.1-8

1995 CENSUS POPULATION PROJECTIONS BY SECTOR WITHIN 80 KILOMETERS OF THE SITE

		KILOMETERS						
SECTOR	0-10 TOTAL	10-20	20-30	30-40	40-50	50-60	60-80	0-80 TOTAL
N	3,678	1,636	4,401	23,904	75,906	115,217	58,249	282,991
NNE	368	742	3,918	3,230	5,610	9,992	36,049	59,909
NE	243	1,567	1,891	2,236	3,919	11,659	15,009	36,524
ENE	142	4,098	3,109	2,078	2,327	5,046	4,924	21,724
E	238	1,181	1,321	2,657	2,888	1,009	4,896	14,190
ESE	220	1,366	552	1,395	2,087	4,975	17,804	28,399
SE	568	462	2,888	1,991	4,205	4,512	8,178	22,804
SSE	294	369	649	2,336	26,843	6,303	9,062	45,856
S	199	996	1,515	6,701	1,718	16,463	6,791	34,383
SSW	214	452	2,037	2,581	732	1,175	17,078	24,269
SW	264	755	2,073	2,661	4,053	9,876	56,867	76,549
WSW	167	439	725	2,366	2,603	4,627	14,466	25,393
W	142	421	6,251	1,939	4,286	29,852	9,448	52,339
WNW	194	1,182	3,634	6,605	7,522	17	0	19,154
NW	230	1,021	5,187	17,392	1,237	0	0	25,067
NNW	1,990	1,218	8,155	53,753	106,278	298,206	103,844	573,444
TOTAL	9,151	17,905	48,306	133,825	252,214	518,929	362,665	1,342,995
CUM. TOTAL	9,151	27,056	75,362	209,187	461,401	980,330	1,342,995	

TABLE A.3.1-9

2000 CENSUS POPULATION PROJECTIONS BY SECTOR WITHIN 10 KILOMETERS OF THE SITE

	KILOMETERS							
SECTOR	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-10	0-10 TOTAL
N	0	0	0	21	17	29	3,628	3,695
NNE	0	0	0	22	42	31	285	380
NE	0	0	7	16	0	13	184	220
ENE	0	0	2	32	0	18	93	145
E	0	0	0	21	76	65	143	305
ESE	0	0	0	1	42	7	153	203
SE	0	0	0	8	21	52	496	577
SSE	0	0	0	0	25	19	249	293
S	0	0	0	4	8	7	180	199
SSW	0	0	0	7	18	21	172	218
SW	0	0	0	7	0	48	216	271
WSW	0	0	0	9	10	9	123	151
W	0	0	5	26	31	18	88	168
WNW	0	0	24	39	12	36	110	221
NW	0	0	0	79	21	2	117	219
NNW	0	0	6	3	10	11	1,930	1,960
TOTAL	0	0	44	295	333	386	8,167	9,225
CUM. TOTAL	0	0	44	339	672	1,058	9,225	

TABLE A.3.1-10

2000 CENSUS POPULATION PROJECTIONS BY SECTOR WITHIN 80 KILOMETERS OF THE SITE

		KILOMETERS						
SECTOR	0-10 TOTAL	10-20	20-30	30-40	40-50	50-60	60-80	0-80 TOTAL
N	3,694	1,639	4,412	24,007	76,416	115,815	58,646	284,629
NNE	368	743	3,929	3,250	5,693	10,104	36,369	60,456
NE	243	1,570	1,927	2,300	4,032	11,993	15,204	37,269
ENE	142	4,135	3,176	2,134	2,393	5,191	5,067	22,238
E	238	1,182	1,321	2,657	2,890	1,009	4,917	14,214
ESE	220	1,368	552	1,395	2,087	4,975	17,806	28,403
SE	568	462	2,893	1,991	4,206	4,512	8,282	22,914
SSE	294	369	649	2,339	26,925	6,194	8,708	45,478
S	199	997	1,518	6,720	1,720	15,797	6,514	33,465
SSW	214	452	2,040	2,587	732	1,138	16,877	24,040
SW	264	755	2,075	2,661	4,065	9,965	57,257	77,042
WSW	167	439	725	2,374	2,627	4,669	14,598	25,599
W	142	422	6,265	1,952	4,324	30,137	9,537	52,779
WNW	194	1,184	3,644	6,619	7,568	17	0	19,226
NW	230	1,022	5,204	17,460	1,242	0	0	25,158
NNW	1,996	1,219	8,189	54,031	106,852	300,033	104,372	576,692
TOTAL	9,173	17,958	48,519	134,477	253,772	521,549	364,154	1,349,602
CUM. TOTAL	9,173	27,131	75,650	210,127	463,899	985,448	1,349,602	

TABLE A.3.1-11

2005 CENSUS POPULATION PROJECTIONS BY SECTOR WITHIN 10 KILOMETERS OF THE SITE

	KILOMETERS							
SECTOR	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-10	0-10 TOTAL
N	0	0	0	21	17	29	3,628	3,695
NNE	0	0	0	22	42	31	285	380
NE	0	0	7	16	0	13	184	220
ENE	0	0	2	32	0	18	93	145
E	0	0	0	21	76	65	143	305
ESE	0	0	0	1	42	7	153	203
SE	0	0	0	8	21	52	496	577
SSE	0	0	0	0	25	19	249	293
S	0	0	0	4	8	7	180	199
SSW	0	0	0	7	18	21	172	218
SW	0	0	0	7	0	48	216	271
WSW	0	0	0	9	10	9	123	151
W	0	0	5	26	31	18	88	168
WNW	0	0	24	39	12	36	110	221
NW	0	0	0	79	21	2	117	219
NNW	0	0	6	3	10	11	1,930	1,960
TOTAL	0	0	44	295	333	386	8,167	9,225
CUM. TOTAL	0	0	44	339	672	1,058	9,225	

TABLE A.3.1-12

2005 CENSUS POPULATION PROJECTIONS BY SECTOR WITHIN 80 KILOMETERS OF THE SITE

		KILOMETERS						
SECTOR	0-10 TOTAL	10-20	20-30	30-40	40-50	50-60	60-80	0-80 TOTAL
N	3,694	1,639	4,412	24,007	76,416	115,815	58,646	284,629
NNE	368	743	3,929	3,265	5,767	10,200	36,680	60,952
NE	243	1,570	1,964	2,365	4,148	12,337	15,403	38,030
ENE	142	4,173	3,245	2,193	2,462	5,341	5,216	22,772
E	238	1,183	1,321	2,681	2,916	1,017	4,961	14,317
ESE	220	1,370	552	1,407	2,105	5,020	17,970	28,644
SE	568	462	2,898	1,995	4,240	4,552	8,439	23,154
SSE	294	369	649	2,342	27,007	6,092	8,368	45,121
S	199	998	1,521	6,739	1,722	15,157	6,246	32,582
SSW	214	452	2,043	2,593	732	1,103	16,679	23,816
SW	264	755	2,077	2,661	4,077	10,054	57,650	77,538
WSW	167	439	725	2,382	2,652	4,711	14,730	25,806
W	142	422	6,274	1,965	4,362	30,427	9,628	53,220
WNW	194	1,184	3,644	6,624	7,607	17	0	19,270
NW	230	1,022	5,204	17,460	1,242	0	0	25,158
NNW	1,996	1,219	8,189	54,031	106,852	300,033	104,372	576,692
TOTAL	9,173	18,000	48,647	134,710	254,307	521,876	364,988	1,351,701
CUM. TOTAL	9,173	27,173	75,820	210,530	464,837	986,713	1,351,701	

TABLE A.3.1-13

2010 CENSUS POPULATION PROJECTIONS BY SECTOR WITHIN 10 KILOMETERS OF THE SITE

	KILOMETERS							
SECTOR	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-10	0-10 TOTAL
N	0	0	0	21	17	29	3,628	3,695
NNE	0	0	0	22	42	31	285	380
NE	0	0	7	16	0	13	184	220
ENE	0	0	2	32	0	18	93	145
E	0	0	0	21	76	65	143	305
ESE	0	0	0	1	42	7	153	203
SE	0	0	0	8	21	52	496	577
SSE	0	0	0	0	25	19	249	293
S	0	0	0	4	8	7	180	199
SSW	0	0	0	7	18	21	172	218
SW	0	0	0	7	0	48	216	271
WSW	0	0	0	9	10	9	123	151
W	0	0	5	26	31	18	88	168
WNW	0	0	24	39	12	36	110	221
NW	0	0	0	79	21	2	117	219
NNW	0	0	6	3	10	11	1,930	1,960
TOTAL	0	0	44	295	333	386	8,167	9,225
CUM. TOTAL	0	0	44	339	672	1,058	9,225	

TABLE A.3.1-14

2010 CENSUS POPULATION PROJECTIONS BY SECTOR WITHIN 80 KILOMETERS OF THE SITE

		KILOMETERS						
SECTOR	0-10 TOTAL	10-20	20-30	30-40	40-50	50-60	60-80	0-80 TOTAL
N	3,694	1,639	4,412	24,007	76,416	115,815	58,646	284,629
NNE	368	743	3,929	3,280	5,843	10,298	36,996	61,457
NE	243	1,570	2,001	2,432	4,267	12,693	15,604	38,810
ENE	142	4,211	3,317	2,253	2,532	5,494	5,367	23,316
E	238	1,184	1,321	2,681	2,918	1,017	4,983	14,342
ESE	220	1,372	552	1,407	2,105	5,020	17,972	28,648
SE	568	462	2,903	1,995	4,241	4,552	8,552	23,273
SSE	294	369	649	2,345	27,089	5,991	8,042	44,779
S	199	999	1,524	6,758	1,724	14,546	5,990	31,740
SSW	214	452	2,046	2,599	732	1,070	16,485	23,598
SW	264	755	2,079	2,661	4,089	10,146	58,048	78,042
WSW	167	439	725	2,390	2,677	4,754	14,864	26,016
W	142	422	6,283	1,978	4,401	30,719	9,719	53,664
WNW	194	1,184	3,644	6,630	7,646	17	0	19,315
NW	230	1,022	5,204	17,460	1,242	0	0	25,158
NNW	1,996	1,219	8,189	54,031	106,852	300,033	104,372	576,692
TOTAL	9,173	18,042	48,778	134,907	254,774	522,165	365,640	1,353,479
CUM. TOTAL	9,173	27,215	75,993	210,900	465,674	987,839	1,353,479	

TABLE A.3.1-15

SELECTED CROPS HARVESTED IN CATTARAUGUS AND ERIE COUNTIES

Selected Crops Harvested	Cattaraugus			Erie		
	1995	1996	1997	1995	1996	1997
Corn for grain	(6,200 A) 713,000 Bu	(6,700 A)[1] 670,000 Bu[2]	(7,100 A) 837,200 Bu	(11,700 A) 1,298,000 Bu	(12,300 A) 1,352,900 Bu	(13,200 A) 1,584,500 Bu
Corn for silage	(13,800 A) 218,000 Bu	(14,400 A) 225,800 Bu	(15,900 A) 248,900 T	(11,500 A) 171,300 Bu	(12,200 A) 184,300 Bu	(13,800 A) 220,800 T
Oats for grain	(2,200 A) 140,800 Bu	(2,500 A) 145,000 Bu	(3,300 A) 231,000 Bu	(2,600 A) 166,400 Bu	(2,200 A) 132,000 Bu	(2,800 A) 196,000 Bu
Total hay[3]	(42,000 A) 100,800 T	(39,800 A) 93,600 T	(38,000 A) 94,600 T	(38,800 A) 85,400 T	(36,000 A) 86,400 T	(36,100 A) 85,100 T
Wheat	Note 4	Note 4	Note 4	(2,100 A) 105,000 Bu	(2,500 A) 110,000 Bu	(2,200 A) 121,000 Bu

NOTES:

1. (Number) is acreage harvested.
2. Number is production in bushels (Bu) and tons (T) harvested.
3. Dry hay only. Excludes silage and green chop.
4. County statistics are included in other Counties.

Source NY Agricultural Statistics. September 1994, July 1997, and July 1998.

TABLE A.3.1-16

NUMBERS OF LIVESTOCK IN CATTARAUGUS & ERIE COUNTIES

Livestock	Cattaraugus		Erie	
	1996	**1997**	**1996**	**1997**
Cattle & Calves[1]	48,000	46,000[3]	34,000	37,000[3]
Beef cows[1]	2,100	2,400[3]	1,500	1,500[3]
Milk cows[1]	22,000	21,500[3]	16,000	17,000[3]
Thousand pounds of Milk produced[1]	359.1	354.8	258.0	265.6
Hogs[2]	900	900	2,600	2,600
Sheep[2]	900	1,000	1,500	1,400

Source:

1 New York Agricultural Statistics Service. Cattaraugus County Farm Statistics and Erie County Farm Statistics, and July 1997.

2 New York Agricultural Statistics Service, 1996.

3 New York State Agricultural Statistics Service, Table 116, Numbers of Livestock on Farms January 1, 1998.

TABLE A.3.1-17

NUMBER OF SCHOOL STUDENTS, TEACHERS, AND DISTRICTS IN ERIE AND CATTARAUGUS COUNTIES (FALL 1996-97)

School District	Number of Students	Number of Classroom Teachers
ERIE COUNTY		
Akron	1,598	107
Alden	1,993	131
Amherst	3,019	209
Buffalo	47,845	3,267
Catholic Diocese of Buffalo	25,506*	1,979*
Cheektowaga Central School	2,316	152
Cheektowaga-Maryvale Union Free School District	1,963	150
Cheektowaga-Sloan Union Free School District	1,735	106
Clarence	4,015	220
Cleveland Hill	1,568	93
Depew	2,670	183
E. Aurora	1,968	119
Eden	1,860	128
Evans-Brant	3,696	247
Frontier	5,498	333
Grand Island	3,228	217
Hamburg	4,265	255
Holland	1,434	100
Hopevale	125	20
Iroquois	2,826	157
Kenmore	9,248	585
Lackawanna	2,335	184
Lancaster	5,225	335
North Collins	5,246	346

TABLE A.3.1-17

(Concluded)

NUMBER OF SCHOOL STUDENTS, TEACHERS, AND DISTRICTS IN ERIE AND CATTARAUGUS COUNTIES (FALL 1996-97)

School District	Number of Students	Number of Classroom Teachers
Orchard Park	733	59
Springville-Griffith Institute	2,458	149
Sweet Home	4,056	269
Tonawanda	2,665	148
W. Seneca	7,337	449
Williamsville	10,621	766
CATTARAUGUS COUNTY		
Allegany - Limestone	1,613	111
Catholic Diocese of Buffalo	306*	20*
Cattaraugus	850	56
Ellicottville	791	52
Franklinville	1,045	77
Gowanda	1,515	110
Hinsdale	613	46
Little Valley	508	34
Olean	2,698	178
Portville	1,343	80
Randolph	1,049	77
Randolph Academy UFSD	167	35
Salamanca	1,525	116
West Valley	532	39
Yorkshire-Pioneer	3,668	239

Source: New York State School Report 1996-97. New York State Education Department March 4, 1998. Albany.

* June 1998 Data

TABLE A.3.1-18

REPORTED COMMERCIAL HARVEST OF 5 SPECIES OF FISH SOLD FROM THE NEW YORK WATERS OF LAKE ERIE 1994, 1996, 1997, and 1998[1]

FISH SPECIES	1994	1996	1997	1998
Whitefish	49 kgs (107 lbs)	0	0	0
Burbot	1374 kgs (3029 lbs)[3]	1532 kgs (3377 lbs)	1306 kgs (2886 lbs)	80 kgs (176.8 lbs)
Yellow Perch	1363 kgs (3006 lbs)	1285 kgs (2833 lbs)	563 kgs (1244 lbs)	600 kgs (1,326 lbs)
Rock Bass	0	0	252 kgs (557 lbs)	211 kgs (466.3 lbs)
White Perch	0	0	292 kgs (645 lbs)	0
TOTAL	2786 kgs (6142 lbs)	2817 kgs (6210 lbs)	2413 kgs (5333 lbs)	891 kgs (1,969.1 lbs)
Number of Commercial fishing licenses issued	2	2	1	1

NOTES:

1) Source: Annual Report Bureau of Fisheries Lake Erie Unit to the Lake Erie Committee and the Great Lakes Fishery Commission. March 1995 and 1997, February 1998, and February, 1999. New York State Department of Environmental Conservation, Albany, NY.

2) Source Table 23. Monthly distribution of the reported commercial catch of 3 species from New York waters of Lake Erie in 1998.

3) In 1994 only 366 kgs (807 lbs) or 27% of the Burbot landings were sold.

TABLE A.3.1-19

LAKE ERIE OPEN WATER SPORT FISHERY HARVEST SUMMARY

Year & Species	1989 (CI%)	1990 (CI%)	1991 (CI%)	1992 (CI%)	1993 (CI%)	1994 (CI%)	1996 (CI%)	1997 (CI%)	1998 (CI%)
Walleye	129,226 27%	47,443 28%	34,137 36%	14,384 38%	40,032 22%	59,345 26%	38,728 (19%)	29,395 (27%)	34,090 (24%)
Yellow perch	172,238 62%	27,575 63%	13,435 91%	13,439 43%	9,360 39%	10,745 39%	3,148 45%	2,274 (90%)	4,744 (75%)
Smallmouth bass	21,093 32%	14,884 37%	17,220 39%	24,472 39%	14,149 24%	22,840 25%	21,794 19%	21,943 (28%)	26,496 (24%)
Lake trout	3,024 44%	1,505 46%	1,835 53%	1,868 63%	1,897 33%	1,341 39%	1,058 42%	227 (75%)	363 (59%)
Chinook salmon	502 67%	136 104%	156 118%	73 133%	116 69%	57 106%	0	0	0
Rainbow trout	727 53%	828 52%	1,667 57%	956 54%	547 40%	454 48%	519 53%	421 (74%)	355 (58%)
Coho salmon	521 60%	389 91%	221 120%	152 103%	141 64%	32 149%	0	0	0
Brown trout	350 70%	118 130%	66 166%	44 152%	556 50%	32 149%	0	0	0
# of angler-hours	657,382	881,447	667,829	606,555	561,091	635,011	551,644	580,225	605,394
# of fishing-trips	NA	160,569	118,269	124,563	NA	NA	N/A	N/A	N/A

CI % = Confidence Intervals, two standard errors given as percent of sample mean, are reported for each year's estimates.

NA Not Available

Source: Table 21 Catch and Harvest of Selected Species NYSDEC March 1991,1992, 1993. April 1994, March 1995, March 1996, February 1998, and Table 16. February, 1999.

TABLE A.3.2-1

**LOCAL FACILITIES REPORTING
SARA TITLE III HAZARDOUS MATERIALS**

Facility in Erie County	Chemical and Quantity Reported	Vulnerability Zone Classification
Robinson/Fiddlers Green Manufacturing Co. 243 West Main St, Springville, NY Housewares, machine knives, injection-molded components manufacturer	Ammonia - 38,000 lbs	> 10 miles
Village of Springville Wastewater Treatment Plant Mill St, Springville, NY Chemicals used for sewage/wastewater treatment	Chlorine - 3,000 lbs Sulfur Dioxide - 3,000 lbs	> 10 miles
Village of Springville Water Treatment Plant 243 W Central Avenue Springville, NY Water Supply Treatment Chemicals	Chlorine - 6,000 lbs	> 10 miles
Winsmith-Peerless Winsmith, Inc. 172 Eaton Springville, NY Machine shop, metal treatment	Ammonia - 6,000 lbs Hazardous Waste Storage of Sodium Cyanide - 200 lbs (Below threshold quantity)	> 10 miles
AT&T Moore Road Springville, NY (Townsend Hill NW of Springville) Long Distance Communications	Emergency power batteries containing sulfuric acid #2 Fuel Oil in an underground tank (< 10,000 lbs)	
National Fuel Gas Supply Corp. Concord Station 5510 Genesee Road Natural Gas supplier	Diesel fuel in an underground tank	--
MCI Telecommunications Cellular One Emerling Rd. near Brown	Emergency power batteries containing sulfuric acid	
Facility in Cattaraugus County		
U. S. DOE (West Valley Demonstration Project) 10282 Rock Springs Road, West Valley, NY 14171-0191	Nitric Acid (CAS # 7697-37-2) Sulfuric Acid (CAS # 7664-93-9) Anhydrous Ammonia (CAS # 7664-41-7)	10

TABLE A.3.4-1

WATER SUPPLY RESERVOIR TRENDS IN WATER-SEDIMENT VOLUME RATIOS FROM 1963 TO 1991

Water Volume (ft^3)

YEAR	RESERVOIR #1	RESERVOIR #2	TOTAL
1963	14,340,909	2,505,671	16,846,580
1980	12,773,761	1,967,253	14,741,014
1991	11,759,723	1,618,855	13,378,579

Sediment Volume (ft^3)

YEAR	RESERVOIR #1	RESERVOIR #2	TOTAL
1963	0	0	0
1980	1,567,148	538,418	2,105,566
1991	2,581,186	886,815	3,468,001

Percent Water

YEAR	RESERVOIR #1	RESERVOIR #2	TOTAL
1963	100	100	100
1980	89	79	88
1991	82	65	79

Percent Sediment

YEAR	RESERVOIR #1	RESERVOIR #2	TOTAL
1963	0	0	0
1980	11	21	12
1991	18	35	21

TABLE A.3.4-2

PROBABLE MAXIMUM FLOOD ELEVATIONS AT STREAM LOCATIONS ADJACENT TO SAFETY-RELATED FACILITIES

Cross-Section No.	Stream	PMF Floodwater Elevation (feet [NGVD])	Feet Below Nearest Facility Elevation (Nearest Facility)
10790	Quarry Creek	1347.2	62.8 (Main Plant)
20160	Erdman Brook	1321.6	53.4 (Lagoons 2 & 3)
21090	Erdman Brook	1347.2	32.8 (IWSF - NDA)
6695	Frank's Creek	1375.8	14.2 (RTS Drum Cell)

TABLE A.3.4-3

HYDROLOGIC DISCHARGE OF THE WVDP FACILITIES WATERSHED

Watershed Data

Drainage area	1.82 sq mi
Average runoff curve number	76
Number of subareas	22
Number of structures	4
Number of reach routings performed	3

	2-Year	10-Year	100-Year	PMP
Rainfall Amount (inches) (In 24 hours)	2.5	3.7	5.2	24.9
Runoff Amount (inches) (In 24 hours)	0.64	1.41	2.55	19.93
Peak Discharge Rate (cfs)	453.35	1,041.06	1,754.00	14,021.18

TABLE A.3.4-4

RESERVOIR DAM CHARACTERISTICS

	Reservoir 1	Reservoir 2
Upstream Side/slope	2.5:1	2.5:1
Downstream Side/slope	2:1	1.5:1
Maximum Height	75 feet	50 feet
Embankment Material	Compacted Earth	Compacted Earth
Anti-Seep Device	Sheet Piling	None
Spillway	Emergency Spillway	Control Structure and 36-in CMP Barrel

TABLE A.3.5-1

HYDRAULIC CONDUCTIVITY AND SATURATED THICKNESS OF THE SURFICIAL SAND AND GRAVEL LAYER

Well Number[1]	Hydraulic Conductivity (cm/sec)*	Saturated Thickness (m)
80-1	2.9×10^{-3}	4.5
80-2	3.0×10^{-4}	2.5
80-3	9.1×10^{-3}	1.0
80-4	2.0×10^{-4}	1.6
80-5	3.0×10^{-4}	3.3
80-6	1.0×10^{-4}	0.8
80-7	4.0×10^{-4}	0.0
80-8	1.7×10^{-3}	2.8
	7.0×10^{-4}**	

* Calculated from slug test data method of Cooper et al. (1967).
** Geometric mean.

(1) See Figure A.3.5-5 for locations.

TABLE A.3.5-2

NORTH PLATEAU HYDRAULIC CONDUCTIVITY ESTIMATES

Well[1]	Hydraulic Conductivity (ft/sec)	x 30.48	Test Situation	Screened Interval (ft)	Screened Materials
0104	8.09×10^{-8}	2.5 E-6 cm/s	Unconfined	6-23	S&G
0105	7.17×10^{-7}	2.2 E-5 cm/s	Unconfined	11-28	S&G
0106	7.26×10^{-8}	2.2 E-6 cm/s	Unconfined	7.5-14	S&G
0301	3.00×10^{-7}	9.1 E-6 cm/s	Unconfined	5-16	S&G
0401	3.93×10^{-7}	1.2 E-5 cm/s	Unconfined	4-12	S&G
0601	2.31×10^{-6}	7.0 E-5 cm/s	Unconfined	3-6	S&G
0602	1.63×10^{-7}	5.0 E-6 cm/s	Unconfined	6-13	S&G
0603	7.38×10^{-8}	2.2 E-6 cm/s	Unconfined	6-13	S&G
0604	9.93×10^{-7}	3.0 E-5 cm/s	Unconfined	5-6	S&G
0605	2.75×10^{-7}	8.4 E-6 cm/s	Unconfined	4-7	S&G
0706	3.56×10^{-7}	1.1 E-5 cm/s	Unconfined	4.5-11	S&G
0801	4.32×10^{-7}	1.3 E-5 cm/s	Unconfined	6-17.5	S&G
0802	2.79×10^{-6}	8.5 E-5 cm/s	Unconfined	5-11	S&G
0803	6.38×10^{-7}	1.9 E-5 cm/s	Unconfined	6-18	S&G
0804	3.65×10^{-7}	1.1 E-5 cm/s	Unconfined	3-9	S&G
R-86-13B	3.18×10^{-5} 5.08×10^{-5}	9.7 E-4 cm/s 1.5 E-3 cm/s	Unconfined	2.5-8	S&G
R-86-13C	2.17×10^{-5}	6.6 E-4 cm/s	Unconfined	1.25-6.5	S&G

(1) See Figure A.3.5-6 for locations.

TABLE A.3.5-3

ESTIMATED GROUNDWATER BUDGET FOR THE SAND AND GRAVEL LAYER OCTOBER 1982 THROUGH SEPTEMBER 1983

	Recharge (cm/yr)
Infiltration from precipitation	50
Underflow from bedrock	12
Leakage from main plant's outfall channel	4
Total	66

	Discharge (cm/yr)
Stream channels	13
Springs and seepage faces	21
French drain, LLWTF	2
Vertical leakage to till	1
Groundwater evapotranspiration	18
Change in storage	4
Total	61*
Mass Balance Error	8%

From Yager 1987.

* Sum not exact due to rounding.

TABLE A.3.5-4

SUMMARY OF HYDRAULIC CONDUCTIVITY DATA FOR SUBSURFACE SOILS AT OR NEAR THE NDA

Geologic Unit	Orientation	Method	No. of Data Points	Geometric Mean (cm/sec)	Arithmetic Mean (cm/sec)	Standard Deviation (cm/sec)	Range (cm/sec)
Weathered Till	K_v	Lab Permeameter Tests*	6	3.5×10^{-8}	4.4×10^{-8}	3.8×10^{-8}	2.1×10^{-8} to 4.3×10^{-8}
Weathered Till	K_h	Slug Tests**	9	3.1×10^{-7}	5.2×10^{-6}	1.3×10^{-5}	2×10^{-8} to 4×10^{-5}
Weathered Till	K_h	Slug Tests***	6		4.28×10^{-6}	2.03×10^{-6}	7.3×10^{-7} to 7.3×10^{-6}
Unweathered Till	K_v	Lab Permeameter Tests; Consolidation Tests+	36	3.2×10^{-8}	3.9×10^{-8}	2.6×10^{-8}	0.9×10^{-8} to 9.3×10^{-8}
Unweathered Till	K_h	Lab Permeameter Tests, Slug Tests++	33	4.1×10^{-8}	7.2×10^{-8}	1.4×10^{-7}	1×10^{-8} to 7.5×10^{-7}
Unweathered Till	K_h	Slug Tests***	7		2.14×10^{-6}	1.22×10^{-6}	4.1×10^{-7} to 4.4×10^{-6}
Lenses of Sorted Material in the Till	K_h	Slug Tests++	10	1.8×10^{-6}	4.3×10^{-6}	6.2×10^{-6}	2×10^{-7} to 2×10^{-5}

Total Porosity : 0.322
Effective Porosity : 0.17
Dry Density 1.86 gm/cm^3
Specific Flux (unweathered till) : 2.4 cm/yr
Specific Flux (unweathered till) : 3.2 cm/yr

* Bergeron 1985
** Prudic 1986
*** Dames & Moore 1990
+ Prudic 1985, Bergeron 1985, WVNs 1985
++ Prudic 1985

TABLE A.3.5-5

HORIZONTAL HYDRAULIC CONDUCTIVITY VALUES

WELL ID[1]	HYDRAULIC CONDUCTIVITY (cm/sec)	TEST SITUATION	SCREENED INTERVAL (ft)	SCREENED MATERIALS	ARITHMETIC MEAN OF UNIT TESTED
1101A	7.32×10^{-7}	Unconfined	5-16	WEATHERED Till	
1102A	3.22×10^{-6}	Unconfined	5-17	WEATHERED Till	
1103A	5.06×10^{-6}	Unconfined	4-16	WEATHERED Till	
1104A	3.86×10^{-6}	Unconfined	3.4-19	WEATHERED Till	
1106A	5.55×10^{-6}	Unconfined	4.5-16	WEATHERED Till	
1107A	7.25×10^{-6}	Unconfined	3.5-19	WEATHERED Till	4.28×10^{-6} cm/sec
1101B	9.07×10^{-7}	Confined	17.5-30	UNWEATHERED Till	
1102B	4.14×10^{-7}	Confined	19.6-31	UNWEATHERED Till	
1103B	2.12×10^{-6}	Confined	19-36	UNWEATHERED Till	
1104B	2.11×10^{-6}	Confined	19-36	UNWEATHERED Till	
1105A	3.00×10^{-6}	Confined	8.8-21	UNWEATHERED Till	
1105B	2.03×10^{-6}	Confined	19-36	UNWEATHERED Till	
1106B	4.40×10^{-6}	Confined	19-31	UNWEATHERED Till	2.14×10^{-6} cm/sec
1101C	3.86×10^{-7}	Confined	91-109	LACUSTRINE/OUTWASH	
1103C	2.29×10^{-8}	Confined	103.5-121	OUTWASH	
1104C	1.25×10^{-6}	Confined	112-124	OUTWASH/LACUSTRINE	

[1] See Figure A.3.5-6 for locations.

TABLE A.3.5-6

SOIL PROPERTIES OF LAVERY TILL SAMPLES

OBTAINED IN VICINITY OF THE NDA

BORING NO.[1]	DEPTH (m)	DRY DENSITY (g/cm^3)	COMPUTED TOTAL POROSITY† (n)	PERCENT MOISTURE CONTENT (wt. basis)	COMPUTED PERCENT SATURATIO N (S)	REFERENCE*
82-1B	0.9 - 1.45	1.83	0.32	17.5	99	1
82-1B	6.1 - 6.6	1.76	0.35	20.5	104	1
82-1B	10.4 - 10.9	1.72	0.36	22.4	106	1
82-1B	10.4 - 10.9	1.77	0.34	20.6	106	1
82-1D	15.2	1.87	0.31	16.3	99	2
82-1D	18.3	2.09	0.23	11.8	109	2
82-1D	21.3	2.05	0.24	13.7	117	2
82-1D	24.3	1.79	0.34	15.0	80	2
82-2A	1.5 - 1.9	1.93	0.29	12.4	84	1
82-2B	6.2 - 6.7	1.82	0.33	18.5	103	1
82-3A	1.2 - 1.7	1.86	0.31	17.0	102	1
82-3A	5.0 - 5.5	2.09	0.23	11.2	104	1
82-3B	9.8 - 10.3	1.86	0.31	17.7	106	1
82-3B	9.8 - 10.3	1.88	0.30	16.6	103	1
82-3D	16.1	1.95	0.28	12.8	90	2
82-3D	18.3	2.03	0.25	11.7	96	2
82-4B	6.1 - 6.6	1.76	0.35	20.5	104	1
82-4B	10.4 - 10.9	1.89	0.30	16.8	106	1
82-4B	10.4 - 10.9	1.92	0.29	16.6	110	1
82-5A	1.8 - 2.3	1.85	0.31	17.3	102	1
82-5B	3.0 - 3.6	1.82	0.33	18.4	103	1
83-1E	13.6	1.85	0.31	20.5	120	2
83-2E	6.1	1.99	0.26	11.7	89	2
83-2E	12.3	1.82	0.33	19.9	111	2
83-2E	15.2	1.56	0.42	27.2	100	2
83-2E	21.3	1.71	0.37	23.0	107	2
83-3E	3.0	1.89	0.30	45.5	98	2

TABLE A.3.5-6 (concluded)

BORING NO.[1]	DEPTH (m)	DRY DENSITY (g/cm^3)	COMPUTED TOTAL POROSITY† (n)	PERCENT MOISTURE CONTENT (wt. basis)	COMPUTED PERCENT SATURATIO N (S)	REFERENCE*
83-3E	6.1	1.95	0.28	13.5	95	2
83-3E	9.1	1.94	0.28	13.5	93	2
83-3E	12.5	1.68	0.38	21.4	95	2
83-3E	15.2	2.26	0.16	11.8	164	2
83-3E	18.3	1.36	0.50	36.0	99	2
Arithmetic Mean Values		1.86	0.311	17.5	103	
Standard Deviation		0.16	0.061	5.2	14	
Range		1.36 - 2.26	0.16 - 0.50	11.2 - 36.0	80 - 164	

† Assumes specific gravity for the till soil of 2.70 gm/cm^3 based on three tests on till samples taken in a boring located north of the NFDA.

* References: 1) Bergeron, and others, 1985.

2) WVNSC, 1985

(1) See Figures A.3.6-15 and A.3.6-22b for locations.

TABLE A.3.5-7
SUMMARY OF POROSITY DATA FOR THE LAVERY TILL

HOLE (#)	DEPTH OF SAMPLE (m)	SOIL DESCRIPTION	SATURATED HYDRAULIC CONDUCTIVITY* (cm/sec)	TYPE OF PERMEABILITY TEST	TOTAL POROSITY	EFFECTIVE POROSITY**
D1	4.4 - 4.6	TILL: Silt with clay; gravel and pebbles	1.9×10^{-8} (V)	Lab. Permeameter (Falling Head)	0.345	0.156
F	10.7 - 10.8	TILL: Silt with clay; gravel and pebbles	6.0×10^{-8} (H) (for depth range: 15.5 - 16.2 m)	Slug Test	0.27	0.18
G	9.3 - 9.4	TILL: Silt with clay; rare gravel and pebbles	3.5×10^{-8} (H) (for depth range: 7.5 - 8.1 m)	Slug Test	0.25	0.16
G	11.1 - 11.2	LACUSTRINE LAYERS: Clay with silt; silt with clay, silt	4.0×10^{-8} (H) (for depth range: 12.3 - 12.9 m)	Slug Test	0.33	0.23
I	11.7 - 11.8	TILL: Silt with clay; gravel and pebbles	3.4×10^{-8} (C)	Lab. Permeameter (Falling Head)	0.30	0.215
112	9.9 - 10.1	TILL: Silt with clay; gravel and pebbles (At 10.0 m, thin layers of fine sand with silt)	2.0×10^{-7} (H)	Slug Test	0.30	0.14
R	7.0 - 7.2	Not Available (Assumed to be Till)	3.5×10^{-8} (H)	Slug Test	0.366	0.164

* (V) = vertical
(H) = horizontal
(C) = composite; mean of horizontal and vertical conductivities
** Defined as porosity of those pores with entrance diameters greater than 0.1 micron.

NOTES:
(1) Moisture-Tension determinations were performed by mercury-injection (mercury porosimeter) tests by the USGS Hydrologic Laboratory in Denver, Colorado.
(2) Total porosity and effective porosity determinations were also made by the USGS Hydrologic Laboratory.
(3) Values for saturated hydraulic conductivity were taken from Prudic (1982).
(4) Values for porosity and effective porosity provided by Prudic (1985b).

(#) See Figure A.3.6-21a for locations.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (1 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
1	Reed, David	Thomas Corners Rd.	1130	D,A	Dug	18"	17	3'	Gravel	4	Sub	6' Flowing	9/82	100 cattle; alternative sources of water
2	Reed, David	Thomas Corners Rd.	1300	D,A	Spring					4			9/82	100 cattle; alternative sources of water.
3	Watson, Rich	Bond Rd.	1245	D,A	Spring					3	S.W.	Flowing	9/82	Supplies a small tree nursery
4	Waterstram	Thomas Corners Rd	1330	D,A	Dug	36"	12		Sand	0	Piston		9/82	Used by Schichtel Nursery; a large tree farm
5	Waterstram	Thomas Corners Rd.	1330	D	Auger	4"	10-12	---	Sand	2	Piston		9/82	
6	Wulff, D.	Thomas Corners Rd.	1330	D	Well Point	2"	12	4'	Sand	3	Piston or Jet		9/82	Never runs dry
7	Wolniewicz, C.	Bond Rd.	1350	D	Spring	cement block holding basin				5	S.W.	Flowing	9/82	
8	Wolniewicz, C.	Bond Rd.	1280	D	36" steel Dug	tube	18		Sand	S.W. 2	Jet	1.0	9/82	
9	Clark, R.	Bond Rd.	1350	D	36" concrete Dug	tube	15		Sand	S.W. 4	Jet	4.0	9/82	Very quick recovery
10	Bond, F.	Bond Rd.	1310	D	Dug	24" tile	20		Sand	5	S.W.	17.0	9/82	
11	Bonds Meat Co.	Bond Rd.	1280	D,S,C	Spring	30" x 7' deep fiberglass tank				5	Sub.+ S.W.	3.0	9/82	Locate 12' below edge of bank; 80 cattle. Board of Health chemical analysis every 6 months.
12	Fuller, Wilber	Bond Rd. + Rt 240	1310	D,S	Drl	6"	150		Shale	2	Sub.	20.25	9/82	7-15 cattle
13	Gilber, Alice	Rt. 240	1260	D	Drl	6"	160	30' 5"	Shale	2	Sub.	17' 7"	9/82	Test yield: 1 gpm
14	Wells, Richard	Rt. 240	1345	U	Dug	36"	12-15		Gravel	0	---	5.0	9/82	
15	Fuller, W. Jr.	Rt. 240	1250	D	Spring						Gravity Fed	Flowing	9/82	In 7/78, spring was dry for two months
16	Miller, Alberta	Beech Tree Rd.	1300	D	Drl	6"	165	0	Shale	0	Sub	92.66	9/82	

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (2 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
17	Fuller, Mag/John	Beech Tree Rd.	1220	D	Drl					1			9/82	
18	Fuller, Mag/John	Beech Tree Rd.	1220	U	Spring								9/82	Used to supply cattle farm in the past
19	Fagnan, R.	Watson Rd.	1310	D	Drl	6"	170	8' at 118'- -126 B.G.	Shale	3	Sub			Tested yield: 15 gpm at 110', 118'-126' B.G. is a screened interval
20	Odvarka, G.	Watson Rd.			Spring									Summer recreational use only not used for drinking water
21	Steiner, R.	Watson Rd.	1190	D	Spring					5	S.W.			Slow recovery in the summer
22	Bobseine, W.	Watson Rd.	1200	D	Spring	1,000 gal. cement tank				3	S.W.			Slow recovery in the summer
23	Fuller, Rich	Beech Tree Rd.		D	Drl	6"	199	162	Shale	3	Sub	89.33'	9/82	
24	Fuller, Rich	Beech Tree Rd.		U	Drl	6"	167		Shale	0	None	84.66'	9/82	
25	Fuller, Rich	Beech Tree Rd.		U	Dug	36"	18	---	Clay/Sand	0	None	0	9/82	
26	Martin, T.	Watson Rd.	1280	D,S	Drl	6"	200	3	Shale	4	S.W. Jet	+0.5'		8 pigs, tested yield 1.5 very good recovery
27	Place, J.	Beech Tree Rd.	1280	D	Well Point	2"	10	4	Sand	4	S.W.			Tested yield; 3 gpm tempo-rary; to be replaced by a drilled well
28	Place, Morris	Beech Tree Rd.	1280	D	Dug	2'	10-15		Sand	3	S.W. Jet	0.5	9/82	
29	Schweiker, T.	Beech Tree Rd.	1374	D	Spring	Stone Cistern				7	Gravity Fed			67 cattle, not a flowing spring
30	DeGrange, L.	Rt. 240	1430	D	Drl	6"	90		Shale	5	Sub	26.0		Tested yield 8 gpm
31	DeGrange, L.	Rt. 240	1325	C	Dug		9		S & G	0	Jet	5		Covered by garage floor
32	Thurbor, A.	Jet or Rt. 240	1280	U	Drl	6"	60			0	Piston			Cap rusted on pipe; could not take reading.
33	Rogers, C.	Thomas Corners Rt. 240	1410	D	Drl	8"	65		Shale	3	Sub			Does not want well opened

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (3 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
34	Buffam, G.	Thomas Corners	1380	D	Drl	6"	105	75	Shale	8				Tested yield, 4 gpm unable to measure s.w.l. well used by Newkirk, D., next door
35	Kean, George	Bond Rd.	1345	D	Dug	24" steel tube	12	Sand and	Gravel	4	Piston or Rotary			Soft water, no supply problems
36	Emerson, R.	Thomas Corners	1360	D,A	Driven Well Point	1 3/4"	22	4	Sand	7	Rotary			12 cattle, cannot be pumped dry
37	Emerson, Ed	Thomas Corners Rd.	1335	D	Dug Tile Lined	24"	12		Sand	2	Sump	4.0 assumed	9/82	Well tapped into a "spring" -never dries up, granular sand, little clay
38	Emerson, Ed	Thomas Corners Rd.	1360	U	Dug and Drilled	3'	40	---	Sand	0		---	---	Not used-water "too hard" dries up in winter
39	Tucholski, J.	Emerson Rd.	1330	D	Dug	24" steel tube	12	---	Sand	2				Site listed as swamps on quad
40	Somas, V.	Emerson Rd.	1330	D	Dug	24" steel tube	12	---	Sand	2				Site listed as swamps on quad
41	Gephart, Wm.	Emerson Rd.	1340	D	Dug	24" steel tube	12	---	Sand	2				Site listed as swamps on quad
42	Morgan, F.	Rt. 240												
43	Brooks, Wm.	Rt. 240 1413	D	Drl	6"	100		Shale	3	Sump				
44	Bond, F.	Cole Rd.	1440	D	Drl	6" x 13' steel case	90-105	77-92	Shale	2	Jet			11' of water in tube (F. Bond 9/82) 8 gpm recovery
45	Offorbeck, J.	Cole Rd.	1465	D	Drl	6"	100 ±2	80	Shale	6	Jet	26.75'	9/82	Tested yield estimate set at 400 gph (owner)
46	Stedman, J.	Cole Rd.	1465	D	Drl	6"	62		Shale	1	Jet			Silt accumulates in water water after a heavy rain
47	Kessler, A.	Cole Rd.	1480	D	Drl	6"			Shale	2	Piston			

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (4 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
48	Evens	Cole Rd.	1460	D	Drl	6"	60-65		Shale	5	Jet	30.5	9/82	Listed depth may be casing length, not well depth
49	Wilson, D.	Cole Rd.	1460	D	Drl	6"	60		Shale	3	Jet			
50	Kendall, R.	Cole Rd.	1460	D	Drl	6"	40			3	Sump			
51	Belscher, K.	Cole Rd.	1550	D	Spring 4'x11'x7' Tile Cistern					3	Gravity fed flowing spring			
51a	Rendell, W.	Cole Rd.	1550	D	Spring					3				51 cattle
52	Rendell, R.	Cole Rd.	1530	D	Spring Supplies Both Homes					4	gravity fed			
52a	Rendell, K.	Cole Rd.	1530	D	Drl					4				
53	Emerson, L.	Cole Rd.	1480	D	Drl	6"	30-40		Shale	4	Sub			Tested yield 4 or 5 gpm (1974) Owner: Yield is higher than 4-5 gpm
54	Codd, R.	Rt. 240	1460	D	Drl	6"	100	65	Shale	2	Sub	41.0	9/82	Tested yield: 18 gpm
55	Rogers, G.	Rt. 240	1460	D	Drl	6"	32	12	Shale	5	S.W.			Tested yield: 10 gpm
56	Boberg, D.	Rt. 240	1450	D	Drl	6"	40			5	Sub	20	1978	Tested yld: 13 gph (owner)
57	Codd, J.	Bond Rd.	1325	D	Dug	24"	12		Sand	2				200' E of house
58	Dobies, J.	Rt. 240	1440	D	Drl	6"	80		Shale	5	Jet	25	1952	Tested yield: 75 gpm-well pumped all day with no drawdown
59	Heinen, F.	Rt. 240	1440	D,S	Drl	6"	100	60	Shale	10	Jet	70'	1969	3,000 chickens; owner; 24 hrs pumping at 25 gpm did not lower the W.L.
60	Smith, G.	Rt. 240	1490	U	Drl	6"	73	8	Shale	0	Sub	50.5	11/61	From LaScala, 1968
61	Nelson, R. Pond No. 3	Rt. 240	1500	D,A,S	Spring						Gravity fed			60 cattle, never dried up
61a	Wilson	Rt. 240												

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (5 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
62	Croakman, H.	Rt. 240 1440	D	Drl	6"	129		Shale	8	Jet	27.33	9/82	Fe-Ca rich	
63	Nelson, R.	Rt. 240	D	Drl	6"	125		Shale	7	Jet	25	1952		
64	Zefers, D.	Rt. 240 1440	D	Drl	6"	155		Shale	3	Sub	20	1972		Well used in past to supply 5,000 chickens, 60 cattle
65	Zefers, D.	Rt. 240 1450	D	Drl	6"	160		Shale	4	S.W.	<20	---		
66	Wagner, R.	Rt. 240 1460	D	Spring						3	Jet			
67	Zefers, M.	Rt. 240 1500	D	Drl	6"	130	130	120- Shale	2	Sub	0			*Will overflow if not pumped
68	Zimmerman	Rt. 240 1510	D,S	Drl	6"	98		Shale	4	Sub	12	1956		74 cattle; tested yield 12-14 gpm; would like water sampled
69	Kester, H.	Rt. 240 1490	D	Drl	6"	165		Shale	6	Jet	---	---	Unable to sample	
70	W.V. Conservation Club	Rt. 240												
71	Goggin, J.	Rt. 240 1500	D	Drl	6"	173	43-53	Shale	3	Sub	17' 11"	9/82		
72	Zakulski, W.	Twitchell Rd. 1520	D	Drl	6"									
73	Rt. 240 + Steffenhagen, P.	Green Rd.	1510	D,S	Drl	6"	105		Shale	6	Jet	*		28 cattle; tested yield 7 gpm; *excellent recovery-overnight the well will overflow if not pumped
74	Lara, I. Rt. 240													
75	Schumacher, G.	Rt. 240 1535	D	Drl	6"	96	92-	Shale	4	Jet	66	'73	Can be pumped dry	Spring
76	Ebel, D.	Twitchell Rd. 1570	D,S	Spring					3	fed	Gravity spring	flowing	9 cattle	
77	Heary, T.	Heinz Rd.	1570	D	Drl	6"	92.4		Shale	3	Jet	58.4	4/28/62	27 cattle, 3 pigs 1-LaScala, 1968
78	Heary, T.	Heinz Rd.	1540	D	Spring					3		20.0	9/82	6 horses
79	Case	Rt. 240 1550	D	Drl	6"	125								

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (6 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
80	Day, K. (Fuller)	Rt. 240 1550	D	Drl	6"	78				3				Well under porch, inacces-sible. New owner has minimal knowledge of well
81	Heary, S.	Rt. 240												
82	Jones, H.	Rt. 240 1450	D	Drl	10"	60		Shale	4	Sub	32	9/82	Tested yield: 4 gpm 60	
83	Latona, J. J.	Rt. 240 1560		Drl	8"	90			2	or jet	Piston 10.25	9/82 90		
84	Flintjer, G.	Buttermilk Rd.	1520	D	Spring					3	S.W.			300 gallon recovery in one day
85	Flintjer, G.	Buttermilk Rd.	1420	D	Drl	8"	110	70	Shale	2	Sub	60	1971	Tested yield 16.66 gpm 110
86	Flintjer, G.	Buttermilk Rd.	1520	U	Spring									
87	Spittler, F.	Fox Valley Rd.	1415	D,S	Drl	6"				3	S.W.			25 cattle, uncooperative
88	Swartz, M.	Fox Valley Rd.	1410	D	Drl	6"								Uncooperative
89	Town of Ashford	Fox Valley Rd.	1450	I	Drl	6"	325		Shale		Sub 325			
90	Widrig, W.	Fox Valley Rd.	1450	D,S	Drl	6"	300		Shale	8	Sub	75.0	Spring '82	60 cattle, sub. pump at 170' B.G. 300
91	Skinner, W.	Dutch Hill Rd.	1890	D	Spring					2	S.W. Jet			B.O.H.
92	Mullen Rock Springs	1840 U	Dug	box	6	48" wooden	fed 6		Spring					
93	Mullen Rock Springs	1840 D	Drl	6"	100	70	Shale	3	Jet	0	9/82	At one time, fed 100 cows 100		
94	Goll; Schumacher	Rock Springs		U	Spring									
95	Hauri, D.	Rock Springs		D,S	Spring					4	Jet			A good supply
96	Lee, Wm.	Dutch Hill	1890	D	Drl	6"	90		Shale	7	Sub	41.66'	9/82 90	
97	Lloyd	Dutch Hill	1845	D	Dug	36"	15		Silty Sand	5	S.W.			Cover over well difficult to move w/o disturbing con-struction of well 15

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (7 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
98	Wilkosz, F.	Dutch Hill	1840	D,S	Drl	6"	100	<60	Shale	7	Jet	25' 7"	9/82	6 cattle
99	Myers, D.	Dutch Hill												
100	Turner, B.	Dutch Hill	1790	D	Drl	6"	100	20		4	Jet	6 (est.)	9/82	
101	Rachic, G.	Dutch Hill	1800	D	Dug	24"	5.3	T	Till			2.8	4/62	Bedrock 5.3' B.G. according to LaScala
102	Rachic, G.	Dutch Hill	1780	D,S	Drl	6"	80	60-70 open	Shale	3	Jet			6 cattle; cannot run dry
103	Serio, J.	Dutch Hill	1780	U										
104	Guimento, J.	Dutch Hill	1780	D						3				Used by two tenants, one neighbor owner around Sundays only
105	Hughes, S.	Dutch Hill	1710	D,S	Drl	8"	76		Shale	1	Sub			6 pigs - tested yield: 3 gpm. 6" column of water in well
106	Warzel, E.	Boberg Rd.	1580	D	Drl	6"	70			1				Unable to locate well in field 150' NE of house
107	Shimmel, H.	Boberg Rd.	1580	D	Drl	6"	83			5	Jet			
108	Sarvar, R.	Boberg Rd.	1600	D,S	Spring	Concrete vault 4'x4'x6'				flows S.W. 2	the pipe from the Jet	Over- vault		5 cattle
109	Harshbarger	Boberg Rd.	1550	D	Drl	6"	86	---	---	2	Sub			
110	Mumbach	Boberg Rd.	1550	D	Drl	6"	50	---		2				
111	Kramer, E.	Boberg Rd.	1550	D	Drl	6"	135		Shale	4	Summer Sub	<10	1980	Tested yield: 26 gpm (?)
112	Cobo, L.	Dutch Hill Rd.	1560	D,A,S	Drl	6"	60	40	Shale	1	Jet	15	1982	100 cattle, tested yield: 33.3 gpm
113	Cobo, D.	Dutch Hill Rd.	1560	D	Drl	6"	40	25	Shale	3	Jet	12	1982	Can be pumped dry in 15 minutes
114	Phillips, G.	Dutch Hill Rd.	1595	D	Drl	8"	50			4	Sub	7.33	9/82	Tied with church next door

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (8 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
115	Hebdon, L.	Dutch Hill Rd.	1640	D,A	Drl	6"	72		Shale	8	Jet	32	1955	Hard water
116	Kern, E. (Penfield)	Cross Rd.	1580	D	Drl	7"	68		Shale	3	Sub	20.5	9/82	
117	Sarver, R.	Cross Rd.	1600	D	Drl	6"	48			2	Jet	34.0	1980	
118	Barney, P.	Cross Rd.	1570	D	Drl	6"	30		S + G	5	S.W.	3.0	1982	
119	Batticci, E.	Cross Rd.	1560	D	Drl	6"	54	42	Shale	2	Sub	17	1980	Tested yield: 5 gpm, soft water
120	Leichtheimer	Cross Rd.	50-1540	D	Drl	6"	60		Shale	2	Jet	34.66	9/82	Greyish coloration to water in summertime
121	Sabab, L.	Cross Rd.	1480	D	Drl	6"	30			2	Piston			Shortage of supply during hot summers
122	Turner, R.	Rt. 12	1490	D	Spring	2,000 gal. tank				4	S.W. Jet	Over-flows observed	9/82	Cannot pump tank dry
123	Lockhard, M.	Cross Rd.	1450	D	Drl	6"	88	18	Shale	7	Jet			Tested yield: 80 gpm (owner). Could not remove cap
124	Lamphier, P.	Rt. 12	1440											
125	Lamphier, J.	Rt. 12	1430	D	Dug	18-36"	20			3	Jet			Cemented over
126	Dickson, J.	Rt. 12	1450	U*	Drl	6"								*Used only in summer
127	Vedder, L.	Rt. 12	1430	D	Drl	6"	43			2	Jet	10	Spring/82	Very good recovery; would like water sampled
128	Juras, W.	Forks Rd.	1436	D	Dug					5	Jet			Under a 6" thick concrete pad
129	Anderson, H.	Forks Rd.	1430	D,A	Drl		80			2	Jet			5 cattle
130	Anderson, H.	Forks Rd.	1430	D	Dug	4'x4' Concrete Lined	30		Sand	4	S.W.	6.0	9/82	
131	Baker, R.	Forks Rd.	1440	D	Well Point	2"	8	4.0	Sand	5	S.W.			Will dry up in autumn

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (9 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
132	Soboleski, R.	Rt. 12	1425	D	Drl	6"	45			4	Sub	10	8/81	
133	Hettrich, D.	Rt. 12	1450	D	Drl	6"	30		Sand-Gravel	7	Jet			
134	Sion, J.	Rt. 12	1420	D	Drl	6"	25			7	S.W. Jet	3.5	9/82	
135	Dickson, R.	Rt. 12	1410	D,S	Drl	6"	<3	10	"Clay"	6	Piston	1.0	9/82	2 cattle0
136	(West) O'Brien, W.	Dutch Hill Rd.	1520	D	Drl	6"	85	80	(West) Shale	3	Sub	24.33	8/82	Tested yield est. by owner 15 gpm
137	(West) Meyers, J.	Dutch Hill Rd.	1510	D	Drl	6"	85	73	(West) Shale	4	Sub	20		4 cattle; 10 gpm recovery
138	Rt. 12 + Fuller, A.	Dutch Hill Rd.	1385	D	Drl	6"	53			4	Sub	8-12		Owner estimate
139	Rambach, J.	Autumn View Trail	1420	D	Drl	6"	40			4	Sub	26	1980	Poor recovery
140	Koch, M.	Schwartz Rd.	1320	D	36" Dug	6 Ceramic Tile			Sand + Gravel	4		0	8/82	8 horses; spring always flowing - that supplies the well
141	(West) Schroeder, D.	Schwartz Rd.	1374	D	Drl	8"	56		Sand	2	Centri-fugal	7.66	8/82	Would like water sampled
142	Kelley, H.	Schwartz Rd.	1370	D	Drl	6"	53'		Shale	7	Jet	13	9/825"	
143	Herrick, M.	Schwartz Rd.	1374	D	Drl	6"	32		Shale	2	Piston	7.75	8/82	Tested yield (1 hr tort.) = 4-500 gph=owner
144	Schmauss, R.	Edies Rd.	1370	D	Drl	6"	100	15	Shale	4	Sub			9 cattle, tested yield = 8.33 gpm
145	Feuz, A.	Edies Rd.	1384	D	Drl	6"	70			4	Sub	35	1981	Tested yield = 2 gpm, drillers log 0-45 S+G; 45-90 clay 90-bedrock, well filled in back to 70'
146	Feuz, W.	Edies Rd.	1320-30	S	Well Point	2"	21		Sand, Gravel	0				5 cattle; tested yield = 2 gpm-buried under barn floor
147	Feuz, W.	Edies Rd.	1320-30	D	Drl	116- 6"	140		Shale	2	Sub			Tested yield = 12 gpm. Unable to measure S.W.L.

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.5-8: LOCAL WATER WELL INVENTORY (10 OF 10)

Well No.	Owner	Location and Address	Approx. Land Surface Elev. (ft)	Well Use*	Well and Type	Well Diameter	Total Depth (ft)	Interval Screened or Interval (ft)	Probable Aquifer Tapped	No. of People Served	Type of Pump	Static Water Level (ft)	Date of Measure-ment	Comments: Water Quality, etc.
148	Felton, F.	Edies Rd.	1285	D	Dug	encased			Sand (clear)	4	Jet	2-3'		Previously used for dairy farm 21
149	Hess, L.	Schwartz Rd.	1360	D	Drl	6"				4	Sub			8 cattle 100+
150	Hess, L.	Schwartz Rd.	1360	U	Dug	6"	40							
151	Preston, J.	Rock Springs Rd.	1460	D	Dug	Lined		---		2	S.W.	2.0	9/82	

*D = domestic; S = stock; C = commercial; I = industrial; A = agricultural; P = public supply; U = unused.

TABLE A.3.6-1

Record of Drilling Projects at the WVDP WNYNSC

HOLE NAMES	DATE DRILLED	LOCATION	REFERENCES
Oil and Gas Holes	Pre-1963	Whole Site	NYSGS Oil and Gas Records
Domestic Wells	Pre-1963	Whole Site	USGS Records
PAH-n, DH-n	1961 - 1962	Whole Site	Stewart 1962a, 1962b; Dames & Moore 1971a
1-25	1963	Security area, plant site	Dames & Moore 1963A/B
1, 1A, 2, 2C, 3, 4	1963	Water supply reservoirs south of security area	Dames & Moore 1963A/B
CH-1 and four others	1967 - 1969	East of security area	de Laguna 1972; NYSGS oil and gas records Sun and Mongan 1974; Sun 1982
26, 27	1970	Security area, plant site	Dames & Moore 1970b
28 - 32	1971	Security area, plant site	Dames & Moore 1971b
33-43	1974	Security area	Dames & Moore 1975
1 - 9	1970	Near plutonium storage area	Dames & Moore 1970a
1-13, 2A-D, 9A-D	1973 - 1974	Perimeter of SDA - NDA	Davis 1974; Duckworth and others 1974; Giardina and others 1977; Bailey 1975
B-1 thru B7 TP-1 thru TP-7	1974	North of LLRWDA	Dames & Moore 1974
B1 thru B5	1975	South and west of security area	Empire Soils Investigations, Inc. 1975
A-Z, HA-n	1975 - 1980	Around SDA	Prudic and Randall 1977
n - na	1976 -1977	Into trenches at SDA	Albanese et al. 1982
80-1 thru 80-10	1980	Security area	Albanese et al. 1983
A82-1-2	1982	East of SDA	Albanese et al. 1984
82-1 thru 82-5	1982	Perimeter NDA	Albanese et al. 1984
83-1 thru 83-3	1983	West of NDA	Albanese et al. 1984

TABLE A.3.6-1 (concluded)

Record of Drilling Projects at the WVDP WNYNSC

Hole Names	Date Drilled	Location	References
83-4E	1983	North Plateau	
DM 83-01 thru DM 83-06	1983	Plant site	Dames & Moore 1983
B-84-01 thru B-84-12	1984	NDA	WVNS, Inc. 1984
B-1 thru B-4; B-8	1985	Plant site	Dames & Moore 1985
B-85-50-n 7 wells; B-01-86 thru B-06-86	1985	Plant site	Dames & Moore 1985
B-86-01 thru B-86-13; B-86-14 thru B-86-20	1986	Plant site	Dames & Moore 1986
B-88-01 thru B-88-05	1988	Plant site	Dames & Moore 1988
B-89-01 thru B-89-04	1989	Plant site	Dames & Moore 1990
20 Boreholes	1989	NDA	Dames & Moore open-file
96 Wells	1989 - 1990	North and South Plateaus	Dames & Moore open-file
24 piezometers	1991	SDA	Dames & Moore, 1993
3 borings	1991	SDA lagoon	Dames & Moore open-file
3 borings	1991	Plant site (UR expansion)	Dames & Moore, 1991b
4 borings	1991	Plant site (STP expansion)	Dames & Moore, 1991a
6 borings	1991 - 1992	Plant site (HLW tanks)	Dames & Moore, 1992a
7 borings	1993	North Plateau	Dames & Moore, 1993
50 borings	1993	North Plateau; NDA	WVDP-EIS-008
80 probe holes	1994	North Plateau	WVDP-220
29 probe holes	1997	North Plateau	WVDP-298
6 Well Points	1998	North Plateau	WVDP-346, Rev. 0

TABLE A.3.6-2 (1 of 3)
HISTORICAL SEISMICITY WITHIN
480 km (300 mi) OF SITE

(Only events with MM intensity ≥ V are listed. Only events shown with a magnitude have an independently-determined magnitude.)

Date (yr/mth/day)		Longitude (°W)	Latitude (°N)	Intensity (MMI)	Magnitude (m_b)	Distance (km)
1737	1219	74.00	40.80	VII-		449.1
1776	0 0	81.90	39.60	VI	4.7	422.3
1783	1130	74.50	41.00	VI		401.7
1840	116	75.00	43.00	VI-		321.5
1840	910	79.90	43.20	V-		113.7
1840	1111	75.20	39.80	-VII-		433.1
1847	929	74.00	40.50	V-		464.9
1848	9 9	74.00	40.40	V		470.6
1853	312	75.50	43.70	VI-		302.3
1853	313	79.40	43.10	V-		74.9
1853	5 2	79.50	38.50	V		458.9
1855	1 3	77.50	39.20	V		392.8
1855	2 7	74.00	42.00	VI		407.7
1857	1023	78.60	43.20	VI-		68.7
1861	713	75.40	45.40	VII-		421.6
1867	1218	75.20	44.70	VI		381.2
1871	10 9	75.50	39.70	+VII-		424.4
1873	425	74.20	44.80	V		456.3
1873	7 6	79.50	43.00	VI-		73.6
1874	1211	73.80	40.90	V		459.5
1877	910	74.90	40.30	V		414.7
1877	1218	76.80	45.70	V		382.7
1878	10 4	74.00	41.50	V		420.4
1879	326	75.50	39.20	V		467.9
1884	531	75.50	40.60	V		354.6
1884	810	74.00	40.60	VII-		459.4
1885	1 3	77.50	39.20	V		392.8
1886	5 3	82.10	39.50	V	3.6	441.5
1889	3 8	76.00	40.00	V		371.9
1893	3 9	74.00	40.60	V		459.4
1895	9 1	74.80	40.70	VI		396.0
1900	4 9	81.90	41.40	VI-	4.7	291.9
1901	517	82.50	39.30	V	4.2	479.9
1903	1225	75.50	44.70	V		361.7
1906	627	81.60	41.40	V	4.2	269.8
1908	531	75.50	40.60	VI		354.6
1908	616	74.80	45.10	V		435.2

TABLE A.3.6-2 (2 of 3)

HISTORICAL SEISMICITY WITHIN

480 km (300 mi) OF SITE

Date (yr/mth/day)		Longitude (°W)	Latitude (°N)	Intensity (MMI)	Magnitude (m_b)	Distance (km)
1909	4 2	78.00	39.40	V		361.5
1912	527	79.70	43.20	V-		100.6
1913	429	75.30	44.90	VI	4.4	388.8
1916	1 5	73.70	43.70	V		444.5
1916	2 2	74.00	42.90	V		403.6
1916	2 3	74.00	43.00	V		404.7
1916	11 2	73.70	43.30	V		434.4
1917	522	75.60	45.10	V		385.9
1918	410	78.40	38.70	V		434.2
1918	410	78.40	38.70	VI		434.2
1919	9 6	78.20	38.80	VI		424.8
1919	9 6	78.20	38.80	V		424.8
1921	126	75.00	40.00	V		429.8
1922	12 8	75.10	44.40	V		368.9
1923	1231	78.00	39.20	V		383.3
1924	715	76.50	45.70	V		394.4
1926	126	75.00	40.00	V		429.8
1926	512	73.90	40.90	V		451.9
1926	11 5	82.10	39.10	-VII-	4.0	476.9
1927	129	81.20	40.90	V		275.8
1927	6 1	74.00	40.30	-VII-		476.4
1928	318	74.30	44.50	VI	4.1	432.1
1928	9 9	82.00	41.50	V	4.2	294.6
1929	812	78.40	42.91	VII-	5.2	48.0 o
1929	12 2	78.30	42.80	V-		47.4 o
1931	420	73.79	43.47	-VII-	4.7	430.8
1931	610	84.00	41.30	V	4.2	459.0
1932	121	81.50	41.10	V	4.2	280.9
1933	125	74.70	40.20	V		434.8
1934	415	73.80	44.70	VI	4.5	479.5
1934	1029	80.20	42.00	V-		134.9
1935	11 1	79.05	46.87	VII-	6.2	474.4
1938	715	78.43	40.68	VI-	3.3	215.4 o
1938	823	74.34	40.10	V	3.9	465.5
1938	1118	75.30	44.80	V		381.7
1939	1115	75.05	39.58	V	4.0	459.5
1939	1126	76.60	39.50	V		390.4
1944	1 8	75.50	39.80	V		416.0
1944	9 5	74.72	44.96	VIII	5.8	430.7
1949	1016	74.90	45.49	V	4.0	457.9
1951	9 3	73.86	41.36	V	3.8	436.3
1952	620	82.02	39.64	VI	4.1	425.2
1952	825	74.50	43.00	V		363.1
1952	10 8	74.00	41.70	V		414.5
1953	327	73.50	41.10	V		474.3

TABLE A.3.6-2 (3 of 3)

HISTORICAL SEISMICITY WITHIN

480 km (300 mi) OF SITE

Date (yr/mth/day)		Longitude (°W)	Latitude (°N)	Intensity (MMI)	Magnitude (m_b)	Distance (km)
1954	1 7	76.00	40.30	VI		346.7
1954	221	75.90	41.20	+VII-		288.5
1955	121	73.70	43.00	V		429.7
1955	526	81.70	41.50	V	3.8	272.0
1955	629	81.70	41.50	V	3.8	272.0
1955	816	78.30	42.90	V		53.5 o
1957	323	74.80	40.60	VI	4.8	402.0
1958	5 1	81.70	41.50	V	4.0	272.0
1961	222	83.40	41.20	V	4.2	415.6
1961	420	74.80	45.00	V	2.0	428.2
1961	915	75.50	40.80	V		341.2
1961	1227	74.80	40.50	V		408.3
1962	327	79.30	43.00	V-	3.0	61.0
1964	1 8	77.53	46.41	V	4.3	436.1
1964	329	74.90	44.90	V		414.7
1964	512	76.41	40.30	VI-	3.2	324.5
1964	1117	73.70	41.20	V		454.8
1966	1 1	78.25	42.84	VI-	4.6	53.2 o
1967	4 8	82.53	39.65	V	3.5	452.7
1967	613	78.23	42.84	VI-	4.4	54.7 o
1967	1122	73.80	41.20	V		446.9
1968	1210	74.82	39.92	V	3.0	446.9
1971	523	74.47	43.87	V	4.1	389.3
1972	211	75.60	39.70	V		419.0
1972	12 8	76.24	40.14	V	3.5	347.3
1973	228	75.44	39.77	V	3.8	421.9
1974	6 7	73.94	41.63	VI	2.9	421.3
1974	1020	81.61	39.06	V	3.8	458.1
1976	311	74.40	41.00	V	2.4	409.3
1976	413	74.00	40.80	VI	3.1	449.1
1977	210	75.50	39.80	VI	2.0	416.0
1977	3 9	83.50	41.00	V		432.1
1978	716	76.34	39.93	V	3.0	361.0
1978	10 6	76.10	40.10	VI	3.0	358.1
1980	820	83.10	42.10	V	3.3	364.6
1995	525	78.867	42.97	IV	2.9	~60
1998	925	80.39	41.49	IV	5.2	179.3

Notes: - Could have been felt at site

o Associated with Clarendon-Linden Structure

TABLE A.3.6-3

SUMMARY OF INDEX PROPERTIES TESTS

SAMPLE NO.	DEPTH (M/FT)	SOIL TYPE	NATURAL MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	SPECIFIC GRAVITY OF SOLIDS	DRY DENSITY (G/CC)
Boring No. 1, Reference 0090,1963								
1	0.305/1	ML	24					1.59
2	1.829/6	GP	7					1.96
3	3.353/11	CL	18					1.81
4	4.877/16	CL	17					1.84
5	6.401/21	CL	17					1.81
6	7.925/26	CL	17					1.94
7	10.363/34	CL	8					1.98
8	12.497/41	CL	13					1.77
9	14.021/46	CL	18					1.73
10	15.545/51	CL	22					1.59
11	17.069/56	CL	18					1.79
12	18.593/61	CL	18					1.85
Boring No. 2, Reference 0090,1963								
1	0.305/1	GP	14					1.79
2	1.829/6	GP	10					1.88
3	3.353/11	CL	16					1.88
4	4.877/16	CL	19					1.77
5	6.401/21	CL	19					1.77
6	7.925/26	CL	21					1.73
7	10.363/34	CL	19					1.77
8	12.497/41	CL	19					1.77
9	14.021/46	CL	16					1.82
10	15.545/51	CL	15					1.59
11	17.069/56	CL	17					1.90
12	18.593/61	CL	19					1.84

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 2 (continued), Reference 0090,1963								
13	18.593/61	CL	20					1.74
14	20.117/66	CL	15					1.92
15	21.641/71	CL	14					1.90
16	23.165/76	CL	15					1.95
Boring No. 3, Reference 0090,1963								
1	0.305/1	GM	12					1.98
2	1.829/6	GM	16					1.87
3	3.353/11	CL	17					1.90
4	4.877/16	CL	19					1.77
5	6.401/21	CL	20					1.76
6	7.925/26	CL	21					1.76
Boring No. 4, Reference 0090,1963								
1	0.305/1	GM	11					1.98
2	1.829/6	GM	10					1.92
3	3.353/11	CL	17					1.82
4	4.877/16	CL	21					1.71
5	6.401/21	CL	19					1.76
6	7.925/26	CL	21					1.70

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 5, Reference 0090,1963								
1	0.305/1	GM	34					1.46
2	1.829/6	GM	13					1.95
3	3.353/11	CL	14					1.93
4	4.877/16	CL	20					1.71
5	6.401/21	CL	20					1.71
6	7.925/26	CL	19					1.79
7	9.449/31	CL	13					1.88
8	10.973/36	CL	26					1.55
9	12.497/41	CL	20					1.63
Boring No. 6, Reference 0090,1963								
1	0.305/1	GM	13					1.85
2	1.829/6	CL	8					2.07
3	3.353/11	CL	15					1.92
4	4.877/16	CL	21					1.70
5	6.401/21	CL	21	29	16	13		1.71
6	7.925/26	CL	25					1.63
7	9.449/31	CL	22					1.71
8	10.973/36	CL	21					1.73
9	12.497/41	CL	14					1.87

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (M/FT)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 7, Reference 0090,1963								
7	9.449/31	CL	31	32	18	14		1.46
8	10.973/36	CL	20					1.74
9	12.497/41	CL	20					1.73
10	14.021/46	CL	16					1.82
11	15.545/51	CL	11					2.04
12	17.069/56	CL	17					1.82
13	18.593/61	CL	16					1.79
14	20.117/66	CL	14					1.93
15	21.641/71	CL	12					1.99
16	26.213/86	CL	8					2.03
17	29.261/96	SM	5					1.79
18	32.309/106	ML	21					1.63
19	35.357/116	ML	25					1.60
20	39.929/131	ML	19					1.71
21	46.025/151	ML	22					1.66
22	49.073/161	ML	16					1.79
Boring No. 8, Reference 0090,1963								
1	0.305/1	GM	11					1.81
2	1.829/6	GM	15					1.96
3	3.353/11	CL	12					1.99
4	4.877/16	CL	20					1.77
5	6.401/21	CL	18					1.82
6	7.925/26	CL	25					1.59
7	9.449/31	CL	27					1.55
8	10.973/36	CL	20					1.76
9	12.497/41	CL	18					1.81

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 9, Reference 0090,1963								
1	0.305/1	GM	22					1.71
2	1.829/6	GM	12					2.06
3	3.353/11	CL	13					1.99
4	5.486/18	CL	18					1.77
5	7.315/24	CL	19					1.76
Boring No. 12, Reference 0090,1963								
1	0.305/1	PT-CL	25					1.26
2	1.829/6	GM	13					1.98
3	3.353/11	GM	8					2.18
4	4.877/16	GM	9					1.90
5	6.401/21	GM	13					2.03
6	7.925/26	CL	20					1.93
7	9.449/31	CL	17					1.71
8	10.973/36	CL	14					1.79
9	12.497/41	CL	21					1.92
10	14.021/46	CL	20					1.74
11	15.545/51	CL	18					1.70
12	17.069/56	CL	18					1.88
13	18.593/61	CL	16					1.74
14	20.117/66	CL	21					1.88
15	21.641.71	CL	11					1.71
16	23.165/76	CL	12					2.15
17	24.689/81	CL	14					1.99

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 15, Reference 0090,1963								
1	0.305/1	ML	21					1.51
2	0.914/3	ML	17					1.79
3	2.134/7	CL	19					1.77
4	2.743/9	CL	20					1.74
5	3.353/11	CL	18					1.79
6	4.877/16	CL	19					1.74
7	6.401/21	CL	21					1.76
8	7.925/26	CL	18					1.77
Boring No. 16, Reference 0090,1963								
1	0.305/1	ML	21					1.37
2	1.829/6	GM-ML	9					1.84
3	3.353/11	GM-ML	12					1.92
4	4.877/16	GM-ML	11					2.06
5	6.401/21	GM-ML	9					2.12
6	7.925/26	GM-ML	10					1.98
7	9.449/31	GM-ML	11					1.98
8	10.973/36	GM-ML	12					2.06
9	12.497/41	CL	17					1.73
10	14.021/46	CL	26					1.63
11	15.545/51	CL	18					1.82
12	17.069/56	CL	19					1.59
13	18.593/61	CL	13					1.96

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 17, Reference 0090,1963								
1	0.305/1	ML	19	4				1.81
2	1.829/6	GM-ML	9					1.96
3	3.353/11	GM-ML	10					1.99
4	4.877/16	GM-ML	12					1.77
5	6.401/21	CL	25	32	23	9		1.82
6	7.925/26	GM-ML	5					1.59
7	9.449/31	CL	18					1.55
8	10.973/36	CL	17					1.76
9	12.497/41	CL	19					1.81
Boring No. 18, Reference 0090,1963								
1	0.305/1	ML	32					1.27
2	1.829/6	GM-ML	11					1.95
3	3.353/11	GM-ML	10					2.07
4	----	--	--					---
5	6.401/21	GM-ML	20					1.73
6	7.925/26	CL	32					1.48
7	9.449/31	CL	28					1.48
8	10.973/36	CL	32					1.40
9	12.497/41	CL	19					1.73
10	14.021/46	CL	16					1.90
11	----	--	--					--
12	17.069/56	CL	14					1.96
13	18.593/61	CL	17					1.79
14	20.117/66	GM-ML	9					2.03

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Boring No. 19, Reference 0090,1963

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
1	0.305/1	ML	30					1.18
2	1.829/6	GP	9					2.07
3	3.353/11	CL	8					2.10
4	4.877/16	CL	23					1.68
5	6.401/21	CL	18					1.71
6	7.925/26	CL	16					1.84
7	9.449/31	CL	27					1.51
8	10.973/36	CL	9					2.07
9	12.497/41	CL	12					2.03
10	14.021/46	CL	11					1.99
11	15.545/51	CL	15					1.96

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 20, Reference 0090,1963								
1	0.305/1	GM-ML	20					1.37
2	1.829/6	GM-ML	17					1.62
3	3.353/11	GM-ML	10					2.04
4	4.877/16	GM-ML	12					1.88
5	7.010/23	SP	22					1.74
6	7.925/26	CL	18					1.79
7	9.449/31	CL	21					1.73
8	10.973/36	CL	22					1.59
9	12.497/41	CL	17					1.87
10	14.021/46	CL	13					1.98
11	15.545/51	CL	13					1.99
12	17.069/56	CL	13					1.98
13	18.593/61	GM-ML	10					1.93
14	20.117/66	GM-ML	10					2.04
15	21.641/71	GM-ML	10					1.88
16	23.165/76	GM-ML	8					2.07
17	24.689/81	GM-ML	6					2.01

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 21, Reference 0090,1963								
1	0.305/1	GM	25					1.33
2	3.353/11	GM-ML	7					2.06
3	3.353/11	GM-ML	15					1.85
4	6.401/21	CL	18					1.68
5	7.925/26	CL	24					1.66
7	10.973/36	CL	21					1.65
8	12.497/41	CL	26					1.63
9	14.021/46	CL	14					1.92
10	15.545/51	CL	13					2.04
11	17.069/56	CL	14					1.88
12	18.593/61	GP-ML	8					2.04
13	21.641/71	GP-ML	9					1.88
Boring No. 22, Reference 0090,1963								
1	0.305/1	GM	8					1.62
2	1.829/6	GM-ML	10					1.84
3	3.353/11	GM-ML	10					1.96
4	4.877/16	GM-ML	11					2.20
5	6.401/21	GM-ML	11					1.98
6	7.925/26	CL	17					1.77
7	9.449/31	CL	19					1.87
8	10.973/36	CL	30					1.52
9	12.497/41	CL	17					1.82
10	14.021/46	CL	21					1.66
11	15.545/51	CL	20					1.65
12	17.069/56	CL	15					1.92
13	20.117/66	CL	15					2.07

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 23, Reference 0090,1963								
1	0.305/1	GM-ML	21					1.29
2	1.829/6	GM-ML	13					1.88
3	3.353/11	CL	21					1.70
4	4.877/16	CL	20					1.71
5	6.401/21	CL	22					1.66
6	7.925/26	CL	16					1.71
7	9.449/31	CL	23					1.63
8	10.973/36	CL	20					1.70
9	12.497/41	CL	24					1.66
10	14.021/46	CL	14					1.55
12	17.069/56	CL	14					1.85
13	20.117/66	CL	13					1.95
14	23.165/76	GM-ML	9					2.01
Boring No. 24, Reference 0090,1963								
1	0.305/1	GM-ML	10					1.59
2	1.829/6	GM-ML	13					1.92
3	3.353/11	GM-ML	11					1.99
4	4.877/16	CL	18					1.79
5	6.401/21	SP	10					1.93
6	7.925/26	CL	17					1.82
7	9.449/31	CL	13					1.96
8	10.973/36	CL	23					1.66
9	12.497/41	CL	12					1.96

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 25, Reference 0090,1963 (Samples No. 29, 30, 30, 31 Reference 0098,1971)								
1	0.305/1	GM	13					1.49
2	1.829/6	GM-ML	13					1.87
3	3.353/11	GM-ML	14					1.88
4	4.877/16	GM-ML	12					1.79
5	6.401/21	SC	18					1.66
6	7.925/26	CL	23					1.71
7	10.363/34	CL	25					1.57
8	12.497/41	CL	16					1.85
9	14.021/46	CL	22					1.55
10	15.545/51	CL	15					1.92
11	17.069/56	GM-ML	9					2.01
12	20.117/66	GM-ML	7					1.93
29	2.438/8			33	19	14		
30	6.401/21			26	14	12		
30	9.144/30			50	26	24		
31	12.497/41			25	15	10		
Boring No. B-3, Reference 0101,1975								
10	20.726/68	CL	22.8					1.65
8	14.630/48	CL	13.7					1.95
4	7.010/23	CL	21.5					1.73
Boring No. B-7, Reference 0101,1975								
7	7.620/25	CL	13.4	26	16	10	--	--
5	4.572/15	CL	23.4	33	19	14	--	--
4	3.048/10	CL	23.3	--	--	--	--	1.57
2	06.610/2	CL-ML	16.8	33	20	13	--	--

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. B-2, Reference 0101,1975								
14	24.384/80	CL	21.7	30	19	11	2.70	--
10	12.192/40	CL	12.2	24	14	10	2.71	--
5	6.096/20	CL	13.0	31	17	114	2.70	--
Boring No. 33, Reference 0102,1975								
1	1.524/5	--	--	--	--	--	2.65	1.74
3	4.724/15.5	CL	19.3	35.4	19.4	16.0	--	1.92
9	13.868/45.5	--	--	--	--	--	2.72	1.90
11A/B	17.069/56	CL	12.1	22.9	13.2	9.7	--	1.95
Boring No. 34, Reference 0102,1975								
9	14.021/46	CL	10.3	23.1	13.8	9.3	2.74	--
13	19.964/65.5	CL	5.6	23.6	13.3	10.3	2.75	--
Boring No. 36, Reference 0102,1975								
12	18.440/60.5	CL-ML	17.7	22.7	15.3	7.4	--	--
Boring No. 38, Reference 0102,1975								
38	3.200/10.5	--	--	--	--	2.69	--	--
Boring No. 39, Reference 0102,1975								
8	12.497/41	CL	12.1	22.6	13.8	8.8	--	--
9	15.545/51	CL	11.6	24.5	14.4	10.1	--	--
Boring No. 40, Reference 0102,1975								
19	30.632/100.5	CL-ML	22.1	24.5	17.9	6.6	2.71	--
23	36.576/120.0	CL-ML	--	--	--	--	2.70	--
Boring No. 42, Reference 0102,1975								
7	10.820/35.5	CL	11.7	23.2	14.4	8.8	--	--

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. 43, Reference 0102,1975								
3	4.724/15.5	CL	24.2	33.5	15.0	18.5	--	--
Boring No. 26, Reference 0097,1970								
--	14.021/465	CL	12.1	22	14	8	--	--
Boring No. 38, Reference 0097,1970								
27	11.582/38	CL-ML	12.9	22	15	7	--	--
Boring No. PPFP-1, Reference 0096,1971								
2	1.829/6	CL	25	46	23		1.33	1.74
4	3.658/12	CL	16				1.85	1.92
5	4.267/14	CL	24				1.44	1.90
8	7.925/26	CL	20	29	16		1.76	1.95
Boring No. PPFP-2, Reference 0096,1971								
1	0.610/2	ML	37	50	33	17		1.26
3	2.438/8	CL	21					1.73
4	3.658/12	CH	20					1.78
12	15.850/52	CH	25					1.63
15	19.812/65	CH	16	23	15	08		1.94
25	35.357/116	CL	27					1.47
30	42.977/141	CL-ML	13	21	13	08		2.03
32	46.330/152	CL-ML	21					1.76
45	65.837/216	CL-ML	12					2.10
Boring No. PPFP-3, Reference 0096,1971								
2	1.219/4	CL	18	33.5	15.0	18.5	--	--

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. PPFP-4, Reference 0096,1971								
2	1.829/6	CL	19	27	19	08		1.81
5	4.877/16	CL	25	35	19	16		1.67
6	6.706/22	CL	33					1.44
Boring No. PPFP-5, Reference 0096,1971								
2	1.524/5	CL	26	46	25	21		----
Boring No. PPFP-6, Reference 0096,1971								
1	0.610/2	CL	17	35	23	12		----
5	3.658/12	CL	23				111	1.78
7	6.706/22	CL	26	28	20	08	101	1.62
Boring No. PPFP-7, Reference 0096,1971								
2	1.219/4	CL	15	27	18	09	---	1.97
4	3.658/12	CL	18	--	--	--		1.86
Boring No. PPFP-8, Reference 0096,1971								
1	1.219/4	CL	--	41	23	18	---	----
Boring No. PPFP-9, Reference 0096,1971								
2	1.5242/5	CL	26	41	25	16	---	----

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. B-1, Reference Duckworth, et al, 1974								
1	1.219/4	CL	13.1					
2	2.743/9	CL	14.9					
3	4.267/14	CL	15.1					
4	5.791/19	ML	16.6					
5	7.315/24	ML	17.5					
6	2.840/29	ML	19.5					
7	10.364/34	ML	16.6					
8	11.888/39	ML	16.3					
9	13.411/44	ML	16.7					
10	14.935/49	ML	16.7					
Boring No. B-2, Reference Duckworth, et al, 1974								
2	2.743/9	CL	16.3					
6	8.840/29	ML	18.9					
10	14.935/49	ML	17.0					
Boring No. B-3, Reference Duckworth, et al, 1974								
3	4.267/14	CH	16.2					
4	5.791/19	CL	15.7					
6	8.840/29	CL	15.8					
10	14.935/49	CL	16.9					
Boring No. B-4, Reference Duckworth, et al, 1974								
2	2.743/9	CL	15.0					
6	8.840/29	CL	15.9					
10	14.935/49	CL	16.1					

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. B-5, Reference Duckworth, et al, 1974								
2	2.743/9	CL	10.7					
6	8.840/29	ML	16.5					
10	14.935/49	ML	15.6					
Boring No. B-6, Reference Duckworth, et al, 1974								
2	2.744/9	CL	10.5					
5	7.315/24	ML	17.7					
10	14.935/49	ML	16.4					
Boring No. B-7B, Reference Duckworth, et al, 1974								
2	2.743/9	CL	11.7					
6	8.840/29	ML	17.8					
10	14.935/49	ML	15.6					
Boring No. B-8, Reference Duckworth, et al, 1974								
2	2.743/9	CL	11.7					
5	7.315/24	CL	12.2					
10	14.935/49	ML	15.6					
Boring No. B-9, Reference Duckworth, et al, 1974								
2	2.743/9	CL	13.6					
5	7.315/24	CL	20.7					
10	14.935/49	ML	16.9					
Boring No. B-10, Reference Duckworth, et al, 1974								
2	2.743/9	CL	13.2					
6	8.840/29	ML	16.8					
10	14.935/49	CL	15.8					

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (continued)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. B-2B, Reference Duckworth, et al, 1974								
1	1.219/4		13.94					
2	1.829/6		13.61					
3	2.439/8		14.85					
4	3.048/10		14.36					
5	4.268/14		15.91					
6	4.877/16		13.79					
Boring No. B-2C, Reference Duckworth, et al, 1974								
1	1.219/4		13.85					
2	1.829/6		14.67					
3	2.439/8		15.81					
4	3.048/10		16.77					
5	4.268/14		16.38					
6	4.877/16		16.34					
Boring No. B-2D, Reference Duckworth, et al, 1974								
1	1.219/4		14.06					
2	1.829/6		14.88					
4	2.439/8		7.48					
5	3.048/10		16.87					
6	4.268/14		14.93					
	4.877/16		16.57					

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-3 (concluded)

SUMMARY OF INDEX PROPERTIES TESTS

Sample No.	Depth (m/ft)	Soil Type	Natural Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Specific Gravity of Solids	Dry Density (g/cc)
Boring No. B-9B, Reference Duckworth, et al, 1974								
1	2.439/8		14.83					
2	3.048/10		15.62					
3	3.658/12		15.75					
4	4.268/14		14.43					
5	4.725/15.5		14.35					
6	4.877/16		12.58					
Boring No. B-9C, Reference Duckworth, et al, 1974								
1	2.439/8		15.92					
2	3.048/10		16.14					
3	3.658/12		16.61					
4	4.268/14		14.81					
5	4.725/15.5		10.22					
6	4.877/16		17.29					

Depth in m - Depth in ft x 00.3048

Dry Density in g/cc = Dry Density in pcf x 0.0157

TABLE A.3.6-4

Results of Direct Shear Tests

Boring No.	Sample No.	Depth (M/FT)	Normal Pressure (KPA)	Shear Strength (KPA)	Water Content %	Dry Density (G/CC)	Soil Classification
1	2	1.829/6	24	38	7	1.96	GP
2	2	1.829/6	24	57	10	1.88	GP
17	4	4.877/16	66	130	12	1.98	GM/ML
17	8	10.973/36	130	144	17	1.74	CL/GP
20	4	4.877/16	83	148	12	1.88	GM/ML
20	8	10.973/36	150	76	22	1.59	CL
22	3	3.353/11	63	160	10	1.96	GM/ML
23	3	3.353/11	54	55	21	1.70	GM/CL

TABLE A.3.6-5
Results of Unconfined and Triaxial Compression Tests

Boring No.	Sample No.	Depth (m/ft)	Cell or Consolidation Pressure (kPa)	Maximum Shear Strength (kPa)	Water Content %	Dry Density (g/cc)	Soil Classification	Remarks
B-2	3	3.353/11	95.8	139.1	19.8	1.73	CL	1
B-2	5	6.096/20	143.7	139.2	13.0	1.98	CL	1
B-2	9	12.192/40	191.6	236.8	12.9	1.97	CL	2
B-2	14	24.384/80	287.4	246.7	22.0	1.67	ML	1
B-1	4	6.096/20	431.1	184.9	--	--	CL	2
B-1	5	7.620/25	143.7	145.9	--	--	CL	2
B-1	3	3.048/10	574.8	282.6	20.0	1.71	CL	2
B-1	4	6.096/20	287.4	184.1	--	--	CL	2
B-1	7	12.192/40	191.6	204.5	16.3	1.84	CL	2
B-7	6	7.620/25	103.5	78.1	25.4	1.56	CL	1
B-7	10	15.240/50	172.4	115.7	--	--	CL	1
B-7	12	18.288/60	227.5	163.2	29.8	1.48	CL	1
26	5	10.668/35	0	124.5	23.3	1.54	CL	3
26	6	18.716/45	0	213.2	12.1	1.99	CL	3
27	5	9.144/30	0	201.2	13.5	1.88	CL	3
30	6	6.096/20	0	67.1	21.5	1.71	CL	3
30	7	7.620/25	413.9	178.8	20.8	1.70	CL	1
31	2	1.524/05	0	117.4	13.4	1.84	ML	3
31	8	9.144/30	413.9	124.5	26.6	1.55	CL	1
PPFP-1	4 5	3.658/12 4.267/14	0 71.4	109.5 109.5	16 24	1.85 1.44	CL CL	3 1

TABLE A.3.6-5
Results of Unconfined and Triaxial Compression Tests

Boring No.	Sample No.	Depth (m/ft)	Cell or Consolidation Pressure (kPa)	Maximum Shear Strength (kPa)	Water Content %	Dry Density (g/cc)	Soil Classification	Remarks
PPFP-2	1	0.610/2	0	66.7	37	1.26	ML	3
	4	3.658/12	142.80	109.5	20	1.78	CH	1
	12	15.850/52	0	35.7	25	1.63	CH	3
PPFP-4	6	6.706/22	142.8	38.1	25	1.44	CL	1
PPFP-7	4	3.658/12	0	85.7	18	1.86	CL	3

1) From Unconsolidated Undrained (UU) Test
2) From Isotropically Consolidated Undrained (CIU) Tests
3) Unconfined Compression Test

TABLE A.3.6-6

Summary of Hydraulic Conductivity Results

Boring No.	Sample No.	Depth (M/FT)	Soil Type (Unified)	Head (KPA)	Effective Confining Pressure (KPA)	Water Content %	Dry Density (G/CC)	Hydraulic Conductivity (CM/SEC)	Reference
2 (U.D.)	9	12.192/40	CL	227.5	191.7	12 .9	1.97	$1.37x10_{-8}$	0101
Block Sample*	--	--	CL	27.6	103.4	11.6	1.73	$4.9x10^{-8}$	0101
	--	--	CL	27.6	172.4	11.6	1.73	$3.8x10^{-8}$	0101
	--	--	CL	27.6	310.3	11.6	1.73	$3.0x10^{-8}$	0101
T.P. -7*	--	--	GM-ML	13.8	103.4	9.5	1.86	$7.6X10^{-7}$	0101
	--	--	GM-ML	13.8	172.4	9.5	1.86	$7.0X10^{-7}$	0101
	--	--	GM-ML	13.8	310.3	9.5	1.86	$4.2X10^{-7}$	0101
83-1-E	--	3.048/10	CL	**	N/A	19.8	1.73	$4.27X10^{-8}$	Dames & Moore, 1983 (b)
	--	13.594/44.6	CL	**	N/A	20.5	1.85	$3.01X10^{-8}$	
83-2-E	--	6.096/20	ML	**	N/A	11.7	1.99	$1.94x10^{-8}$	Dames & Moore 1983 (b)
		12.314/40.4	ML	**	N/A	19.9	1.82	$2.00X10^{-8}$	
		15.240/50	ML	**	N/A	27.2	1.56	$3.13X10^{-8}$	
		21.336/70	CL	**	N/A	23.0	1.71	$2.89X10^{-8}$	
83-3-E	--	3.048/10	CL	**	N/A	15.5	1.89	$3.12x10_{-8}$	Dames & Moore 1983 (b)
		6.096/20	CL	**	N/A	13.5	1.95	$1.47X10^{-8}$	
		9.144/30	ML	**	N/A	13.5	1.94	$1.58X10^{-8}$	
		12.466/40.9	ML	**	N/A	21.4	1.68	$3.96X10^{-8}$	
		15.240/50	SM-SC	**	N/A	11.8	2.26	$4.42X10^{-8}$	
		18.288/60	ML	**	N/A	36.0	1.36	$3.81X10^{-8}$	
82-1-D	--	15.240/50	CL	**	N/A	16.3	1.87	$5.04X10^{-8}$	Dames & Moore 1983 (a)
		18.288/60	CL	**	N/A	11.8	2.09	$8.03x10^{-8}$	
		21.306/69.9	CL/GC	**	N/A	13.7	2.05	$3.80x10^{-8}$	
		24.293/79.7	CL/ML	**	N/A	15.0	1.79	$7.27x10^{-8}$	
82-3-D	--	16.124/52.9	CL	**	N/A	12.8	1.95	$7.91X10^{-8}$	Dames & Moore 1983 (a)
		18.288/60	CL	**	N/A	11.7	2.03	$5.67x10^{-8}$	
		24.944/82	CL/ML	**	N/A	25.4	1.60	$1.26x10^{-8}$	

* Tests were run on samples prepared in laboratory by compacting these samples at optimum moisture content.

** Falling heat test.

Table A.3.6-7

Semiquantitative Spectrographic Analyses of Deposits at the Western New York Nuclear Service Center

(Analyses by Geochemistry & Petrology Branch, U.S. Geological Survey, Washington, D.C.; borehole locations are shown on Figure 7-2.)

Results are reported in percent to the nearest number in the series 1.0, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, etc., which represent approximate midpoints of group data on a geometric scale. The assigned group for semiquantitative results will include the quantitative value about 30% of the time.

These data should not be quoted without stating these limitations.

Symbols used are:

M = major constituent--greater than 10%
0 = looked for but not detected (see table of detectabilities)
- = not looked for
< , with number = less than number shown; usual detectabilities do not apply.

Lab No.	159429	159430	159219	159220	159221	159431	159432	159433	159222	159223
Hole No.	DH-4	DH-4	DH-6	DH-6	DH-6	DH-7	DH-7	DH-7	PAH-4	PAH-4
Depth (ft)	15-16½	25½-26½	36½-38	87-89	170-171	8-37	37-52	52-75	11½-13	21-23
Geologic Unit	Coarse, granular deposits(AT)	Silty clay till(BT)	Silty clay till(BT)	Silty clay till(BT)	Silty clay till(BT)	Silty clay till(BT)	Sandy clay till(SBT)	Silty clay till(BT)	Silty clay till(BT)	Sand and gravel(S,G)
Si	M	M	M	M	M	M	M	M	M	M
Al	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	5.0
Fe	5.0	3.0	3.0	2.0	3.0	5.0	3.0	5.0	2.0	2.0
Mg	1.0	1.5	1.5	1.0	1.0	1.5	1.5	1.5	1.5	1.0
Ca	2.0	5.0	5.0	3.0	3.0	7.0	7.0	5.0	5.0	3.0
Na	0.7	0.7	0.7	1.0	0.7	1.0	1.0	0.7	0.7	0.7
K	2.0	3.0	3.0	2.0	2.0	3.0	3.0	3.0	3.0	2.0
Ti	0.3	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Mn	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Ag	0.00001	0.00001	0	0	0.00015	0.000015	0.00001	0.00001	0	0
B	0.01	0.01	0.007	0.005	0.007	0.01	0.015	0.015	0.007	0.005
Ba	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
Be	0.00007	0.0001	0.00007	0.00007	0.00007	0.0001	0.0001	0.0001	0.00007	0.00007
Ce	0	0	0	0.01	0	0.01	0	0	0	0
Co	0.0015	0.0015	0.001	0.001	0.0015	0.0015	0.0015	0.0015	0.001	0.001
Cr	0.005	0.005	0.005	0.003	0.003	0.007	0.007	0.007	0.003	0.002
Cu	0.003	0.003	0.002	0.002	0.003	0.003	0.003	0.003	0.002	0.002
Ga	0.0015	0.002	0.0015	0.0015	0.0015	0.002	0.002	0.002	0.0015	0.001
La	0	0	0.003	0.003	0.003	0.005	0	0.005	0.003	0
Mo	0	0.0003	0.0003	0	0	0.0005	0.001	0.001	0	0

Table A.3.6-7 (concluded)

Semiquantitative Spectrographic Analyses of Deposits at the Western New York Nuclear Service Center.

(Analyses by Geochemistry & Petrology Branch, U.S. Geological Survey, Washington, D.C.; borehole locations are shown on Figure 7-2.)

Results are reported in percent to the nearest number in the series 1.0, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, etc., which represent approximate midpoints of group data on a geometric scale. The assigned group for semiquantitative results will include the quantitative value about 30% of the time.

These data should not be quoted without stating these limitations.

Symbols used are:
M = major constituent--greater than 10%
0 = looked for but not detected (see table of detectabilities)
- = not looked for
< , with number = less than number shown; usual detectabilities do not apply.

Lab No.	159429	159430	159219	159220	159221	159431	159432	159433	159222	159223
Hole No.	DH-4	DH-4	DH-6	DH-6	DH-6	DH-7	DH-7	DH-7	PAH-4	PAH-4
Depth (ft)	15-16½	25½-26½	36½-38	87-89	170-171	8-37	37-52	52-75	11½-13	21-23
Geologic Unit	Coarse, granular deposits(AT)	Silty clay till(BT)	Silty clay till(BT)	Silty clay till(BT)	Silty clay till(BT)	Silty clay till(BT)	Sandy clay till(SBT)	Silty clay till(BT)	Silty clay till(BT)	Sand and gravel(S,G)
Nb	0.001	0.0007	0	0	0	0.001	0.0007	0.0007	0	0
Ni	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Pb	0.001	0.0015	0.001	0.001	0.001	0.001	0.0015	0.0015	0.002	0.001
Sc	0.0015	0.0015	0.001	0.001	0.001	0.0015	0.0015	0.0015	0.001	0.001
Sr	0.01	0.015	0.02	0.015	0.015	0.02	0.02	0.02	0.05	0.01
V	0.01	0.01	0.015	0.01	0.01	0.015	0.01	0.02	0.01	0.007
Y	0.005	0.003	0.003	0.003	0.003	0.005	0.003	0.005	0.003	0.003
Yb	0.0005	0.0003	0.0003	0.0003	0.0003	0.0005	0.0003	0.0005	0.0003	0.0003
Zr	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.015	0.015

Pr, Nd, Sm, and Eu were looked for only when La or Ce were found. Looked for in all instances; detected in no instance.

Gd, Tb, Dy, Ho, Er, Tm, and Lu were looked for only when Y was found above 0.005%. Looked for in all instances; detected in no instance.

Ir, Os, Rh, and Ru would have been looked for only had Pd or Pt been found. Neither Pd or Pt were found in any instance.

Cs and Rb were looked for only as requested. No request was made.

The following elements were looked for but not detected in any instance:

P, As, Au, Bi, Cd, Ge, Hf, Hg, In, Li, Pd, Pt, Re, Sb, Sn, Ta, Te, Th, U, W, and Zn.

Table A.3.6-8

Percentage chemical composition of deposits at the Western New York Nuclear Service Center, as oxides.

(Analyses by Geochemistry & Petrology Branch, U. S. Geological Survey, using rapid-rock methods described in U.S.G.S. Bulletin 10360)

Laboratory No. Field Number (feet)	159668 PAH35 5-6	159670 PAH-62 7-20	159672 PAH-92 0-15	159673 PAH-92 15-40	159674 DH-3 62-72	159429 DH-4 15-16	159430 DH-4 25-26
Geologic Unit	Coarse, Granular Deposits (AT)	Silty Clay Till (BT)	Sand and Silt (S)	Silty Clay Till (BT)	Bedrock Core	Coarse, Granular Deposits (AT)	Silty Clay Till (BT)
SiO_2	74.4	58.2	78.2	66.6	63.5	70.7	56.1
Al_2O_3	10.0	14.6	9.5	13.0	17.4	10.9	14.5
Fe_2O_3	2.5	2.1	2.9	2.6	1.4	2.7	2.9
FeO	1.4	3.0	1.0	2.2	4.0	1.6	2.1
MgO	1.1	2.6	0.77	1.9	1.7	1.6	2.8
CaO	1.7	4.6	0.46	2.6	1.0	2.9	5.8
Na_2O	1.0	0.75	1.1	0.90	0.52	0.94	0.64
K_2O	2.0	3.2	1.9	2.8	3.7	2.2	3.1
H_2O^-	0.64	0.80	0.50	0.94	0.53	0.60	1.4
H_2O+	2.3	3.8	2.1	3.3	4.4	2.6	3.7
TiO_2	0.75	0.79	0.64	0.72	0.78	0.77	0.76
P_2O_5	0.14	0.14	0.11	0.14	0.16	0.13	0.13
MnO	0.07	0.07	0.08	0.08	0.07	0.06	0.07
CO_2	1.4	4.2	<0.05	2.1	1.3	2.3	5.6
	99	99	99	100	100	100	100
Powder Density by air Pycnometer	2.77	2.82	2.74	2.80	2.34	----	----

Table A.3.6-8 (concluded)

Percentage chemical composition of deposits at the Western New York Nuclear Service Center, as oxides.

(Analyses by Geochemistry & Petrology Branch, U. S. Geological Survey, using rapid-rock methods described in U.S.G.S. Bulletin 10360)

Laboratory No. Field Number (feet)	159675 PAH35 5-6	159676 PAH-62 7-20	159219 PAH-92 0-15	159220 PAH-92 15-40	159221 DH-3 62-72	159431 DH-4 15-16	159432 DH-4 25-26	1593433 DH-7 52-57
Geologic Unit	Coarse, Granular Deposits (AT)	Silty Clay Till (BT)	Sand and Silt (S)	Silty Clay Till (BT)	Bedrock Core	Coarse, Granular Deposits (AT)	Silty Clay Till (BT)	Silty Clay Till (BT)
SiO_2	74.2	62.5	58.2	68.0	67.0	56.6	58.1	56.5
Al_2O_3	9.8	16.3	14.4	11.0	12.4	14.7	13.5	15.9
Fe_2O_3	1.3	2.2	2.2	2.0	2.3	2.4	1.9	2.0
FeO	2.3	4.4	2.8	2.2	2.9	2.8	2.7	3.3
MgO	0.93	1.8	2.6	1.9	1.8	2.6	2.3	2.8
CaO	3.3	1.1	5.5	3.9	2.8	5.8	5.8	4.4
Na_2O	0.66	0.57	0.76	1.0	0.77	0.71	0.73	0.65
K_2O	1.7	3.5	3.1	2.3	2.4	3.2	3.0	3.5
H_2O^-	0.24	0.50	0.57	0.36	0.30	0.75	0.56	0.77
H_2O^+	2.7	4.1	3.6	2.8	3.2	3.7	3.9	4.2
TiO_2	0.62	0.90	0.78	0.76	0.92	0.79	0.72	0.79
P_2O_5	0.12	0.14	0.10	0.10	0.10	0.13	0.12	0.13
MnO	0.10	0.10	0.07	0.07	0.07	0.06	0.06	0.06
CO_2	2.5	1.5	5.0	3.6	2.6	5.3	5.6	4.0
	100	100	100	100	100	99	99	99
Powder Density by air Pycnometer		2.76	2.74	2.82	2.76	2.77	----	----

TABLE A.3.6-9

CHEMICAL ANALYSES OF BURIAL MATERIALS (PERCENT OF TOTAL SAMPLE)

A. Clay-rich till, unweathered (olive-gray)

	159430	159219	159431	159432	159433	NYGS-05	NYGS-12	NYGS-17	Average
SiO_2	56.1	58.2	56.6	58.1	56.5	58.3	58.2	58.8	57.6 ± 1.0
TiO_2	0.76	0.78	0.75	0.56	0.77	0.87	0.87	0.85	0.78 ± 0.10
Al_2O_3	14.5	14.4	14.7	13.5	15.9	14.6	14.6	14.5	14.6 ± 0.7
Fe_2O_3	2.9	2.2	2.4	1.9	2.0	2.0	2.0	2.0	2.2 ± 0.3
FeO	2.1	2.8	2.8	2.7	3.3	3.0	3.3	3.1	2.9 ± 0.4
MgO	2.8	2.6	2.6	2.3	2.8	2.8	2.8	2.8	2.7 ± 0.2
CaO	5.8	5.5	5.8	5.8	4.4	5.4	5.2	5.1	5.4 ± 0.5
Na_2O	0.64	0.76	0.71	0.73	0.65	0.70	0.71	0.72	0.70 ± 0.4
K_2O	3.1	3.1	3.2	3.0	3.5	3.3	3.4	3.2	3.2 ± 0.2
P_2O_5	0.13	0.10	1.13	0.12	0.13	---	---	---	0.12 ± 0.01
H_2O^+	3.7	3.6	3.7	3.9	4.2	3.2	3.0	3.0	3.5 ± 0.4
CO_2	5.6	5.0	5.3	5.6	4.0	6.2	6.6	6.3	5.6 ± 0.8
"free Fe_2O_3"*	-	-	-	-	-	0.35	0.33	0.34	0.34 ± 0.1

* That portion of the total Fe_2O_3 leachable by hot ammonium citrate/sodium dithionite solution.

TABLE A.3.6-9 (continued)

CHEMICAL ANALYSES OF BURIAL MATERIALS (PERCENT OF TOTAL SAMPLE)

B. Clay-rich till, weathered (brown)

	NYGS-06	NYGS-13	NYGS-16	AVERAGE
SiO_2	59.4	60.2	59.6	59.7 ± 0.4
TiO_2	0.91	0.89	0.89	0.90 ± 0.01
Al_2O_3	14.9	14.9	15.0	14.9 ± 0.1
Fe_2O_3	2.2	2.2	2.4	2.3 ± 0.1
FeO	3.3	3.2	2.9	3.1 ± 0.2
MgO	2.6	2.5	2.5	2.5 ± 0.1
CaO	4.8	4.8	4.7	4.8 ± 0.1
Na_2O	0.70	0.71	0.71	0.71 ± 0.1
K_2O	3.3	3.4	3.3	3.3 ± 0.1
P_2O_5	-	-	-	-
H_2O^+	2.7	3.0	3.0	2.9 ± 0.2
CO_2	5.3	5.2	5.3	5.3 ± 0.1
"free Fe_2O_3"*	0.89	1.12	1.04	1.02 ± 0.12

* That portion of the total Fe_2O_3 leachable by hot ammonium citrate/sodium dithionite solution.

TABLE A.3.6-9 (continued)

CHEMICAL ANALYSES OF BURIAL MATERIALS (PERCENT OF TOTAL SAMPLE)

C. Silt- and Sand-rich till and lacustrine deposits

	159429	159220	159221	NYGS-14	NYGS-15	AVERAGE
SiO_2	70.7	68.0	67.0	68.3	69.6	68.7 ± 1.4
TiO_2	0.77	0.76	0.92	0.62	0.56	0.73 ± 0.14
Al_2O_3	10.9	11.0	12.4	8.0	7.7	10.0 ± 2.1
Fe_2O_3	2.7	2.0	2.3	0.6	1.1	1.7 ± 0.9
FeO	1.6	2.2	2.9	2.1	2.1	2.2 ± 0.5
MgO	1.6	1.9	1.8	2.7	2.5	2.1 ± 0.5
CaO	2.9	3.9	2.8	6.6	6.4	4.5 ± 1.9
Na_2O	0.94	1.0	0.77	1.3	1.3	1.1 ± 0.2
K_2O	2.2	2.3	2.4	1.7	1.6	2.0 ± 0.4
P_2O_5	0.13	0.10	0.10	-	-	0.11 ± 0.02
H_2O'	2.6	2.8	3.2	1.0	0.95	2.1 ± 1.1
CO_2	2.3	3.6	2.6	7.1	7.0	4.5 ± 2.4
"free Fe_2O_3"*	-	-	-	0.14	0.84	0.49 ± 0.49

* That portion of the total Fe_2O_3 leachable by hot ammonium citrate/sodium dithionite solution.

TABLE A.3.6-9 (concluded)

SAMPLE LOCATIONS

(Samples Analyzed by USGS Geochemistry and Petrology Laboratory)

159429	NFS drill hole #4	15 - 16.5 feet
159430	NFS drill hole #4	25 - 16.5 feet
159219	NFS drill hole #6	36.5 - 38 feet
159220	NFS drill hole #6	87 - 89 feet
159221	NFS drill hole #6	170 - 171 feet
159431	NFS drill hole #7	8 - 37 feet
159432	NFS drill hole #7	37 - 52 feet
159433	NFS drill hole #7	52 - 57 feet

(Samples Analyzed by NYSGS Geochemistry Laboratory)

NYGS-05, 06	Samples taken from fresh road excavation at NW corner of low-level waste burial area; October 1975
NYGS-05	Unweathered till, 6 feet below present ground surface
NYGS-06	Brown, weathered till along a vertical fracture adjacent to NFS-05
NYGS-12, 17	Samples taken from excavation for holding lagoon W of burial site, October 1975
NYGS-12	Unweathered till, 12 feet below present surface, SE corner of lagoon
NYGS-13	Weathered till, 6 feet below surface, SE corner of lagoon
NYGS-14	Fine sand, gray, from small irregular lens 14 feet below surface, W side of lagoon
NYGS-15	Fine sand, red, small lens, 12 feet below surface, S end of lagoon
NYGS-16	Weathered till, 5 feet below surface, W side of lagoon
NYGS-17	Unweathered till, 12 feet below surface, W side of lagoon

TABLE A.3.6-10

Mineralogical Data of the Surficial Material from West Valley Low-Level Radioactive Waste Burial Site

SAND LENSES

FRESH TILL WEATHERED TILL FRESH

OXIDIZED

	NYGS	NYGS	NYGS	AVG	NYGS	NYGS	NYGS	AVG	NYGS	NYGS
	05	12	17		06	13	16		14	15
Clay Fraction (<2µ)										
Illite (1)	.99	1.14	1.32	1.15	1.74	1.31	1.19	1.41	.62	.60
Chlorite (2)	.83	.80	.90	.84	.98	.44	.35	.59	.57	.37
Quartz (3)	.11	.10	.05	.09	.10	.09	.10	.10	.11	.10
Illite/Chlorite	1.19	1.48	1.47	1.38	1.78	2.98	3.42	2.73	1.09	1.62
10.0A/10.5A	10.2	7.7	7.1	8.3	6.8	7.3	5.1	6.4	10.1	7.0
14A/7A	30	.38	.38	.35	.45	1.15	1.06	0.88	.32	.66
Silt Fraction (<62µ)										
Mica (4)	.84	.95	.86	.88	.77	.92	.87	.85	.36	.28
Chlorite (5)	.68	.54	.58	.60	.40	.32	.34	.35	.27	.19
Quartz (6)	2.98	2.66	2.38	2.67	2.26	2.69	2.50	2.48	3.08	3.98
K-Feldspar (7)	.09	.09	.11	.10	.10	.10	.10	.10	.18	.22
Plagioclase (8)	.22	.21	.27	.23	.29	.23	.24	.25	.45	.53
Calcite (9)	.19	.19	.18	.19	.15	.19	.20	.18	.17	.16
Dolomite (10)	.26	.22	.17	.22	.16	.15	.21	.17	.42	.44
Illite/Chlorite	1.24	1.76	1.48	1.49	1.93	2.88	2.55	2.45	1.33	1.47
% >62µ	9.9	12.3	15.8	12.7	11.9	11.9	12.6	12.1	42.6	61.0
% 2.62µ	49.4	47.7	45.6	47.6	52.8	47.8	48.2	49.6	50.8	34.6
% <2µ	40.7	40.0	38.6	39.8	35.3	40.3	39.2	38.3	6.6	4.4

(1)	Area Ratio 10.0A/1.93A	(6)	Height Ratio 3.34A/3.15A
(2)	Area Ratio 7.1A/1.93A	(7)	Height Ratio 3.24A/3.15A
(3)	Area Ratio 4.25A/1.93A	(8)	Height Ratio 3.18A/3.15A
(4)	Height Ratio 10.0A/3.15A	(9)	Height Ratio 3.02A/3.15A
(5)	Height Ratio 7.1A/3.15A	(10)	Height Ratio 2.89A/3.15A

TABLE A.3.6-11

Mineral Composition of Selected Core Samples from Western New York Nuclear Service Center[1]

(All values are in weight percent. Locations of test holes are shown on Figure A.3.6-29.)

Test-hole identification symbol; depth interval; [2] and material

Minerals	F 22.4 - 22.9 Till	I3 7.5 - 7.9 Oxidized Till	J 52.7 - 53.2 Till	N 24.5 - 24.9 Till	C2 9.5 - 10.0 Oxidized Till	C2 42.5 - 43.0 Till	D 14.0 - 14.5 Till	D 29.8 - 30.3 Lake Beds	G 36.2 - 36.7 Lake Beds	L 15.3 - 15.8 Lake Beds
QUARTZ	24	24	24	22	26	22	27	32	23	33
POTASSIUM FELDSPAR	1	<1	<1	1	2	1	1	3	0	3
PLAGIOCLASE FELDSPAR	7	7	5	4	7	5	5	9	6	10
CALCITE	11	7	7	8	9	7	9	11	7	9
DOLOMITE	5	3	5	5	7	5	5	9	5	11
CHLORITE	3	0	4	4	1	12	5	4	6	4
KAOLINITE	9	9	10	9	7	0	9	6	8	5
ILLITE	24	27	27	21	28	26	30	16	19	15
MONT-MORILLONITE	0	<1	0	0	0	0	0	0	0	0
MIXED-LAYER CLAY MINERALS	4	9	4	6	4	1	<1	4	7	5
TOTALS	88	86	86	80	91	79	91	94	81	95

[1] Mineral composition determined by B. J. Anderson, U.S. Geological Survey, by X-ray diffraction according to method of Schultz (1964). Totals between 90 and 105 percent are considered normal for this semiquantitative method. Low totals in some samples probably indicate a higher iron content; the fluorescent radiation produced by iron causes loss of peak intensity and therefore generally lower percentages (B. J. Anderson, written commun., 1978).

[2] Depths are in feet below land surface.

TABLE A.3.6-12

X-ray Peak Heights[1] and Chemical Analyses[2] for Silt- and Clay-Size Fractions of Lavery Till and Kent Till

	10.1A ILL	7.1A CHL	4.25A QTZ	3.25A KSPAR	3.19A PLAG	3.04A CALC	2.89A DOLO	% QTZ	% FELD.	% CARB.
CCRA *1	.50	0.00	22.80	3.80	8.00	4.40	9.80			
2	2.80	2.30	22.80	2.00	6.00	2.50	5.80			
3	5.80	5.50	27.50	2.00	8.50	7.00	14.50			
4	9.80	8.50	24.50	2.00	6.30	7.00	7.30	55.0	6.2	13.8
5	17.50	14.80	22.00	2.80	5.30	7.80	6.00			
6	22.80	21.30	16.80	2.50	3.80	6.50	4.80	36.0	5.2	8.0
7	28.50	30.00	12.80	2.50	3.30	5.80	3.00			
8	74.80	51.50	5.80	0.00	2.50	2.50	3.30	8.8	3.8	3.0
9	49.50	21.50	2.80	0.00	0.00	0.00	0.00	1.2	2.6	
CCRB *1	0.00	0.00	22.90	0.00	9.80	4.00	7.80			
2	2.30	3.30	21.00	3.00	10.50	0.00	0.00			
3	6.80	9.30	27.50	4.00	7.80	3.50	11.30			
4	14.50	16.80	22.80	1.00	5.30	5.80	7.80	53.5	6.4	
5	18.50	17.80	16.50	1.50	4.50	7.80	5.30			
6	35.50	36.00	11.80	3.80	4.00	7.00	3.80	25.7	7.0	
7	38.50	40.00	22.80	3.30	4.80	3.50	1.00			
8	45.50	49.30	4.50	2.00	1.80	3.30	1.50	7.4	6.0	
9	52.00	53.50	.80	0.00	2.50	1.80	0.00	2.5	2.9	

[1] X-ray diffractograms run with 1960 vintage Phillips, CuKa radiation, 45 Kv, 25Ma, Ni filter, .006 inch receiving slot, 2 degrees 2θ per minute scanning speed, PHS: baseline 100, window 200.

[2] Analytical methods are cited in WVDP-EIS-004 (WVNS).

TABLE A.3.6-12 (continued)

X-ray Peak Heights[1] and Chemical Analyses[2] for Silt- and Clay-Size Fractions of Lavery Till and Kent Till

	10.1A ILL	7.1A CHL	4.25A QTZ	3.25A KSPAR	3.19A PLAG	3.04A CALC	2.89A DOLO	% QTZ.	% FELD.	% CARB.
80-10IA *1	.30	.80	39.80	0.00	5.90	8.30	0.00			
2	3.00	3.30	26.00	3.50	6.30	5.30	9.00			
3	13.80	12.50	26.00	2.00	8.50	5.80	8.00			
4	23.50	22.30	16.30	.80	4.00	2.30	4.50	35.7	9.9	
5	31.30	27.30	12.00	1.80	3.50	1.80	2.50			
6	37.00	36.00	18.30	2.00	2.80	2.80	2.00	21.3	7.8	
7	28.30	25.30	6.00	.80	2.30	1.80	2.00			
8	48.30	42.00	3.30	.80	2.30	1.30	2.80			
CR Till *1	0.00	0.00	31.10	.60	11.80	3.30	10.00			
2	1.30	2.30	24.50	1.50	6.50	6.30	12.50			
3	4.50	5.50	25.80	3.50	7.00	8.00	17.30			
4	7.50	11.00	23.50	4.30	5.50	11.00	10.50	64.7	22.7	15.3
5	17.00	21.00	17.50	2.30	4.30	9.80	5.30			
6	21.30	26.00	14.00	2.30	4.00	10.00	4.50	34.8	7.7	13.5
7	28.50	35.00	8.50	3.80	4.00	9.30	4.00			
8	69.50	70.00	3.80	0.00	2.00	4.30	3.00	8.3	3.4	4.0
9	71.00	63.80	2.00	0.00	0.00	0.00	1.00	0.8	2.7	

[1] X-ray diffractograms run with 1960 vintage Phillips, CuKa radiation, 45 Kv, 25Ma, Ni filter, .006 inch receiving slot, 2 degrees 2θ per minute scanning speed, PHS: baseline 100, window 200.

[2] Analytical methods are cited in WVDP-EIS-004 (WVNS).

TABLE A.3.6-12 (concluded)

X-ray Peak Heights[1] and Chemical Analyses[2] for Silt- and Clay-Size Fractions of Lavery Till and Kent Till.

	10.1A ILL	7.1A CHL	4.25A QTZ	3.25A KSPAR	3.19A PLAG	3.04A CALC	2.89A DOLO	% QTZ.	% FELD.	% CARB.
SR-1 *1	0.00	0.00	28.60	4.10	10.80	4.10	11.10			
2	3.50	4.30	24.00	2.00	8.80	5.00	9.30			
3	5.50	8.50	20.00	2.80	6.80	10.00	20.00			
4	9.80	11.80	19.00	.50	6.30	8.80	10.30	44.9	7.2	
5	16.30	16.00	14.00	1.80	5.80	3.80	6.00			
6	16.80	15.00	14.30	1.80	5.30	2.30	6.50	36.3	18.1	
7	21.50	28.30	9.80	2.00	3.50	1.50	4.30			
8	39.00	44.00	3.00	0.00	1.80	0.00	1.80			
9	62.00	23.80	1.00	0.00	0.00	0.00	1.00			

*Size Fractions 1, 2, 3, 4 are silt grades:

.063 - .031mm (4ϕ-5ϕ);
.031 - .016mm (5ϕ-6ϕ);
.016 - .008mm (6ϕ-7ϕ);
.008 - .004mm (7ϕ-8ϕ);

Size Fractions 5, 6, 7, 8, 9 are clay grades:

.004 - .002mm (8ϕ-9ϕ);
.002 - .001mm (9ϕ-10ϕ);
.001 - .0005mm (10ϕ-11ϕ);
.0005 - .00025mm (11ϕ-12ϕ);
.00025 and finer. The smallest size was set arbitrarily at 14ϕ or .000063mm for purposes of drawing grain size distributions.

[1] X-ray diffractograms run with 1960 vintage Phillips, CuKa radiation, 45 Kv, 25Ma, Ni filter, .006 inch receiving slot, 2 degrees 2θ per minute scanning speed, PHS: baseline 100, window 200.

[2] Analytical methods are cited in WVDP-EIS-004 (WVNS).

TABLE A.3.6-13
Ratios[1] of X-ray Peak Heights (same samples as Table A.3.6-12)

	ILL/CH	ILL/QTZ	CHL/QTZ	KS/QTZ	PL/QT	CA/QTZ	DO/QTZ	K+P/QTZ	C+D/QTZ
CCRA *1	.00	.02	0.00	.17	.35	.19	.43	.52	.62
2	1.22	.12	.10	.09	.26	.11	.25	.35	.36
3	1.05	.21	.20	.07	.31	.25	.53	.38	.78
4	1.15	.40	.35	.08	.26	.29	.30	.34	.58
5	1.18	.80	.67	.13	.24	.35	.27	.37	.63
6	1.07	1.36	1.27	.15	.23	.39	.29	.38	.67
7	1.42	2.23	1.56	.20	.26	.45	.23	.45	.69
8	1.45	12.90	8.88	0.00	.43	.43	.57	.43	1.00
9	2.30	17.68	7.68	0.00	0.00	0.00	0.00	0.00	0.00
CCRB *1	0.00	0.00	0.00	0.00	.43	.17	.34	.43	.52
2	.70	.11	.16	.14	.50	0.00	0.00	.64	0.00
3	.73	.25	.34	.15	.28	.13	.41	.43	.54
4	.86	.64	.74	.04	.23	.25	.34	.28	.60
5	1.04	1.12	1.08	.09	.27	.47	.32	.36	.79
6	.99	3.01	3.05	.32	.34	.59	.32	.66	.92
7	.96	1.69	1.75	.14	.21	.15	0.00	.36	.15
8	.92	10.10	10.96	.44	.40	.73	.33	.84	1.07
9	.97	65.00	66.87	0.00	3.12	2.25	0.00	3.12	2.25
80-10IA *1	.38	.01	.02	0.00	.15	.21	0.00	.15	.21
2	..91	.12	.13	.13	.24	.20	.35	.38	.55
3	1.10	.53	.48	.08	.33	.22	.31	.40	.53
4	1.05	1.44	1.37	.05	.25	.14	.28	.29	.42
5	1.15	2.61	2.27	.15	.29	.15	.21	.44	.36
6	1.03	2.02	1.97	.11	.15	.15	.11	.26	.26
7	1.12	4.72	4.22	.13	.38	.30	.33	.52	.63
8	1.15	14.64	12.74	.24	.70	.39	.85	.94	1.24

[1] Numbers from Table A.3.6-12 were used to calculate ratios.

TABLE A.3.6-13 (concluded)

Ratios[1] of X-ray Peak Heights (same samples as Table A.3.6-12)

	ILL/CH	ILL/QTZ	CHL/QTZ	KS/QTZ	PL/QT	CA/QTZ	DO/QTZ	K+P/QTZ	C+D/QTZ
CR Till *1	0.00	0.00	0.00	.02	.38	.11	.32	.40	.43
2	.57	.05	.09	.06	.27	.26	.51	.33	.77
3	.82	.17	.21	.14	.27	.31	.67	.41	.98
4	.68	.32	.47	.18	.23	.47	.45	.42	.91
5	.81	.97	1.20	.13	.25	.56	.30	.38	.86
6	.82	1.52	1.86	.16	.29	.71	.32	.45	1.04
7	.81	3.35	4.12	.45	.47	1.09	.47	.92	1.56
8	.99	18.29	18.42	0.00	.53	1.13	.79	.53	1.92
9	1.11	35.50	31.90	0.00	0.00	0.00	.50	0.00	.50
SR-1 *1	1.02	0.00	0.00	.14	.38	.14	.39	.52	.53
2	.81	.15	.18	.08	.37	.21	.39	.45	.60
3	.65	.28	.43	.14	.34	.50	1.00	.48	1.50
4	.83	.52	.62	.03	.33	.46	.54	.36	1.01
5	1.02	1.16	1.14	.13	.41	.27	.43	.54	.70
6	1.12	1.17	1.05	.13	.37	.16	.45	.50	.62
7	.76	2.19	2.89	.20	.36	.15	.44	.56	.59
8	.89	13.00	14.67	0.00	.60	0.00	.60	.60	.60
9	2.61	62.00	23.80	0.00	0.00	0.00	1.00	0.00	1.00

[1] Numbers from Table A.3.6-12 were used to calculate ratios.

TABLE A.3.6-14

CATION EXCHANGE CAPACITIES - A

(See U.S.G.S. Open-File Report 83-682 for Logs)

Boring Location	Depth (feet)	CEC	Interval Description	Geologic Unit
61 PAH 2	26.5 - 28	16.8	Wet gy snd, compact	Sat'd snd lens in Lavery
61 PAH 3	25 - 26.5 (Fine) 25 - 26. 5 (Coarse)	11.6 03.8	Moist gy slt Wet gy snd, compact	Lavery till, u-wx Sat'd snd lens in Lavery
61 PAH 7	5 - 15 20 - 21	06.0 13.5	Moist yel, br snd, and R gvl, Firm moist gy slt, hard	Fluvial terrace (Wfg) Lavery till, u-wx
61 PAH 29	5 - 16.5	12.1	Gy, br silt, zoned moist & dry	Lavery till, u-wx
61 PAH 35	5 - 6.5 11 - 26.5	06.0 09.8	Wet yel-br snd & gvl Wet gy slt	Alluvium (Haf) Lavery till, u-wx
61 PAH 39	0 - 6 6 - 32	07.4 08.1	Moist br-gy slt, gy @ 5 ft. Gy slt, plastic	Lavery till, sl. wx Lavery till, u-wx
61 PAH 42	0 - 6 6 - 32	12.6 17.4	Br, yell, gy slt Gy slt, plastic	Lavery till (possibly Wrm), wx Lavery till, u-wx
61 PAH 50	0 - 12 12 - 21	06.9 06.9	Silt, some snd & gvl Br slt	Fluvial Terrace (Wfg) Lavery till, wx
61 PAH 51	0 - 6 6 - 14 (rock @ 14)	17.0 12.6	Br slt w/pbls Gy slt & sh frags	Kent till, wx Kent till, u-wx
61 PAH 52	0 - 12 12 - 23 (rock @ 23)	15.4 11.3	Br slt Wrm/WH Br slt & sh frags	Kent ground moriane (Wrm) Kent till, wx (WH)
62 PAH 58	10 - 35	10.0	Gy slt, plastic	Lavery till, u-wx
62 PAH 59	10 - 40	09.8	Gy slt, plastic	Lavery till, u-wx
62 PAH 62	7 - 20	12.3	Gy slt, soft, plastic	Lavery till, u-wx
62 PAH 66	0 - 9 9 - 20	06.7 09.5	Moist br slt (0' - 5'); Wet gy slt & VF snd; wet gy slt	Fluvial terrace (Wfg) Lavery till, u-wx
62 PAH 81	0 - 45	09.0	Br slt (0'-8'); gy slt, plastic (8'-45')	Lavery till, wx/u-wx
62 PAH 92	0 - 15 14 - 40	05.1 10.7	Br, yel snd, slt Br slt/br-gy slt/gy slt (@ 25')	Lavery till, wx Lavery till, wx/u-wx
62 PAH 94	0 - 20 20 - 40	18.5 11.8	Br, yel slt & VF snd Br slt/gy slt (@ 35')	Lavery till, wx Lavery till, wx/u-wx
12 PAH 95	0 - 10 15 - ?	18.8 12.8	Br-yel slt w/snd; gvl Gy slt & wx sh, v. hard	Lavery till, wx Lavery till, u-wx

TABLE A.3.6-14 (concluded)

CATION EXCHANGE CAPACITIES - A

(See U.S.G.S. Open-File Report 83-682 for Logs)

BORING LOCATION	DEPTH (FEET)	CEC	INTERVAL DESCRIPTION	GEOLOGIC UNIT
61 DH 3	?	05.4	SHOULD OPEN IN WTC; SEE LOG SH @ ~65'; TD:65'	-----
61 DH 4	5 - 6.5 20 - 21.5 ?	06.1 07.2 03.5	MOIST BR SLT W/SOME SND, GVL. MOIST BR SLT W/SOME SND, GVL. (WET GY SLT @ 38' - 60')	LAVERY TILL OR ALLUVIUM LAVERY TILL, WX
62 DH 5	?	05.6	OPENS IN LAVERY, ~@ PAH 58 SH @ ~175'; TD:181'	---
61 DH 6	36.5 - 38 87 - 89 170 - 171	10.2 07.0 06.9	WET GY SLT, PLASTIC WET GY SLT, SOME F AND MOIST GY SLT	LAVERY TILL, U-WX LACUSTRINE UNIT (WLB) KENT TILL, U-WX
61 DH 7	0 - 8 8 - 37 52 - 75 75 - 115	17.7 10.1 17.9 04.3	MOIST, BR-GY SLT, HARD WET GY SLT, PLASTIC WET GY SLT, PLASTIC MOIST BR SND/WSLT, GVL, V. COMPACT	LAVERY TILL, WX/SL WX LAVERY TILL, U-WX LAVERY TILL, U-WX LACUSTRINE UNIT (WLB)
62 DH 13	8.5 - 10	09.6		FLUVIAL TERRACE/LAVERY TILL

TABLE A.3.6-15

Cation Exchange Capacities - B

BORING LOCATION	DEPTH (FEET)	CEC	ORGANIC CONTENT (%)	INTERVAL DESCRIPTION	GEOLOGIC UNIT
83-1-E	10. - 11.75	----	----	Brown silty clay/clayey silt, trace sand, little gravel. Stiff gray silty clay, trace gravel. Stiff gray silty clay with some gravel.	Lavery till, wx/u-wx
83-1-E	21.1 - 22.0	4.47	1.84	Gray silty clay/clayey silt with sand, gravel.	Lavery till, u-wx
83-1-E	30.55 - 32.0	5.74	1.12	Brown-gray clayey, silty gravel with some sand.	Alluvium or moraine
83-1-E	44.6 - 46.7	4.69	2.48	Gray silty clay with little sand, trace gravel. Gray clayey silt with little sand, trace gravel; slightly fissured.	Lavery till, u-wx
83-2-E	9.55 - 10.8	----	----	Brown-gray clayey, silty gravel; little sand.	Alluvium
83-2-E	20 - 21.1	4.36	2.32	Brown silty clay with 1.5" diameter void in center. Root fragments first 2". Gray clayey silt, some sand, gravel. Gravel silty clay with some sand, little gravel.	Lavery till, wx/u-wx
83-2-E	30 - 31.72	3.84	0.96	Dark gray silty clay, some sand, gravel. Dark gray clayey silt, some sand, little gravel.	Lavery till, u-wx
83-2-E	40.36 - 42	6.11	2.16	Medium still dark gray silt and clay, trace sand gravel. Grading to stiff silt and clay, same coarse composition.	Lavery till, u-wx

TABLE A.3.6-15 (continued)

Cation Exchange Capacities - B

BORING LOCATION	DEPTH (FEET)	CEC	ORGANIC CONTENT (%)	INTERVAL DESCRIPTION	GEOLOGIC UNIT
83-2-E	50. - 51.9	6.10	2.24	Medium still gray silt and clay.	Lavery till, u-wx
83-2-E	62.6 - 63.5	3.67	2.40	Brown-gray clayey silt, some sand, little gravel	Lavery till, sl/wx
83-2-E	70 - 71.05	1.87	1.20	Gray silty clay grading to clayey silt. Gray silt	Lavery till, u-wx
83-2-E	10 - 11.9	4.93	2.40	Soft to medium still gray silty clay, some sand, little gravel. gray coarse silty sand. Medium stiff gray silty clay, some sand, little gravel. Becoming stiff gray clayey silt, same coarse combination as above.	Lavery till, u-wx
83-3-E	20 - 22	4.57	1.68	Medium still gray silty clay/clayey silt with some sand, little gravel. Stiff gray clayey silt with some sand, little gravel.	Lavery till, u-wx
83-3-E	30 - 32.0	7.64	2.40	Brown-gray silt, gravelly clay, still gray clayey silt with some sand, gravel.	Lavery till, u-wx
83-3-E	40.9 - 42.0	5.87	1.76	Brown-gray silty clay with trace of sand, little gravel. 5" pocket of silt. Brown-gray clayey silt, little gravel, occasional layers of silt.	Lavery till, u-wx
83-3-E	50 - 51	3.38	1.36	Dark gray silty clay grading to gravelly silty clay. Dark gray silty clayey sand, little gravel.	Lacustrine unit

TABLE A.3.6-15 (concluded)

Cation Exchange Capacities - B

BORING LOCATION	DEPTH (FEET)	CEC	ORGANIC CONTENT (%)	INTERVAL DESCRIPTION	GEOLOGIC UNIT
83-3-E	60. - 61.0			Medium still gray silt and clay.	Lavery till, u-wx
82-1-D	50.0 - 52.0	5.82	1.76	Dark gray gravelly silty clay.	Lavery till, u-wx
	60.0 - 61.9	6.57	1.52	Dark gray to blue-green gravelly silty clay.	Lavery till, u-wx
	69.9 - 72.2	3.41	1.28	Brownish-gray silty clay/dark gray medium stiff gravelly clay.	Lavery till, u-wx
	79.7 - 81.6	4.50	0.96	Dark gray silty clay with gravel, with layers of brownish-green clay and light gray silt.	Lavery till, u-wx and Lacustrine unit.
82-3-D	52.5 - 53.3	3.93	0.88	Gray silty and sandy clay.	Lavery till, u-wx
	60.0 - 61.8	4.23	0.88	Gray silty clay with gravel.	Lavery till, u-wx
	82.0 - 83.4	3.63	1.28	Gray silty clay with some sand, gravel.	Lacustrine unit.

Information on procedures provided to Dames and Moore by Rutgers Soil Testing Laboratory.
Certified Lab Procedure:

1.0 N NH_4OAc (pH 7.0), using centrifuge (Agric. Handbook #60, USDA)

Description of Preparation of Sample:

Soil samples were air-dried and sieved using stainless steel sieves with 2mm openings.

Analytical Procedure:

NH_4 -N was analyzed by AutoAnalyzer using the alkaline phenol method.
(Bolleter el al., 1961. Anal. Chem 33:592-594)

TABLE A.3.6-16
Summary of GM K_d Values for 48 Selected Elements by Soil Type
(in ml/g)

Element	Sand	Loam	Clay	Organic
Ac [a]	450	1 500	2 400	5 400
Ag [b]	90	120*	180*	15 000*
Am	1 900*	9 600*	8 400*	112 000*
Be	250	800	1 300	3 000
Bi	100	450	600	1 500
Br	15	50	75	180
C	5	20	1	70
Ca	5	30	50	90
Cd	80*	40*	560*	800*
Ce	500*	8 100*	20 000*	3 300*
Cm	4 000*	18 000*	6 000	6 000*
Co	60*	1 300*	550*	1 000*
Cr	70*	30*	1 500	270*
Cs	280*	4 600*	1 900*	270*
Fe	220*	800*	165*	600*
Hf	450	1 500	2 400	5 400
Ho	250	800	1 300	3 000
I	I*	5*	1*	25*
K	15	55	75	200
Mn	50*	750*	180*	150*
Mo	10*	125	90*	25*
Nb	160	550	900	2 000
Ni	400*	300	650*	1 100*
Np	5*	25*	55*	1 200*
P	5	25	35	90
Pa	550	1 800	2 700	6 600
Pb	270*	16 000*	550	22 000*
Pd	55	180	270	670
Po	150*	400*	3 000	7 300
Pu	550*	1 200*	5 100*	1 900*
Ra	500*	36 000*	9 100*	2 400
Rb	55	180	270	670
Re	10	40	60	150
Ru	55*	1 000*	800*	66 000*
Sb	45*	150	250	550
Se	150	500	740	1 800
Si	35	110	180	400
Sm	245	800	1 300	3 000
Sn	130	450	670	1 600
Sr	15*	20*	110*	150*
Ta	220	900	1 200	3 300
Tc	0*	0*	1*	1*
Te	125	500	720	1 900
Th	3 100*	3 300	5 800*	89 000*
U	35*	15*	1 600*	410*
Y	170	720	1 000	2 600
Zn	200*	1 300*	2 400*	1 600*
Zr	600	2 200	3	7 300

[a] - Values with regular numbering are default values predicted using CRs.
[b] - Values with **bold** numbering followed by an * (asterick) come from the literature.

SOURCE: Sheppard and Thibault, 1990.

TABLE A.3.6-17

Distribution Coefficients for 22 Nuclides
for
Four Site-Specific Geochemical Environments (in ml/g)

NUCLIDE	OVERLAND FLOW	WASTE MASS	LAVERY TILL	LACUSTRINE
H-3	0	0	0	0
C-14	0.1	0.1	1	0.1
Mn-54	50	10	100	50
Fe-55	750	150	1500	750
Ni-59	150	50	150	150
Co-60	500	100	1000	500
Ni-63	150	50	1000	150
Sr-90	*30	30	*7	3
Nb-94	350	70	350	350
Tc-99	0.1	0.1	1	0.1
Ru-106	220	70	220	220
Sb-125	45	50	45	45
I-129	0.01	0.01	1	0.01
Cs-134, 135, 137	200	200	*48	200
Ce-144	1100	2000	1100	1100
Eu-154	*4300	2000	*600	*4300
Ra-226	220	400	220	220
U-234, 235, 238	70	70	700	70
Np-237	5	5	5	5
Pu-238, 239, 241, 242	1800	700	1800	1800
Am-241, 242	4700	800	*420	*4700
Cm-243, 244	3300	700	700	3300

*Based on site-specific data reported by Pietrzak et al, 1981.

TABLE A.3.6-18

Distribution Coefficients for Trench Water and Till from West Valley, New York, Disposal Site (in ml/g ± σ)

Water Condition

	Oxic Water		Anoxic Water	
	Soil Condition			
RADIONUCLIDE	ULTRASONIC DISAGGREGATION	GROUND 100-200 MESH FRACTION	ULTRASONIC DISAGGREGATON	GROUND 100-200 MESH FRACTION
^{152}Eu	4300 ± 500	3700 ± 600	600 ± 60	2100 ± 220
^{241}Am	4700 ± 100	4000 ± 600	420 ± 60	1000 ± 200
^{85}Sr	32 ± 1	25 ± 1	6.9 ± 0.4	7.4 ± 0.2
^{134}Cs	200 ± 10	100 ± 30	49 ± 6	260 ± 10
^{137}Cs	200 ± 10	100 ± 30	48 ± 5	260 ± 70
^{60}Co	2.3 ± 0.2	1.8 ± 0.1	1	5 ± 1

Trench Water: Trench 2-1A
Soil: Unweathered till, Test hole A1 (WV-A2)
Solution/Soil Ratio: 20 ml/g
Reaction Containers: Screw cap, septum sealed, glass test tubes
Equilibration Time: 100h
Source: Pietrzak and others, 1981

TABLE A.3.6-19

Sorption of Cs-137, Sr-85, Ru-106, and Co-60
by Samples of Lavery Till Taken at the SDA

	Cs		Sr		Ru		Co	
D	4 Hr.	16 Hr.	4 Hr.	16 Hr.	4 Hr.	16 Hr.	4 Hr.	16 Hr.
Hole -1								
5	97.15	98.72	89.68	87.60	98.25	98.45	98.96	98.95
10	98.06	98.65	80.58	78.21	98.25	98.59	99.19	99.42
15	98.25	99.23	57.88	53.92	98.26	98.64	99.45	99.62
20	97.65	99.21	60.37	49.31	98.26	98.77	99.58	99.54
25	98.25	99.14	55.85	52.53	98.22	98.44	99.57	99.65
30	98.52	98.85	60.41	57.88	98.42	98.51	99.44	99.59
35	98.22	99.11	63.27	60.83	98.14	98.50	99.54	99.59
40	98.00	99.07	62.07	58.29	98.05	98.31	99.14	99.55
45	98.54	99.02	57.65	53.96	98.39	98.52	99.68	99.64
50	98.23	99.03	62.86	54.19	97.50	97.68	99.56	99.60
Hole -2								
10	97.10	99.22	85.28	85.51	97.41	98.24	99.24	99.48
30	99.35	99.49	59.72	55.19	97.55	98.40	99.64	99.73
50	98.83	99.51	60.32	55.09	97.70	98.31	99.69	99.52
Hole -3								
10	98.75	99.77	83.38	81.30	97.58	97.84	99.44	99.59
30	98.93	99.54	60.46	58.90	97.65	98.31	99.38	99.62
50	98.69	99.44	62.41	58.19	97.68	98.13	99.43	99.44
Hole -4								
10	98.89	99.81	85.69	86.81	97.44	98.17	99.34	99.54
30	98.96	99.46	57.96	55.32	97.57	97.83	99.46	99.62
50	79.19	99.11	38.43	43.98	97.48	97.81	99.29	99.39
Hole -5								
10	99.04	99.34	89.23	88.82	96.43	97.75	99.02	99.21
30	99.10	99.25	64.71	59.73	96.85	98.01	99.21	99.32
50	99.06	99.43	60.90	57.29	98.08	98.49	99.53	99.54
Hole -6								
10	99.66	99.84	85.79	81.08	97.04	97.78	99.71	99.80
25	99.25	99.52	61.13	56.74	97.12	97.91	99.64	99.54
50	99.28	99.55	59.28	52.94	97.00	98.22	99.67	99.70

D = Depth (in feet)

TABLE A.3.6-19 (concluded)

Sorption of Cs-137, Sr-85, Ru-106, and Co-60
by Samples of Lavery Till Taken at the SDA

	Cs		Sr		Ru		Co	
Hole -7								
D	4 Hr.	16 Hr.	4 Hr.	16 Hr.	4 Hr.	16 Hr.	4 Hr.	16 Hr.
10	99.39	99.65	88.19	84.62	97.12	98.20	99.53	99.69
30	99.38	99.54	64.57	55.16	96.78	97.46	99.60	99.72
50	99.27	99.47	68.73	58.87	97.00	97.19	99.57	99.57
Hole -8								
10	98.99	99.87	83.49	79.11	95.92	97.51	99.35	99.48
25	99.19	99.52	56.46	50.26	96.25	97.78	99.54	99.68
50	99.26	99.44	53.39	51.82	95.96	97.55	99.59	99.67
Hole -9								
10	98.53	99.55	85.89	83.23	95.84	96.71	99.44	99.68
25	99.37	99.57	59.43	52.50	96.39	97.97	99.58	99.73
50	99.32	99.38	57.40	49.58	96.43	98.02	99.54	99.69
Hole -10								
10	99.15	99.67	79.43	78.02	94.08	96.98	98.89	99.34
30	99.28	99.63	59.79	54.84	96.11	96.68	99.60	99.60
50	99.27	99.46	58.49	54.63	96.20	96.86	99.62	99.64

TABLE A.3.6-20

K_d Values Corresponding to Sorption Data in Table A.3.6-19

	CESIUM		STRONTIUM		RUTHENIUM		COBALT		IODINE
Hole	4 Hr.	16 Hr.	4 Hr.	16 Hr.	4 Hr.	16 Hr.	4 Hr.	16 Hr.	
1	852	1928	217	177	1404	1588	2379	2356	
1	1264	1827	104	90	1404	1748	3061	4285	0.641
1	1404	3222	34	29	1412	1813	4520	6554	1.738
1	1039	3140	38	24	1412	2008	5927	5410	
1	1404	2882	32	28	1379	1578	5789	7118	0.720
1	1664	2149	38	34	1557	1653	4439	6073	
1	1379	2784	43	39	1319	1642	5410	6073	0.747
1	1225	2663	41	35	1257	1454	2882	5531	
1	1687	2526	34	29	1528	1664	7788	6919	
1	1387	2552	42	30	975	1053	5657	6225	1.206
2	837	3180	145	148	940	1395	3264	4783	
2	3821	4877	37	31	995	1538	6919	9234	
2	2112	5077	38	31	1062	1454	8040	5183	
3	1975	10845	125	109	1008	1132	4439	6073	
3	2311	5410	38	36	1039	1454	4407	6554	
3	1883	4439	42	35	1053	1312	4361	4439	
4	2227	13133	150	165	952	1341	3763	5410	3.409
4	2379	4605	34	31	1004	1127	4605	6554	1.096
4	95	2784	16	20	967	1117	3496	4073	
5	2579	3763	207	199	675	1086	2526	3140	
5	2753	3308	46	37	769	1231	3140	3651	
5	2635	4361	39	34	1277	1631	5294	5410	
6	7328	15600	151	107	820	1101	8596	12475	
6	3308	5183	39	33	843	1171	6919	5410	
6	3447	5531	36	28	808	1379	7551	8308	
7	4073	7118	187	138	843	1364	5294	8040	2.503
7	4007	5410	46	31	751	959	6225	8904	0.720
7	3400	4692	55	36	808	865	5789	5789	0.355
8	2450	19206	126	95	588	979	3821	4783	
8	3061	5183	32	25	642	1101	5410	7788	
8	3353	4439	29	27	594	995	6073	7551	
9	1676	5531	152	124	576	735	4439	7788	
9	3943	5789	37	28	668	1207	5927	9234	
9	3651	4007	34	25	675	1238	5410	8040	
10	2916	7551	97	89	397	803	2227	3763	
10	3447	6732	37	30	618	728	6225	6225	
10	3400	4605	35	30	633	771	6554	6919	

TABLE A.3.6-21

Summary of K_d Data for Samples of Lavery Till
Taken at the SDA (in ml/g)

	CESIUM		STRONTIUM		RUTHENIUM		GOBALT	
	4 Hr.	16 Hr.	4 Hr.	16 Hr.	4 Hr.	16 Hr.	4 Hr.	16 Hr.
Range, 37 samples	95-7328	1827-19206	16-217	20-199	397-1557	728-2008	2227-8596	2356-12475
AM, 37 samples	2496	5344	71	60	964	1281	5086	6272
AM, 11 wx samples	2562	8153	151	131	873	1207	3983	5718
AM, 26 uwx samples	2469	4167	37.38	30.62	1002	1313	5552	6506
GM, 37 samples	2093	4542	55	46	914	1240	4806	5961
GM, 11 wx samples	2106	6210	146	126	819	1168	3686	5162
GM, 26 uwx samples	2088	3979	36.65	30.28	957	1272	5377	6336

AM = Arithmetic mean
GM = Geometric mean

TABLE A.3.6-22

COMPARISON OF SITE-SPECIFIC[1] AND GENERIC[2] SORPTION DATA

	LAVERY TILL	LOAM SOIL	CLAY SOIL
		CESIUM (CS)	
Range (ml/g)	1827 - 19206	4560 - 61000	37 - 31500
No. of Values	37	54	28
Geometric Mean (ml/g)	4542	4600	1900
		STRONTIUM (SR)	
Range (ml/g)	20 - 200	01. - 300	3.6 - 32000
No. of Values	37	43	24
Geometric Mean (ml/g)	46	20	110
		RUTHENIUM (RU)	
Range (ml/g)	730 - 2000	--	--
No. of Values	37	2	1
Geometric Mean (ml/g)	1240	1000	800
		COBALT (CO)	
Range (ml/g)	2356 - 12475	100 - 9700	20 - 14000
No. of Values	37	23	15
Geometric Mean (ml/g)	5961	1300	550
		IODINE (I)	
Range (ml/g)	0.35 - 3.4	0.1 - 43	0.2 - 19
No. of Values	10	33	8
Geometric Mean (ml/g)	1.06	5	1

[1] Duckworth et al., 1974
[2] Sheppard and Thibault, 1990

TABLE A.3.6-23
CESIUM SORPTION ON NEW YORK SOIL SAMPLES

Clay: 0.5 g of 2 mm fraction (A)
Solution: 25 ml of Oak Ridge tap water plus 10,500 cpm per ml Cs137.

		1-Hr. Contact		4-Hr. Contact		24-Hr. Contact	
Field Number	Feet	% Sorption	K_d*	% Sorption	K_d*	% Sorption	K_d*
DH-3	10 - 11-1/2***	96.57	1410	97.44	1910	98.72	3860
DH-4	15 - 16-1/2**	98.02	2480	98.71	3830	99.38	8020
DH-4	25-1/2 - 26-1/2**	98.51	3310	98.51	3310	98.99	4900
DH-7	37 - 52***	98.18	2700	98.45	3180	98.90	4500
PAH-1	10-1/2 - 12**	98.92	4580	99.08	5380	99.27	6800
PAH-4	11-1/2 - 13***	97.51	1960	98.30	2890	98.53	3350
PAH-4	21 - 23***	95.73	1120	97.15	1700	98.56	3420
PAH-10	5 - 15***	96.91	1570	97.79	2210	98.65	3650

Cesium Sorption With Potassium Added (B)

Clay: 0.5 g of 2 mm fraction
Solution: 25 ml of 150 ppm potassium plus 19,000 cpm per ml Cs137.

		1-Hr. Contact		4-Hr. Contact		24-Hr. Contact	
Field Number	Feet	% Sorption	K_d*	% Sorption	K_d*	% Sorption	K_d*
DH-3	10 - 11-1/2***	92.22	595	94.72	900	94.14	805
DH-4	15 - 16-1/2**	92.73	640	95.58	1080	93.34	700
DH-4	25-1/2 - 26-1/2**	95.23	1000	97.71	2130	97.36	1840
DH-7	37 - 52***	86.57	320	88.08	370	86.86	300
PAH-1	10-1/2 - 12**	93.54	725	95.60	1080	94.03	790
PAH-4	11-1/2 - 13***	88.99	405	91.36	530	89.15	410
PAH-4	21 - 23***	83.22	250	87.44	350	89.59	430
PAH-10	5 - 15***	91.62	545	93.53	725	91.93	570

* $K_d = \frac{\text{Percent Radionuclide Sorbed/Weight of Material}}{\text{Percent Radionuclide in Solution/Volume of Solution}}$

** Lavery till, wx

*** Lavery till, u-wx

TABLE A.3.6-23 (continued)
STRONTIUM SORPTION ON NEW YORK SOIL SAMPLES

(C)

Oak Ridge Tap Water
Clay: 0.5 g of 2 mm fraction
Solution: 25 ml of Oak Ridge tap water plus 12,000 cpm per ml Sr85.

		1-Hr. Contact		4-Hr. Contact		24-Hr. Contact	
Field Number	Feet	% Sorption	K_d*	% Sorption	K_d*	% Sorption	K_d*
DH-3	10 - 11-1/2***	38.86	32	40.99	35	42.87	38
DH-4	15 - 16-1/2**	51.67	53	54.12	59	55.05	61
DH-4	25-1/2 - 26-1/2**	58.12	69	57.75	68	59.51	74
DH-7	37 - 52***	30.15	22	29.64	21	29.99	21
PAH-1	10-1/2 - 12**	40.62	34	37.78	30	38.96	32
PAH-4	11-1/2 - 13***	38.80	32	37.79	30	37.82	30
PAH-4	21 - 23***	25.62	17	26.98	18	27.97	19
PAH-10	5 - 15***	49.78	50	48.57	47	50.74	52

(D)

Demineralized Water, Calcium Added

Clay: 0.5 g of 2 mm fraction
Solution: 25 ml of 15 ppm calcium plus 12,000 cpm per ml Sr85.

		1-Hr. Contact		4-Hr. Contact		24-Hr. Contact	
Field Number	Feet	% Sorption	K_d*	% Sorption	K_d*	% Sorption	K_d*
DH-3	10 - 11-1/2***	40.96	35	46.67	44	42.10	36
DH-4	15 - 16-1/2**	54.15	59	56.00	64	57.56	68
DH-4	25-1/2 - 26-1/2**	61.94	81	62.63	84	60.78	77
DH-7	37 - 52***	32.78	24	32.87	24	31.40	23
PAH-1	10-1/2 - 12**	42.12	36	40.14	34	39.38	33
PAH-4	11-1/2 - 13***	40.70	34	39.86	33	39.26	32
PAH-4	21 - 23***	28.78	20	29.90	21	30.11	22
PAH-10	5 - 15***	49.77	50	49.99	50	51.52	53

* $K_d = \frac{\text{Percent Radionuclide Sorbed/Weight of Material}}{\text{Percent Radionuclide in Solution/Volume of Solution}}$

** Lavery till, wx

*** Lavery till, u-wx

TABLE A.3.6-23 (concluded)

STRONTIUM SORPTION ON NEW YORK SOIL SAMPLES

New York Well Water (E)

Clay: 0.5 g of 2 mm fraction
Solution: 25 ml of New York well water plus 11,000 cpm per ml Sr85.

		1-Hr. Contact		4-Hr. Contact		24-Hr. Contact	
Field Number	Feet	% Sorption	K_d*	% Sorption	K_d*	% Sorption	K_d*
DH-4	15 - 16-1/2"	58.68	71	57.62	68	59.77	74
DH-4	25-1/2 - 26-1/2"	62.12	82	59.97	75	60.65	77
PAH-1	10-1/2 - 12"	43.98	39	40.54	34	41.97	36
PAH-10	5 - 15'''	50.80	52	49.25	49	50.62	51

Ruthenium Sorption On New York Soil Samples (F)

Clay: 0.5 g of 2 mm fraction
Solution: 25 ml of ruthenium from seepage pits at ORNL diluted 1:1 with demineralized water.

		1-Hr. Contact		4-Hr. Contact		24-Hr. Contact	
Field Number	Feet	% Sorption	K_d*	% Sorption	K_d*	% Sorption	K_d*
DH-4	15 - 16-1/2"	1.82	0.9	1.68	0.9	1.42	0.7
DH-4	25-1/2 - 26-1/2"	0.79	0.4	0.17	0.1	0.54	0.3
PAH-1	10-1/2 - 12"	1.25	0.6	1.51	0.8	0.87	0.4
PAH-10	5 - 15'''	1.68	0.9	0.55	0.3	0.00	0.0

* $K_d = \frac{\text{Percent Radionuclide Sorbed/Weight of Material}}{\text{Percent Radionuclide in Solution/Volume of Solution}}$

** Lavery till, wx

*** Lavery till, u-wx

TABLE A.3.6-24

Radioactivity of Burial Till
(μCi/ml)

Hole	Depth	Total	Total	Description
A	13.0 - 13.5'	1.7×10^{-5}	3.6×10^{-5}	Weathered silt and fine sand
B	34.0 - 43.3'	1.9×10^{-5}	3.6×10^{-5}	Lacustrine clayey silt
C	6.5 - 7.0'	1.1×10^{6}	1.1×10^{6}	Weathered and fractured till
C	8.1 - 8.6'	2.2×10^{-5}	3.8×10^{-5}	Weathered till with 0.1' sandy layer
D	28.0 - 28.5'	$<8 \times 10^{-6}$	3.8×10^{-5}	Mass of sandy silt in till
D	30.3 - 30.8'	$<9 \times 10^{-6}$	2.8×10^{-5}	Lacustrine clayey silt with 0.2'
D_2	4.9 - 5.4'	$<1 \times 10^{-7}$	4.7×10^{-6}	Weathered pebbly till
E	9.5 - 10.0'	1.7×10^{-5}	3.3×10^{-5}	Till with weathered fractures
E	30.0 - 30.5'	1.4×10^{-5}	3.5×10^{-5}	Olive gray till, massive, pebbly, unweathered
E_2	7.0 - 7.5'	2.5×10^{-5}	4.6×10^{-5}	Weathered till, fractures lined with MN, Fe oxides
F	4.5 - 5.0'	3.7×10^{-5}	1.8×10^{-5}	Weathered and fractured till
F	7.0 - 7.5'	$<1.1 \times 10^{-5}$	3.1×10^{-5}	Weathered till, Mn oxides on fractures
N	10.8 - 11.3'	4.3×10^{-5}	4.3×10^{-5}	Coarse, calcarious weathered silt
R	15.5 - 16.0'	$<1.0 \times 10^{-5}$	3.2×10^{-5}	Olive gray till with pebbly silt inclusions, unweathered

Calculated till: 1.8×10^{-5} 3.2×10^{-5}

TABLE A.3.6-25

Gamma Spectrometry Analyses of Burial Till

Hole	Depth	Raev (ppm)	Th (ppm)	K (%)	Description
$C-_2$	40.0 - 40.5	3.9	12.6	3.0	Till, few pebbles (<5%)
E	29.5 - 30.0	3.8	13.5	3.1	Till, pebbly (10-15% pebbles)
E	46.0 - 46.3	3.8	13.3	2.9	Olive gray till, 5-10% pebbles
E	46.3 - 46.7	3.9	11.9	3.0	Olive gray till, 5-10% pebbles
I	6.0 - 6.5	3.6	11.4	2.8	Yellowish brown pebbly till, weathered
I	24.0 - 24.5	3.7	11.7	2.7	Till, minor silt, 5% pebbles
I	25.0 - 25.5	3.8	11.8	2.9	Till, minor silt, 5% pebbles
I	27.0 - 27.6	3.6	10.9	2.6	Till, minor silt, 5% pebbles
I	28.0 - 28.6	3.7	11.6	2.9	Till, minor silt, 5% pebbles
J	22.0 - 22.5	3.3	9.7	2.4	Till, minor silt, 5% pebbles
M	10.0 - 10.5	3.8	11.6	2.8	Yellowish brown till, weathered
M	25.5 - 26.0	3.3	10.0	2.5	Till, 5-10% pebbles
M	40.7 - 41.0	3.6	12.0	2.4	Silt and clayey silt, lacustrine
M	50.7 - 51.0	3.9	12.2	3.1	Till, minor silt, pebbles <5%
M	27.1 - 27.3	2.3	8.5	2.0	Till, sand lens large pebble
N	38.0 - 38.5	3.6	12.0	2.8	Till, 10-15% pebbles
N	42.0 - 42.5	3.8	11.6	2.8	Till, 10-15% pebbles
P	27.2 - 27.6	3.5	11.0	2.7	Till
P	45.0 - 45.5	3.7	11.7	2.8	Till

Averages: 3.6 ± 0.3 11.5 ± 1.2 2.7 ± 0.3

SR1-311A.DWG

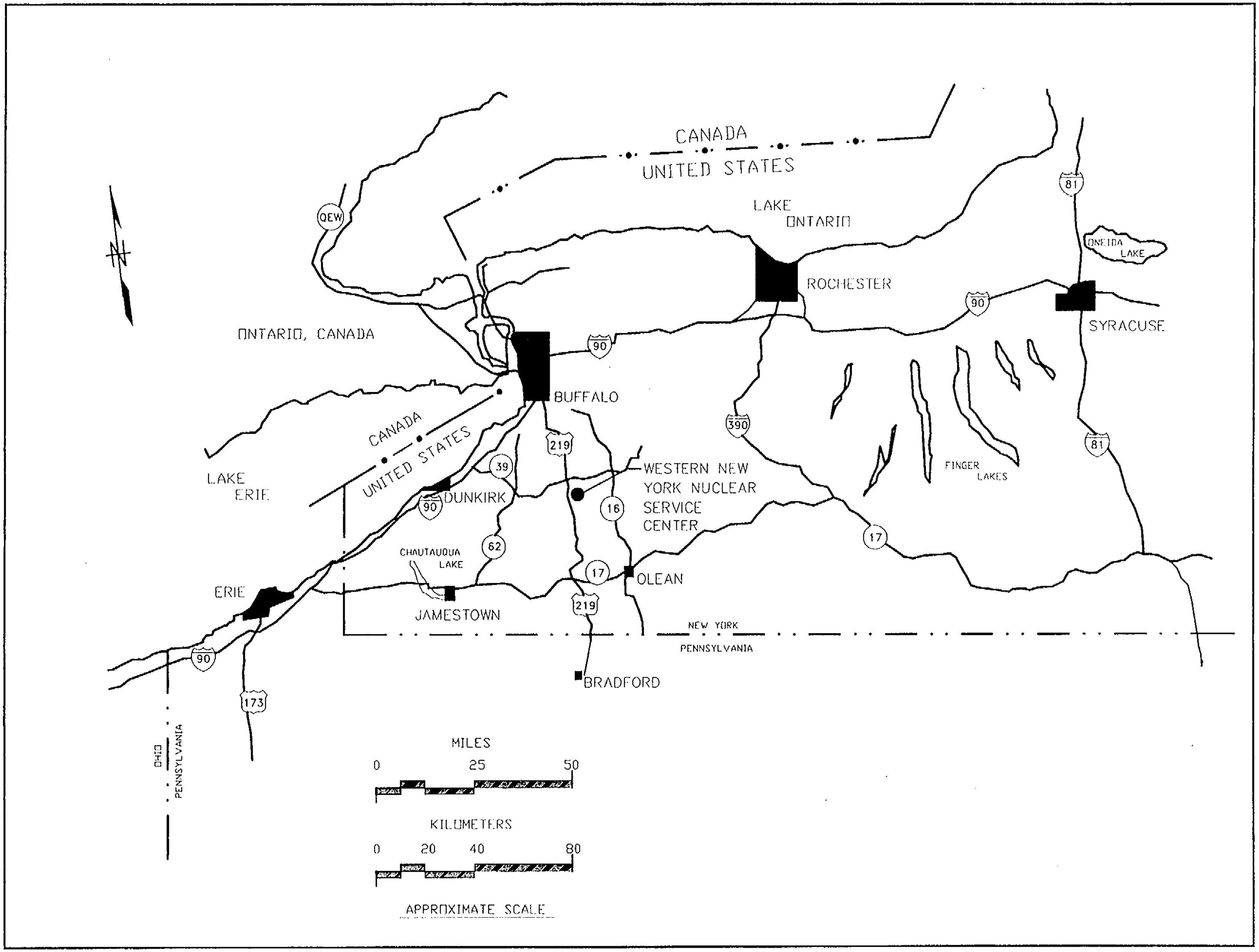


Figure A.3.1–1a Location of the Western New York Nuclear Service Center.

SR1-311B.DWG

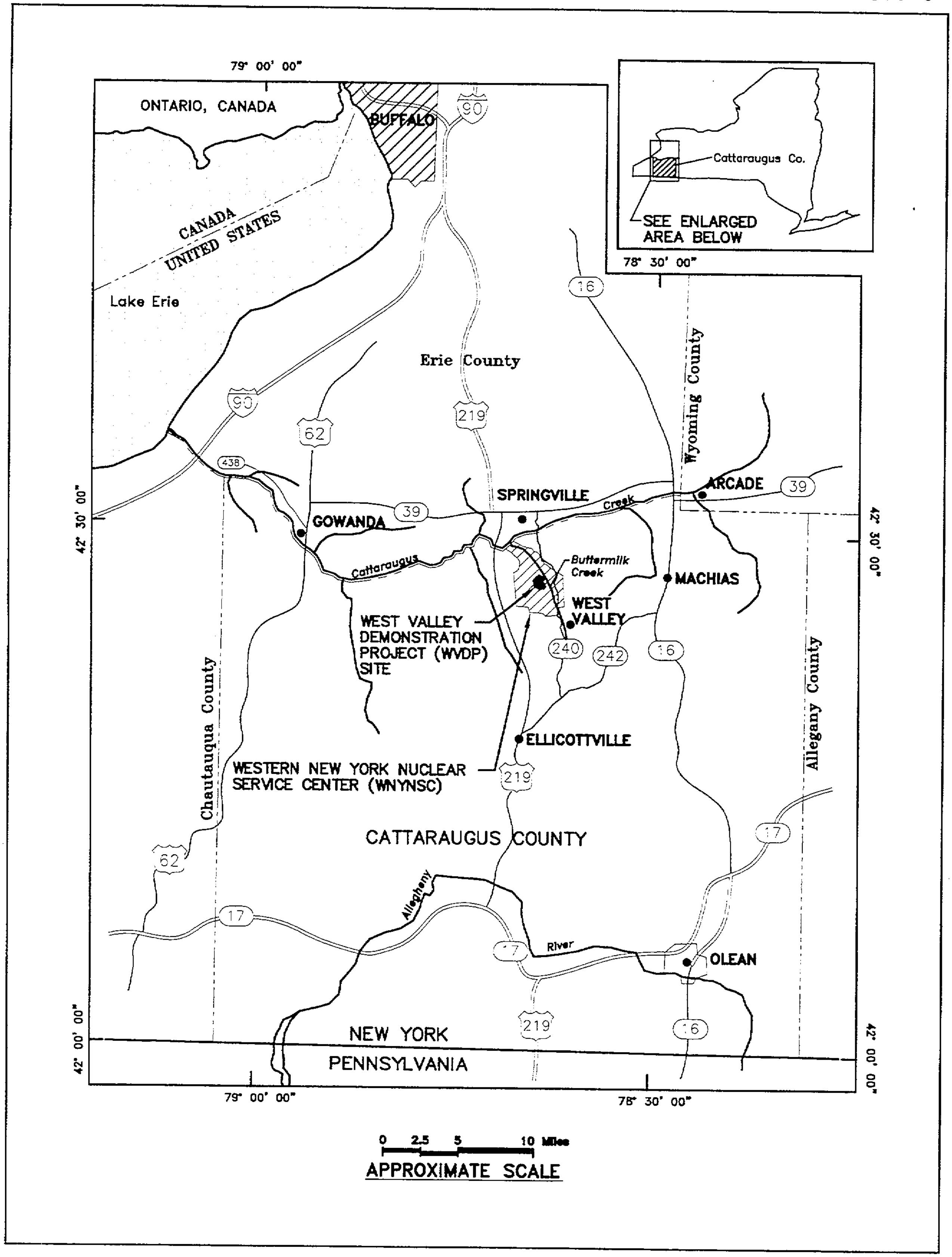


Figure A.3.1-1b Location of the Western New York Nuclear Service Center.

SR1-312A.DWG

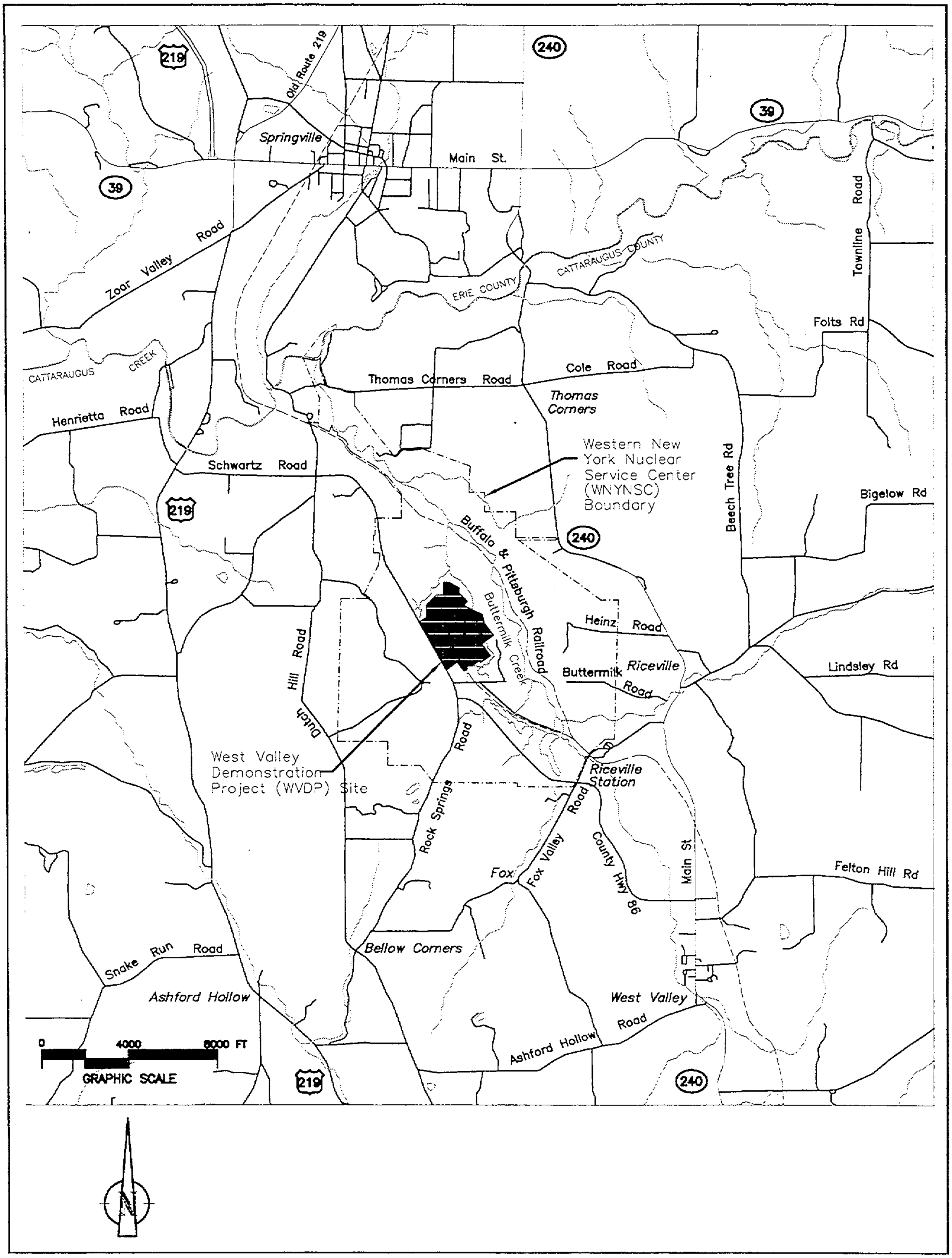


Figure A.3.1-2a Local Area Surrounding The WVDP Site.

SR1-312B.DWG

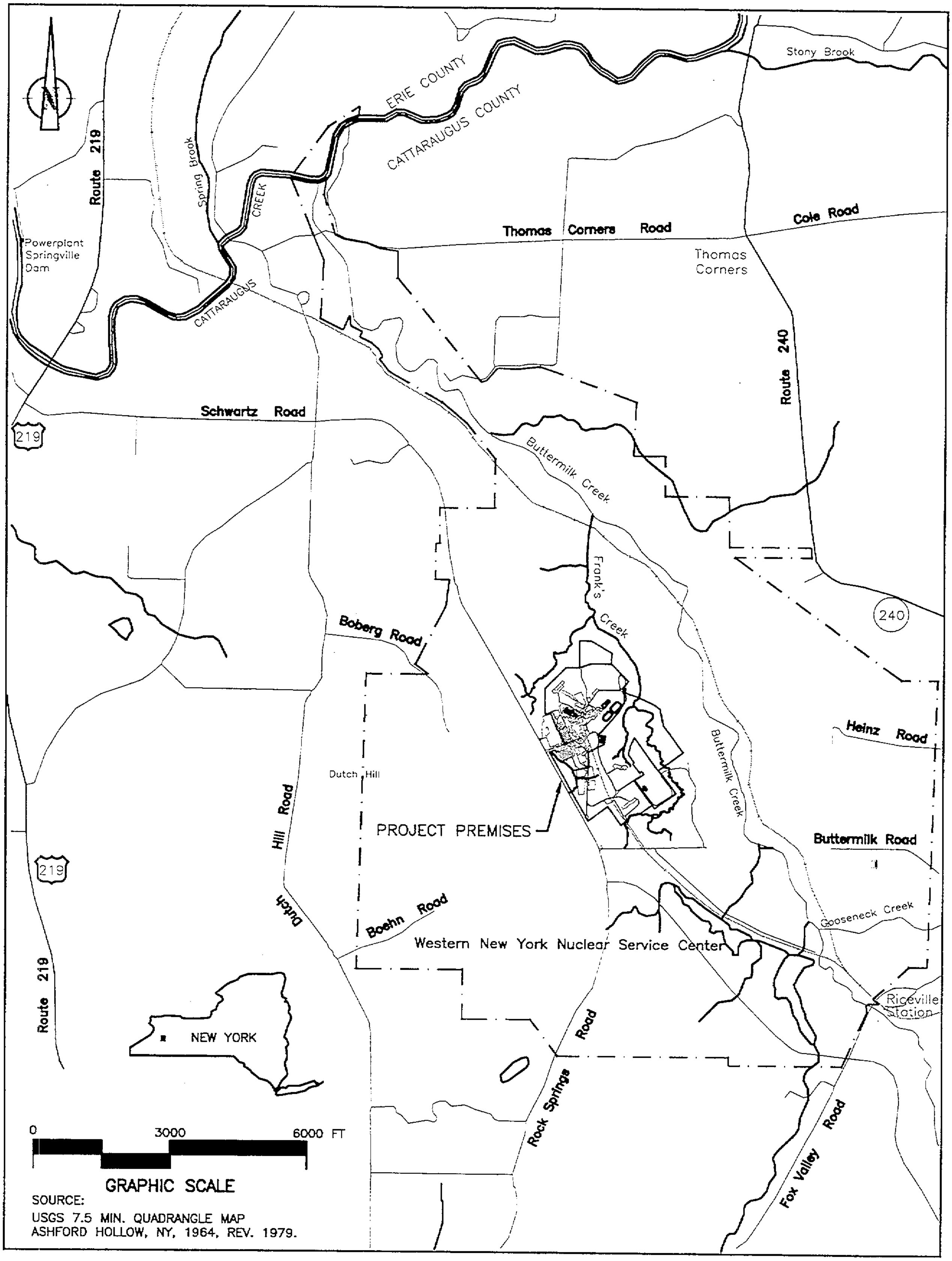


Figure A.3.1–2b Location of West Valley Demonstration Project Site.

SR1-313A.DWG

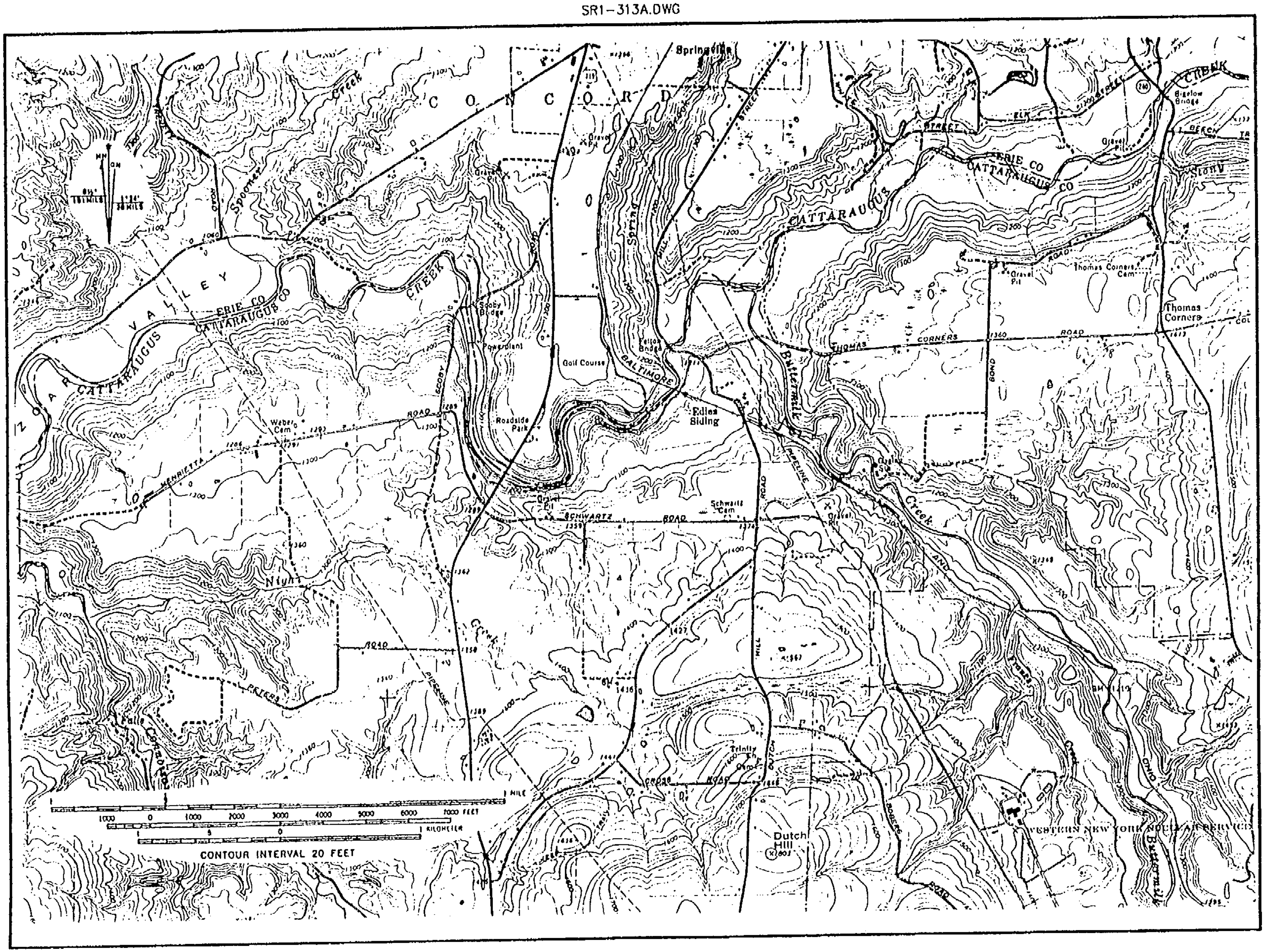


Figure A.3.1-3a WNYNSC Vicinity Map – Northern Portion

SR1-313B.DWG

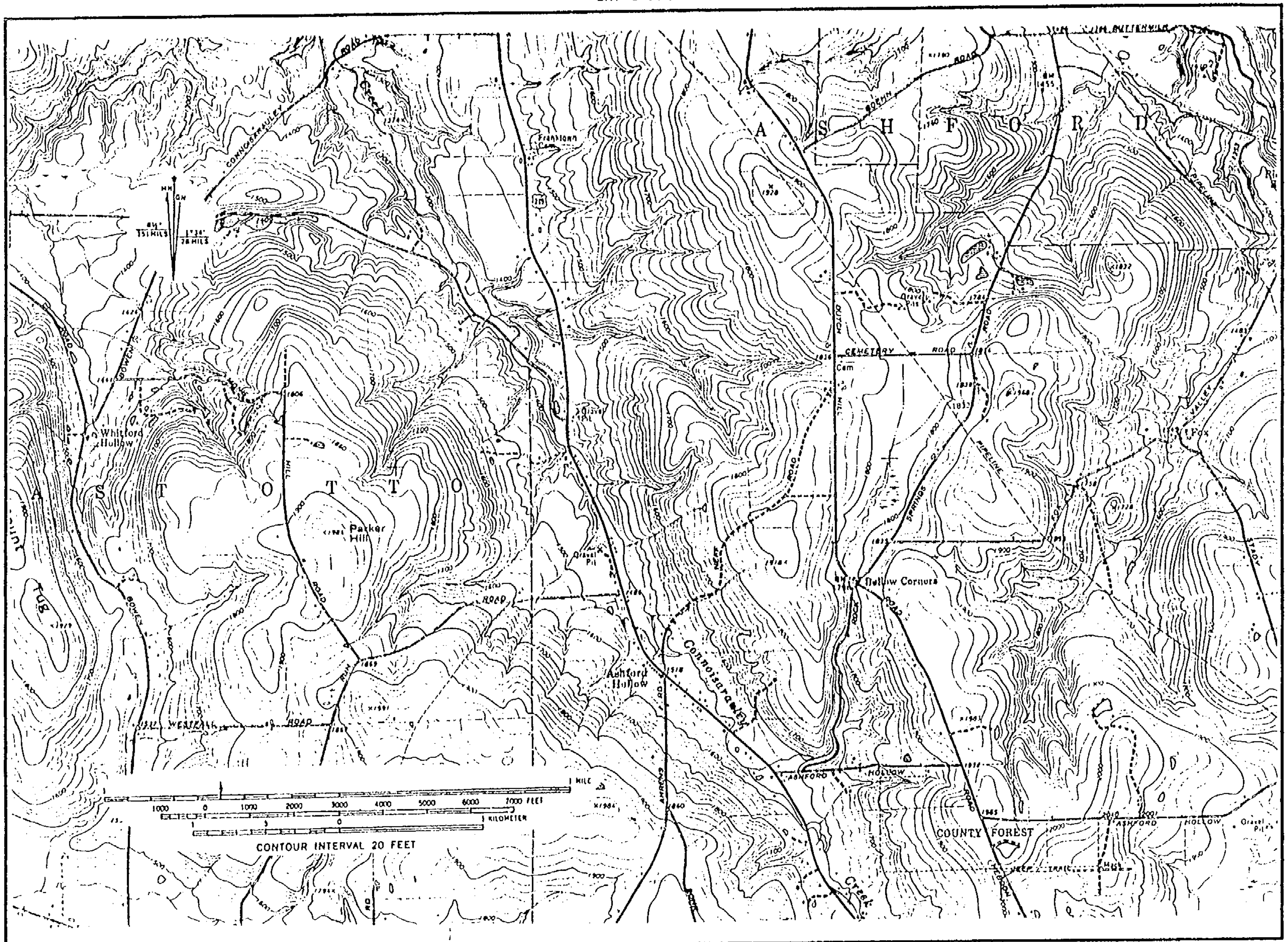


Figure A.3.1-3b WNYNSC Vicinity Map – Southern Portion

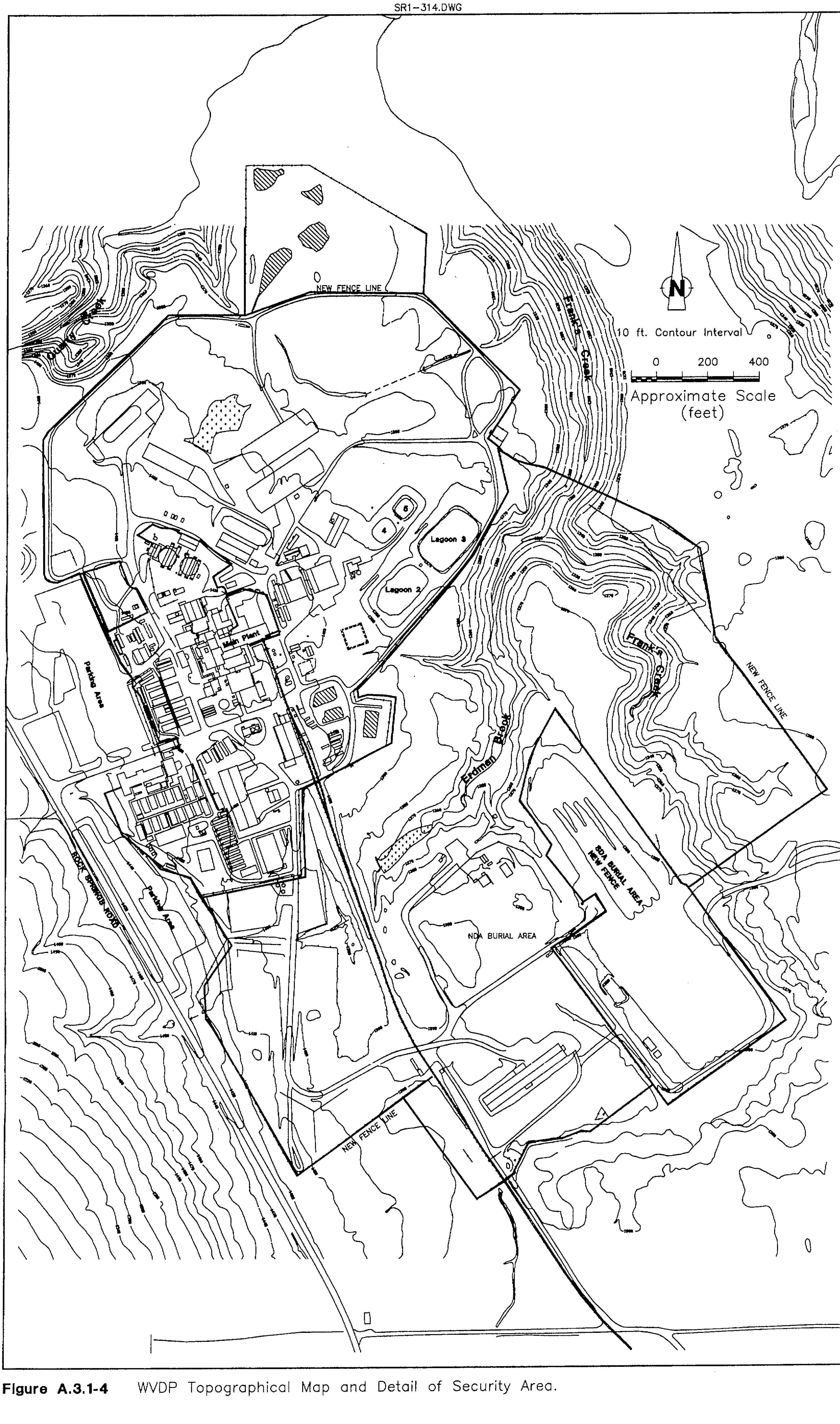


Figure A.3.1-4 WVDP Topographical Map and Detail of Security Area.

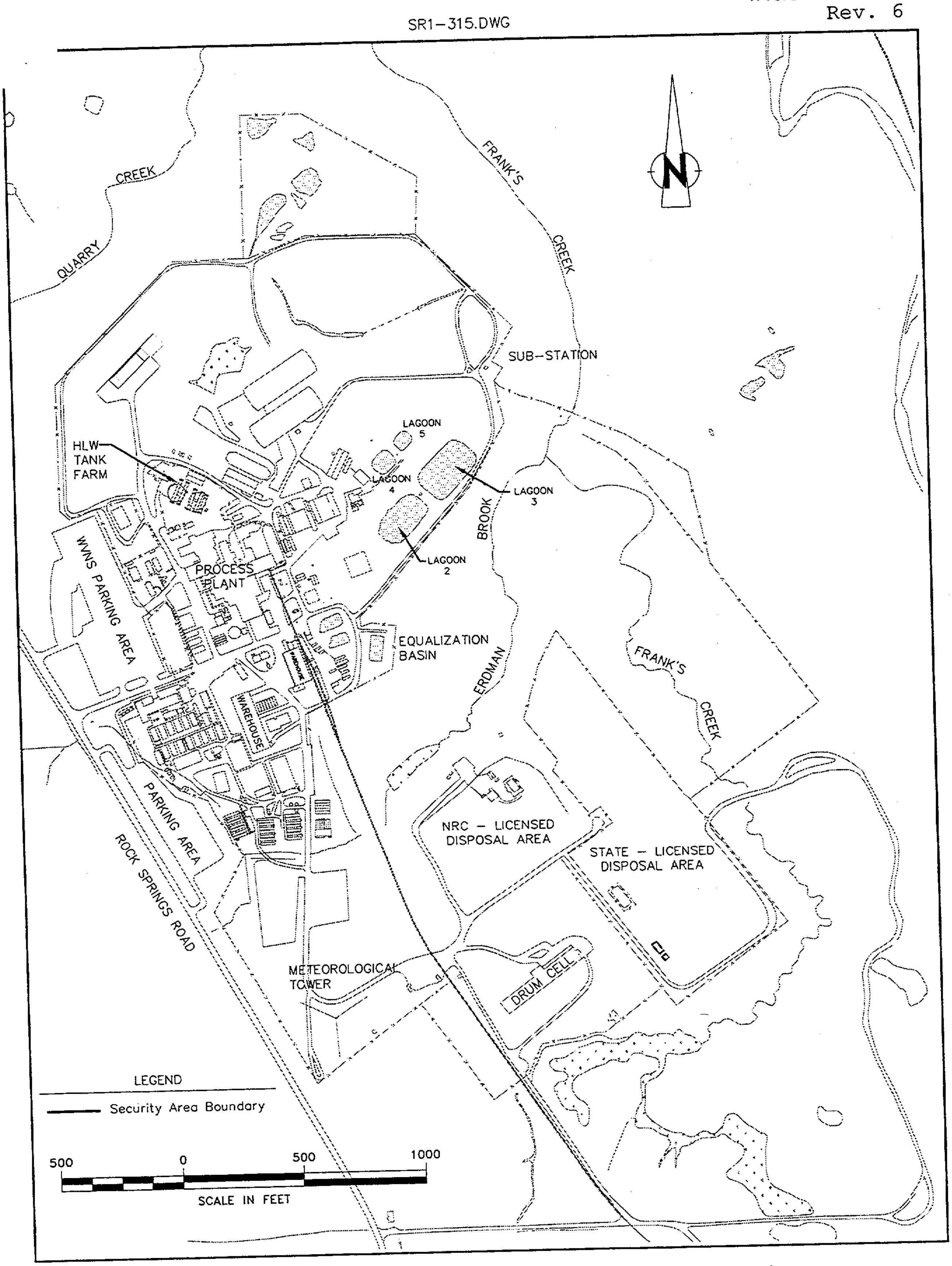
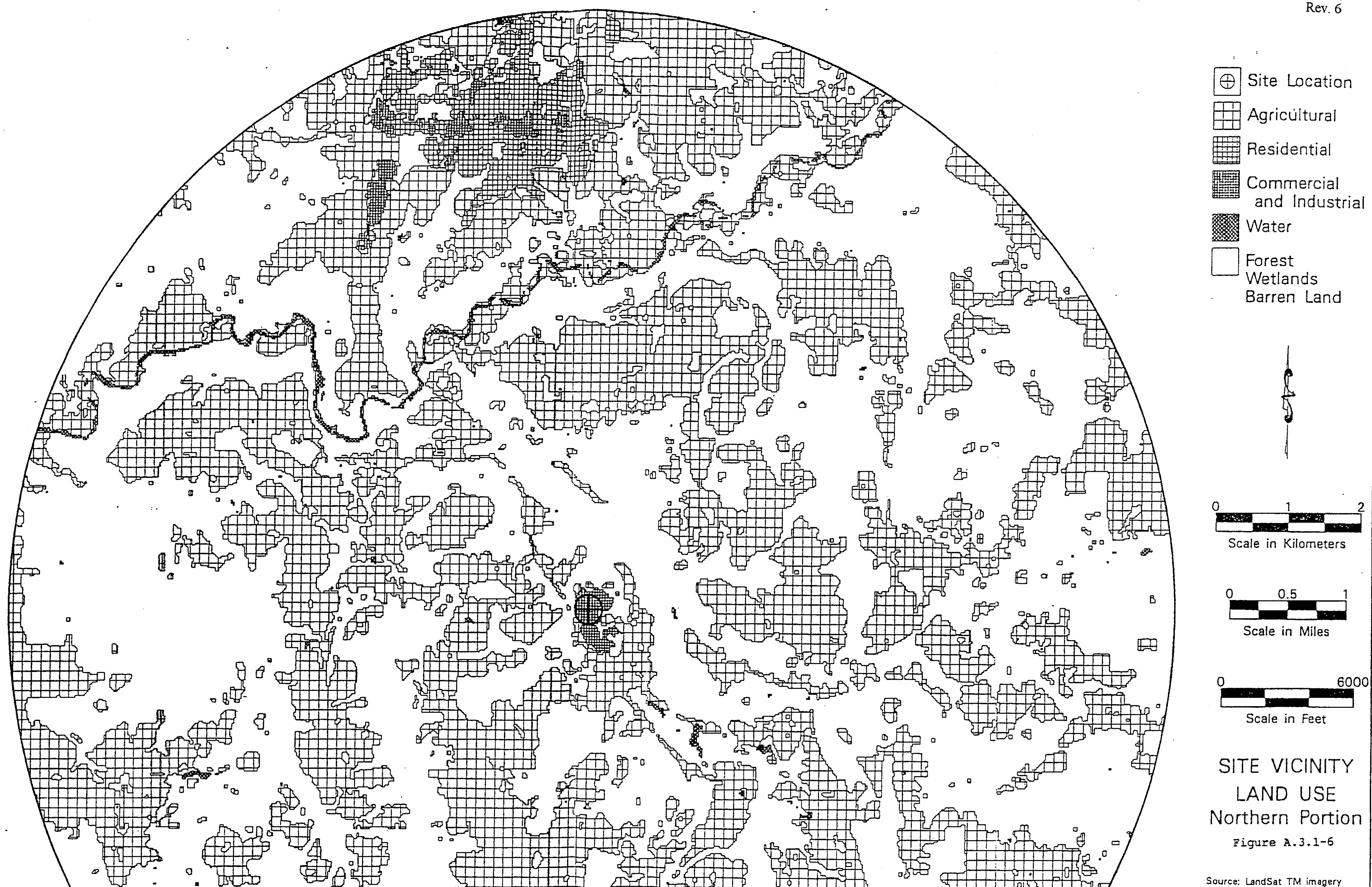


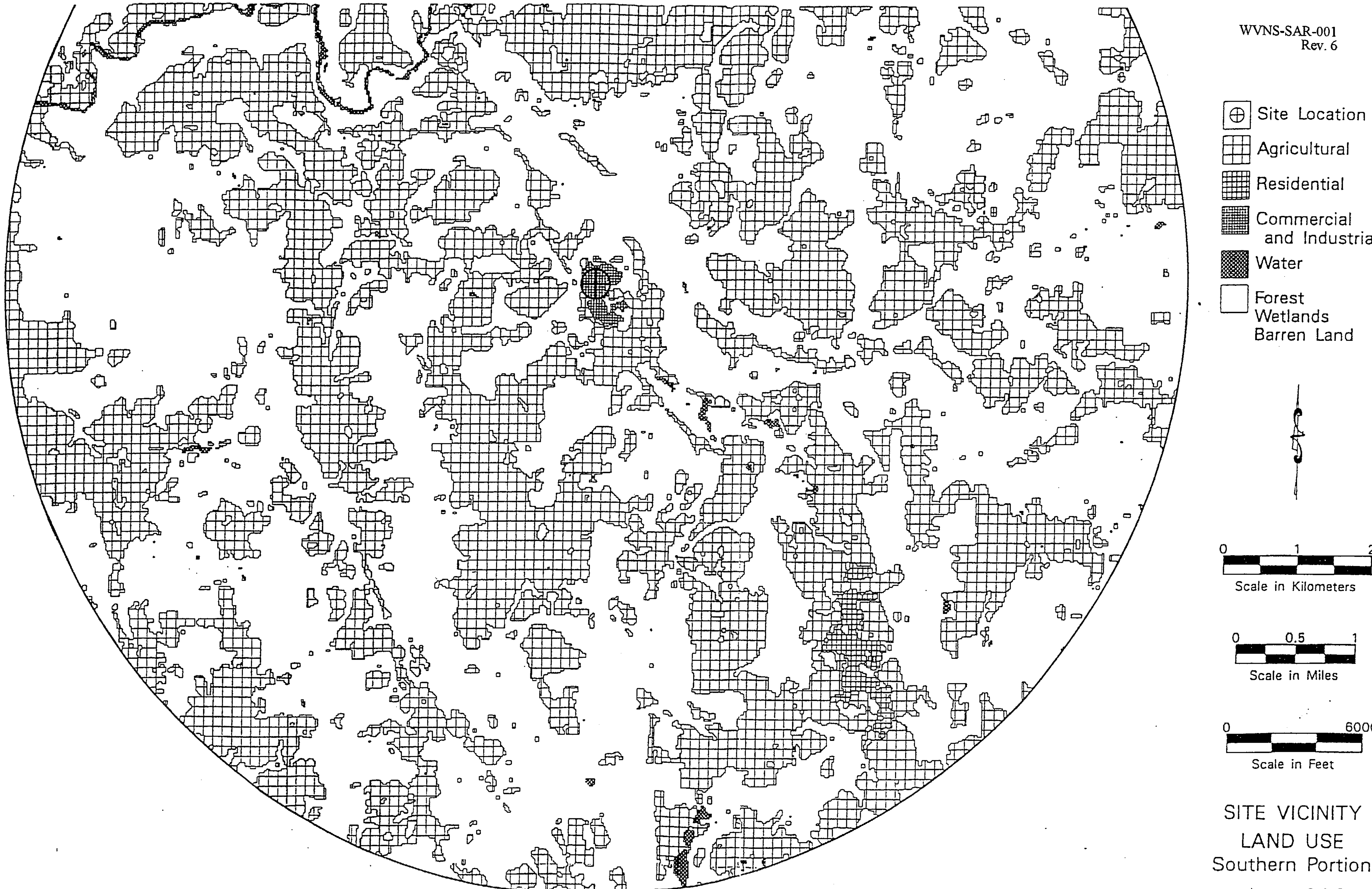
Figure A.3.1-5 WVDP Facility Layout and Security Area Boundary



SITE VICINITY LAND USE Northern Portion

Figure A.3.1-6

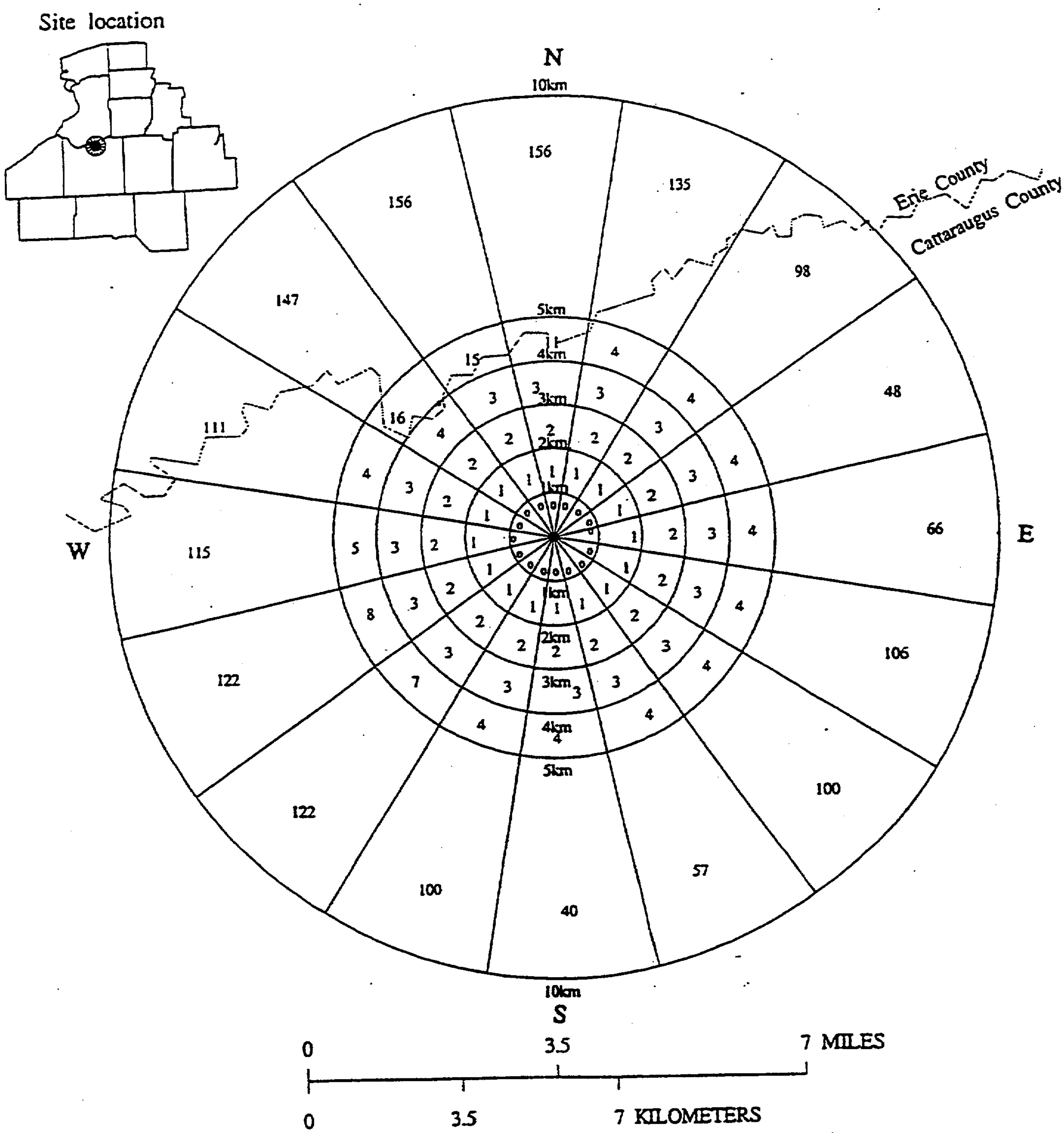
Source: LandSat TM imagery on April 7, 1991



SITE VICINITY
LAND USE
Southern Portion

Figure A.3.1-7

Source: LandSat TM imagery on April 7, 1991

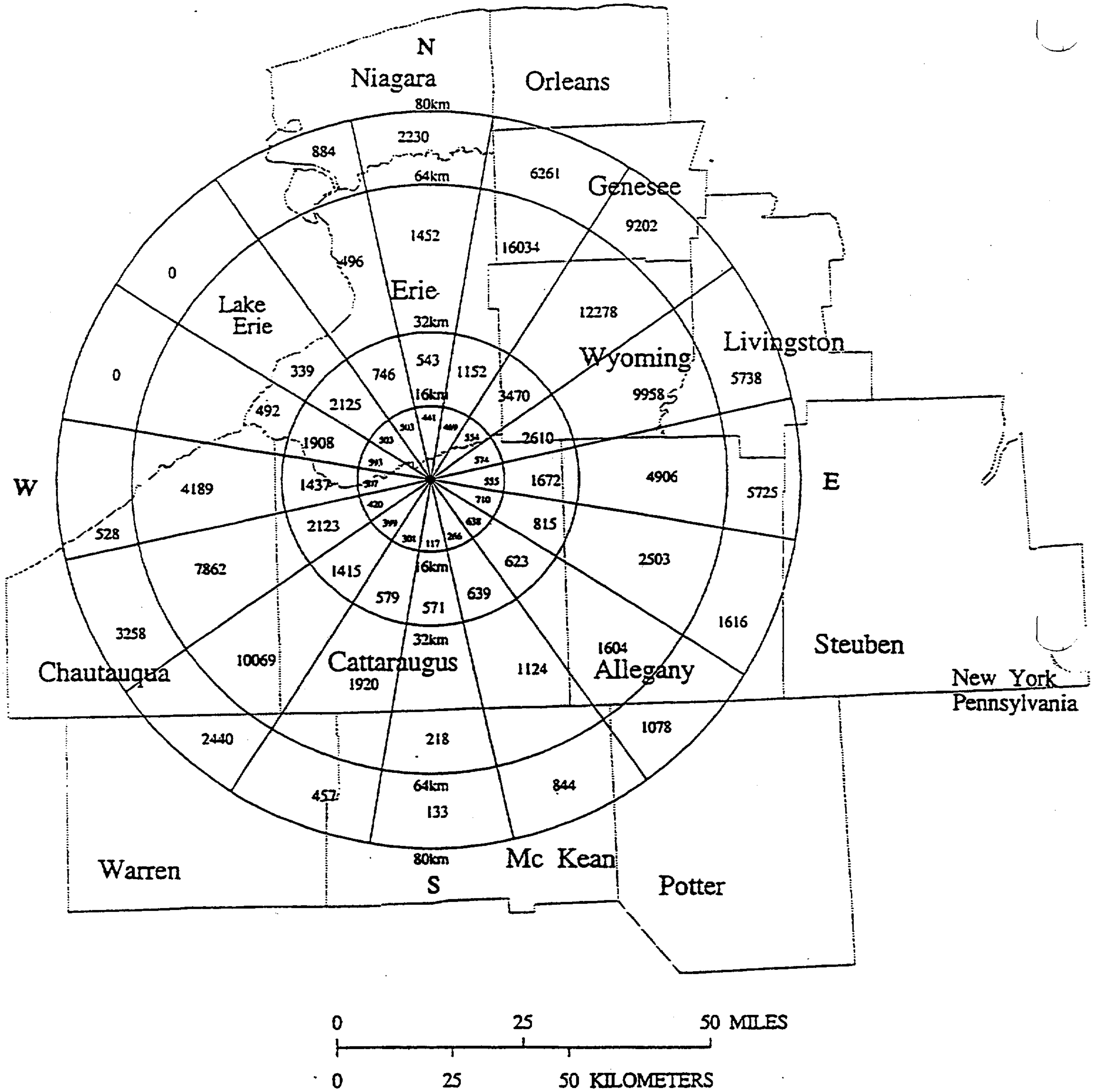


NUMBER OF DAIRY COWS BY SECTOR
WITHIN 10 KILOMETERS (6.2 MILES) OF SITE

Figure A.3.1-8

Reference:
U.S. Departement of Commerce,
Bureau of the Census, 1992;
Zipcode data by Geographic Data Technology

Dames & Moore

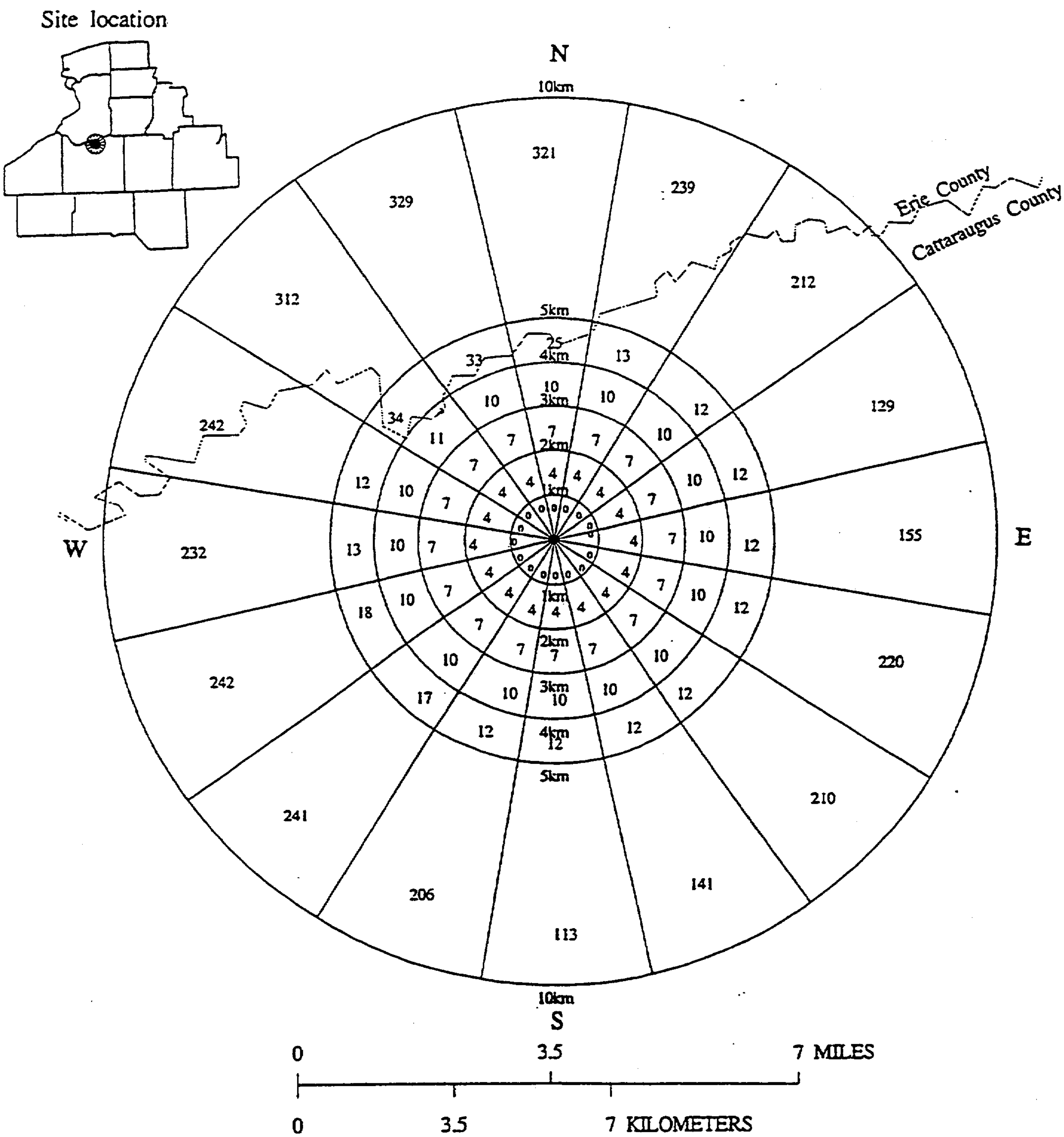


NUMBER OF DAIRY COWS BY SECTOR
WITHIN 80 KILOMETERS (50 MILES) OF SITE

Figure A.3.1-9

Reference:
U.S. Departement of Commerce,
Bureau of the Census, 1992;
Zipcode data by Geographic Data Technology

Dames & Moore

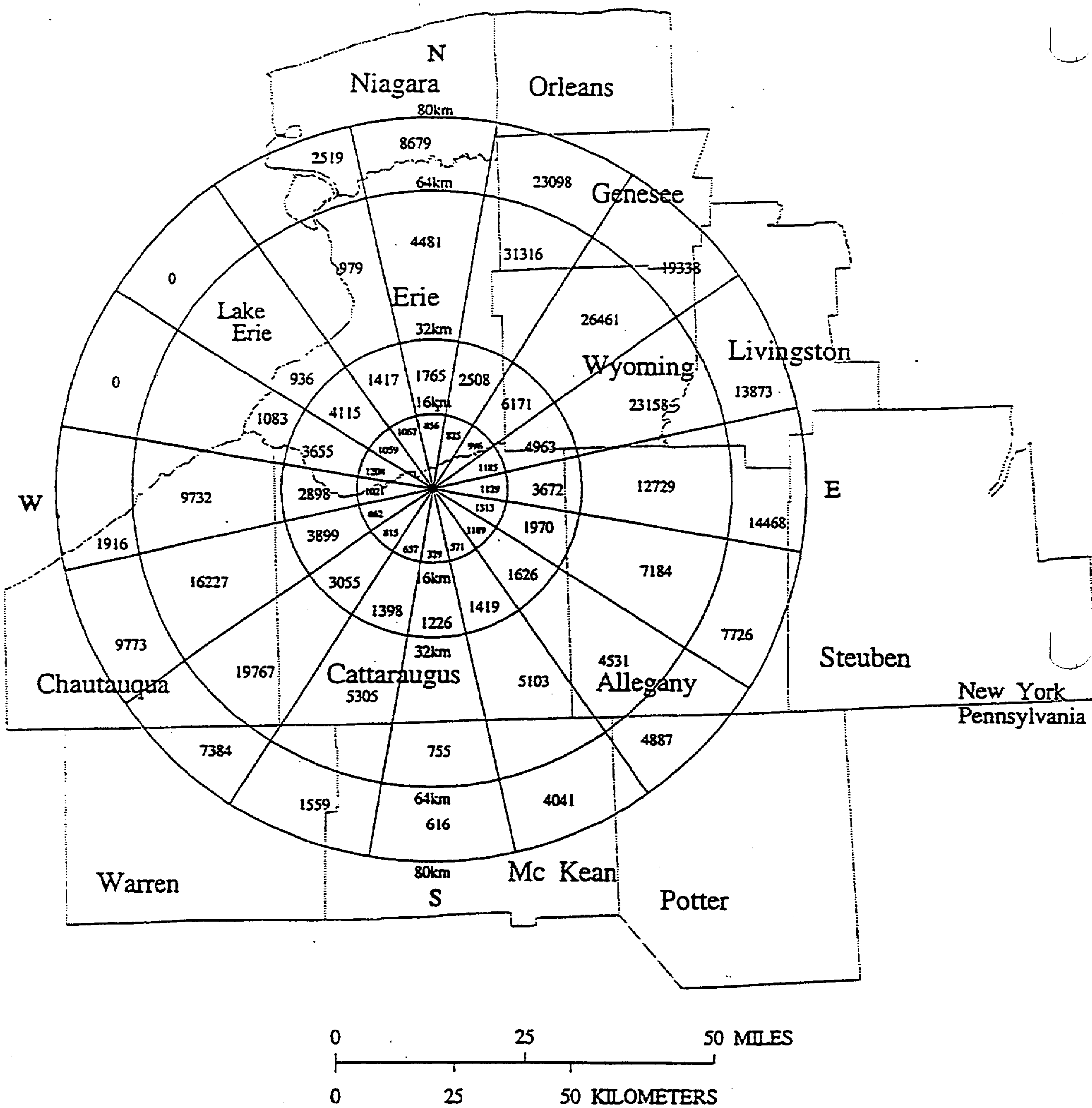


NUMBER OF MEAT – PRODUCTION ANIMALS BY SECTOR
WITHIN 10 KILOMETERS (6.2 MILES) OF SITE

Figure A.3.1-10

Reference:
U.S. Departement of Commerce,
Bureau of the Census, 1992;
Zipcode data by Geographic Data Technology

Dames & Moore

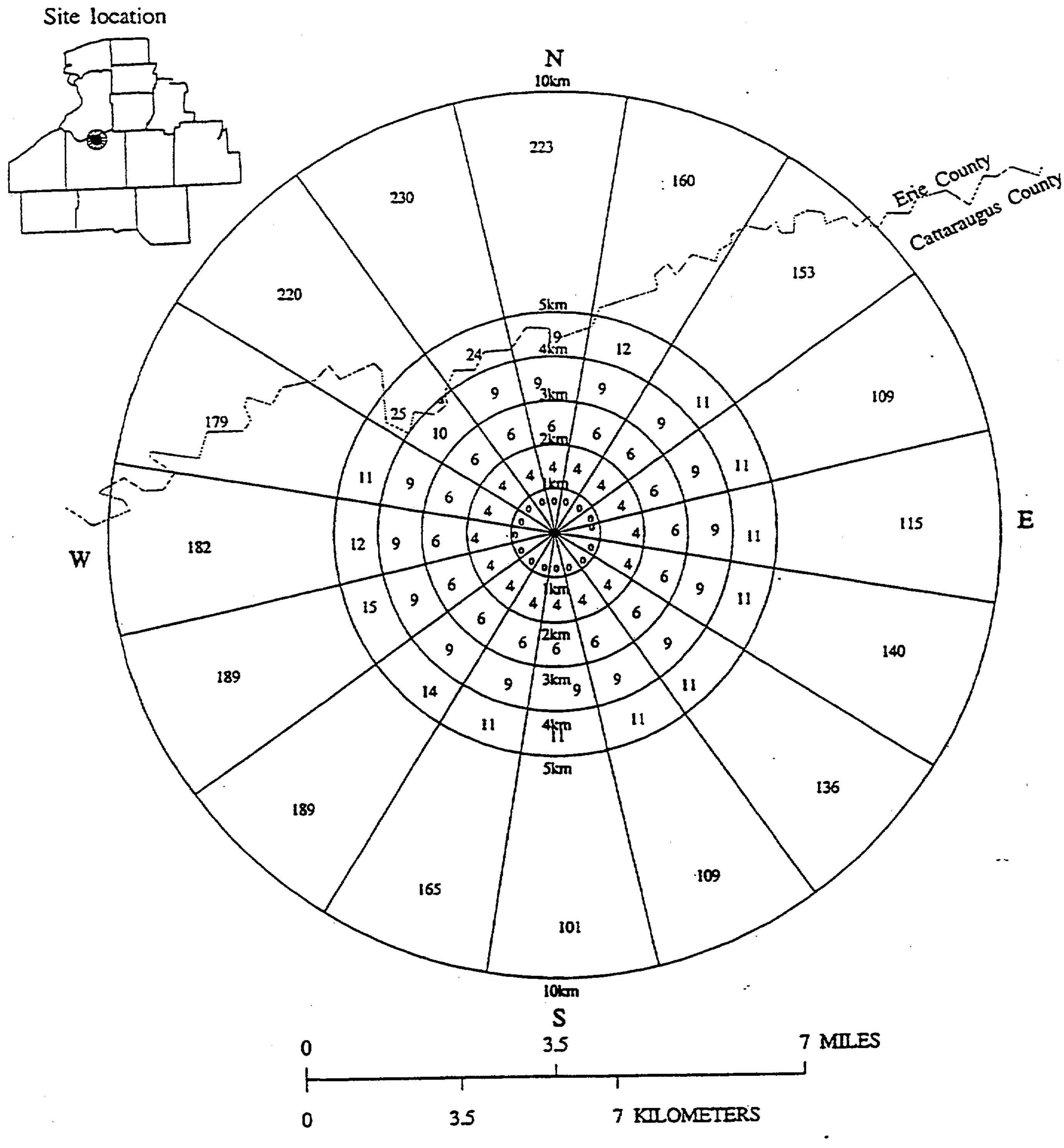


NUMBER OF MEAT – PRODUCTION ANIMALS BY SECTOR
WITHIN 80 KILOMETERS (50 MILES) OF SITE

Figure A.3.1-11

Reference:
U.S. Departement of Commerce,
Bureau of the Census, 1992;
Zipcode data by Geographic Data Technology

Dames & Moore



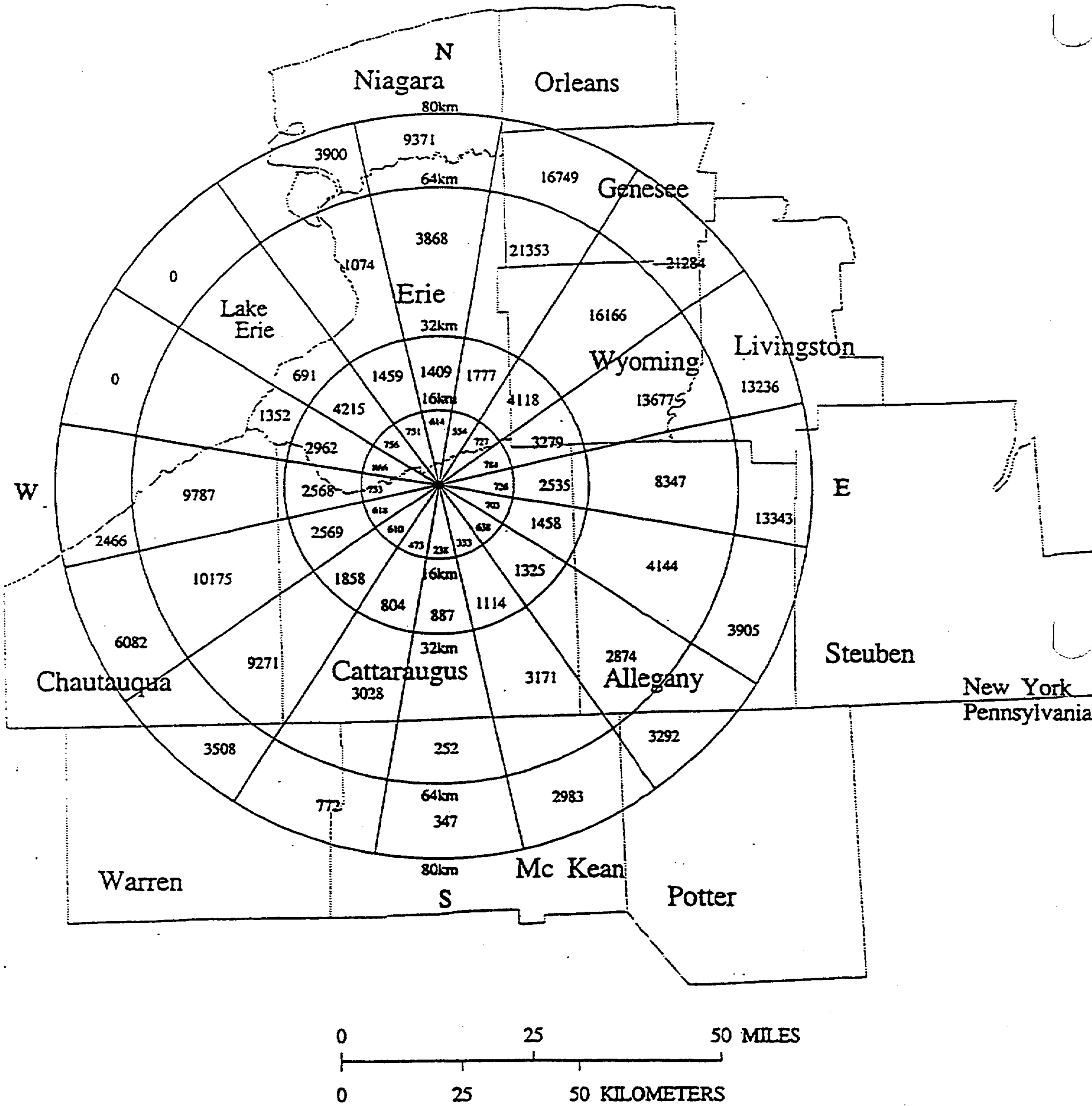
AGRICULTURAL PRODUCE LAND AREA (ha) BY SECTOR

WITHIN 10 KILOMETERS (6.2 MILES) OF SITE

Figure A.3.1-12

Reference:
U.S. Departement of Commerce,
Bureau of the Census, 1992;
Zipcode data by Geographic Data Technology

Dames & Moore



AGRICULTURAL PRODUCE LAND AREA (ha) BY SECTOR
WITHIN 80 KILOMETERS (50 MILES) OF SITE

Figure A.3.1-13

Reference:
U.S. Department of Commerce,
Bureau of the Census, 1992;
Zipcode data by Geographic Data Technology

Dames & Moore

SR1-3114.DWG

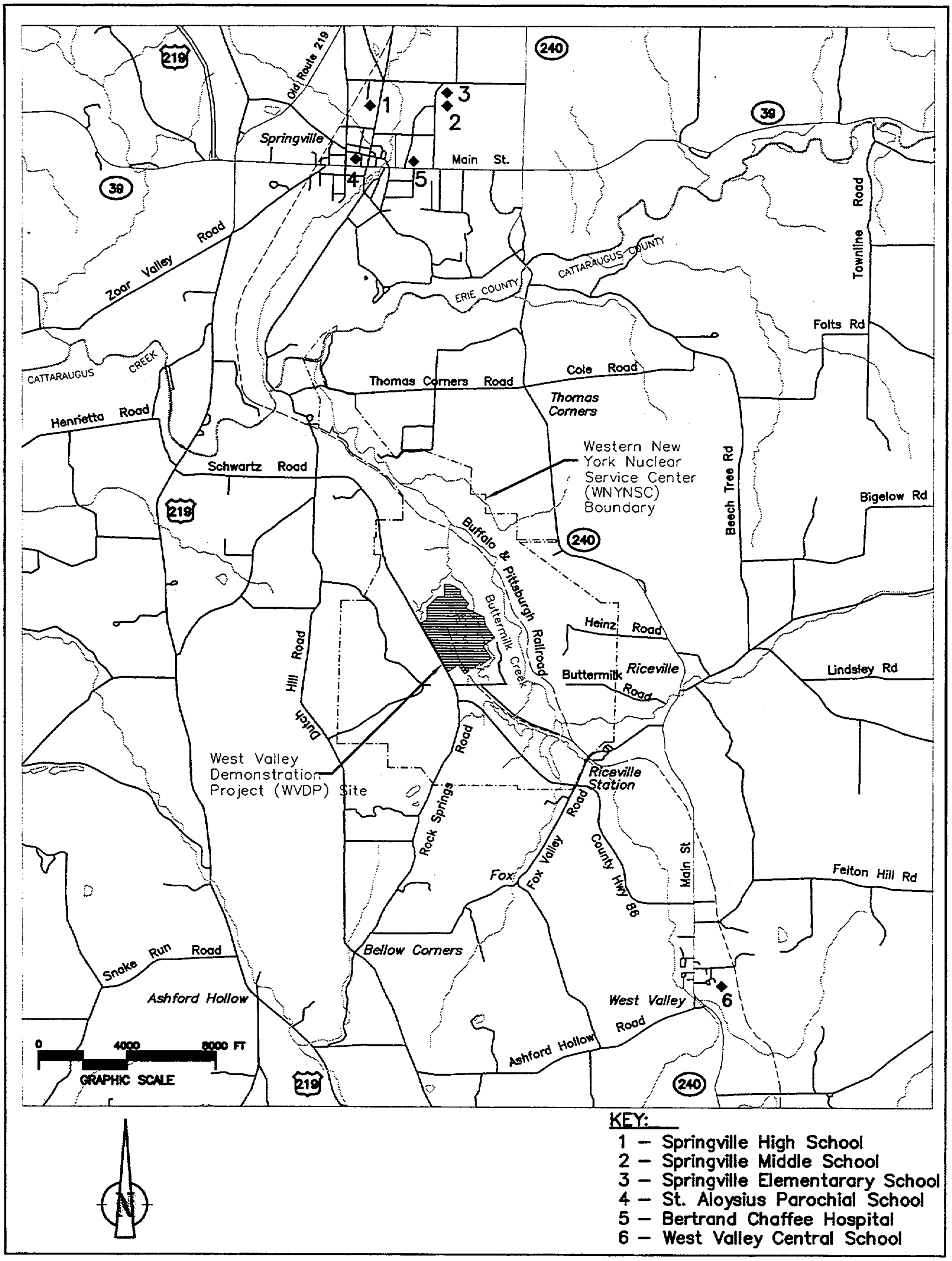


Figure A.3.1–14 Institutions In The Vicinity Of The WVDP Site.

SR1-341.DWG

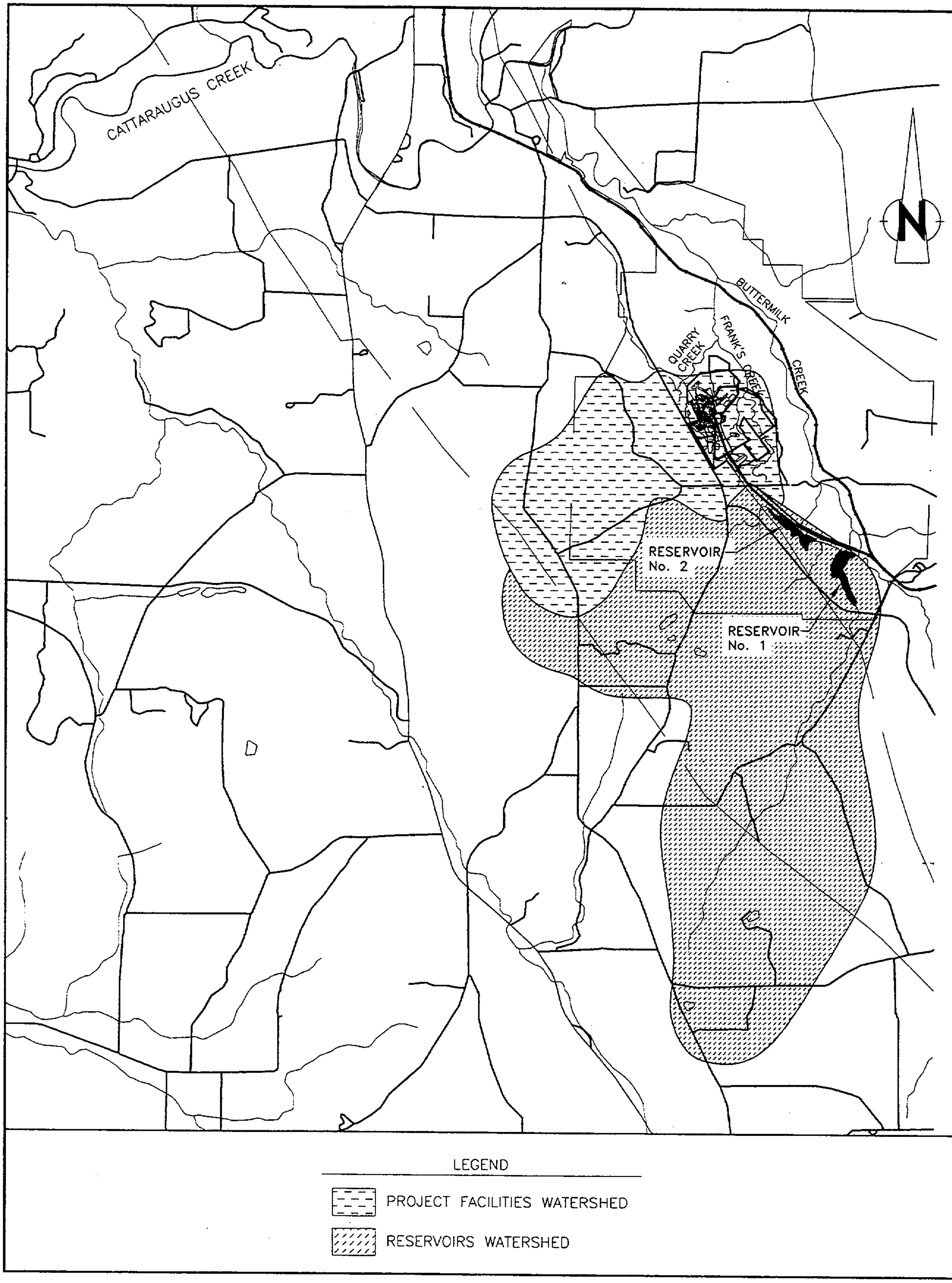


Figure A.3.4-1 Watershed Areas

SR1-342.DWG

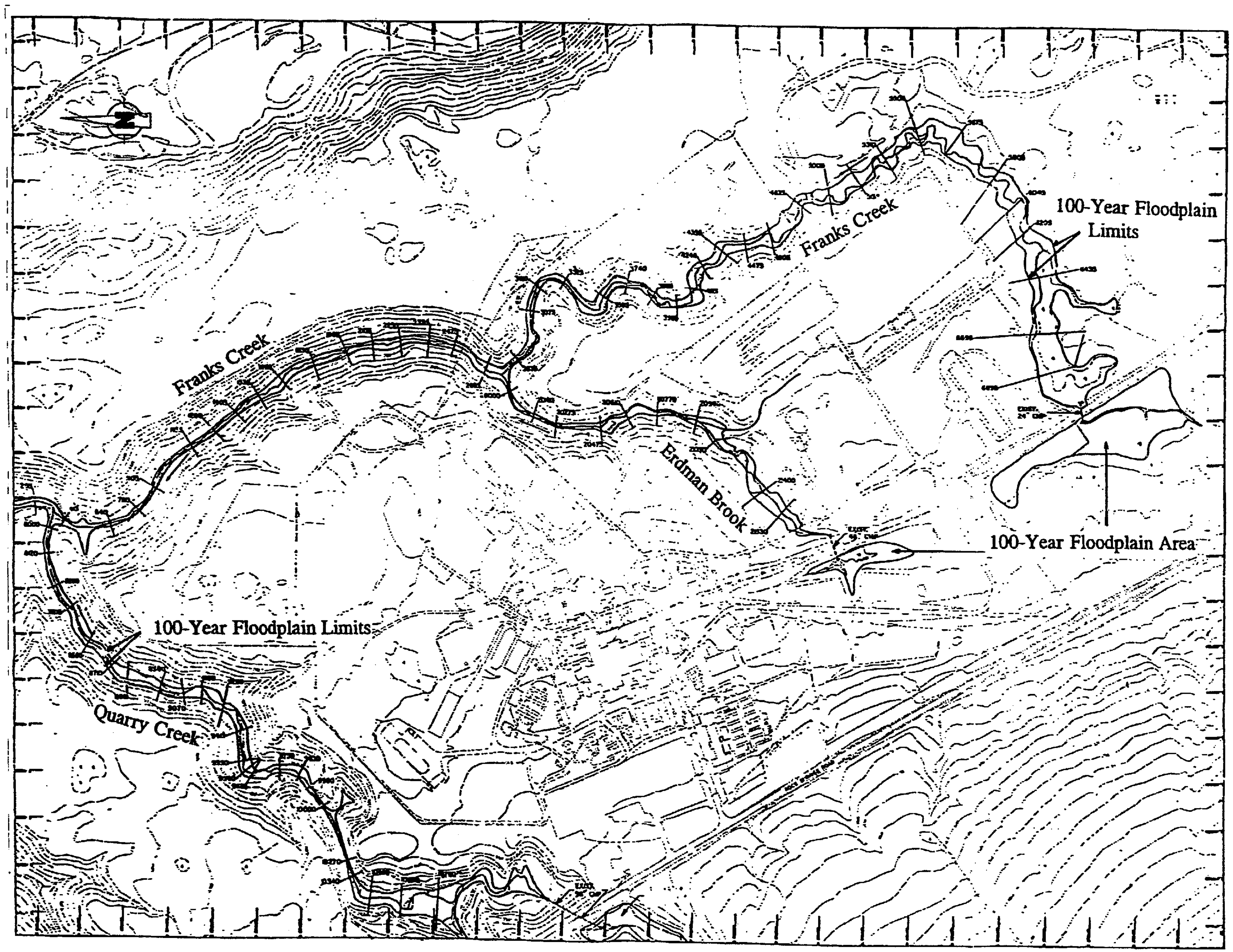


Figure A.3.4-2
100 Year Floodplain Map
(Modified From EID Vol. III, Part 2.)

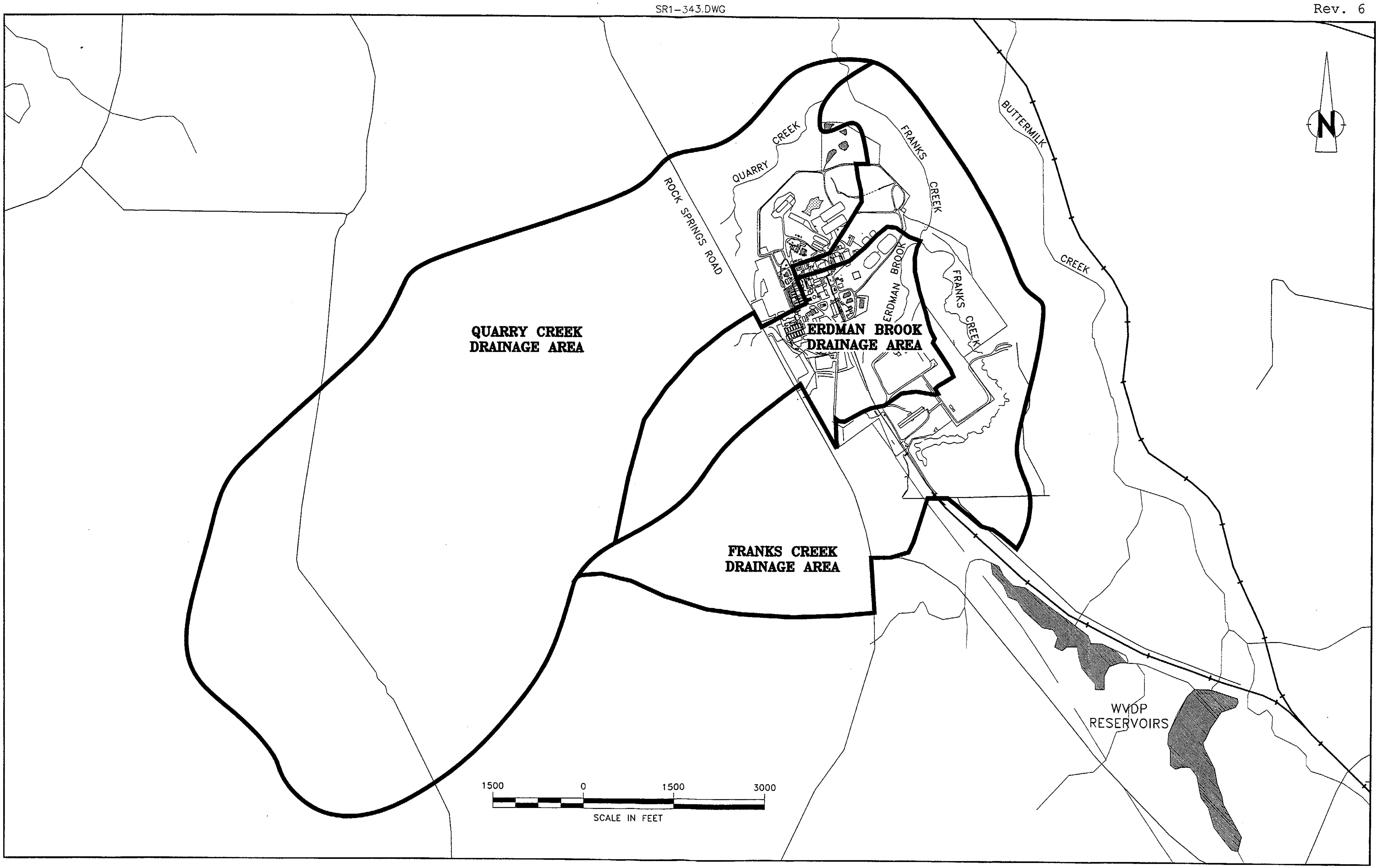


Figure A.3.4-3
Watershed Area Map

SR1-34-4.DWG

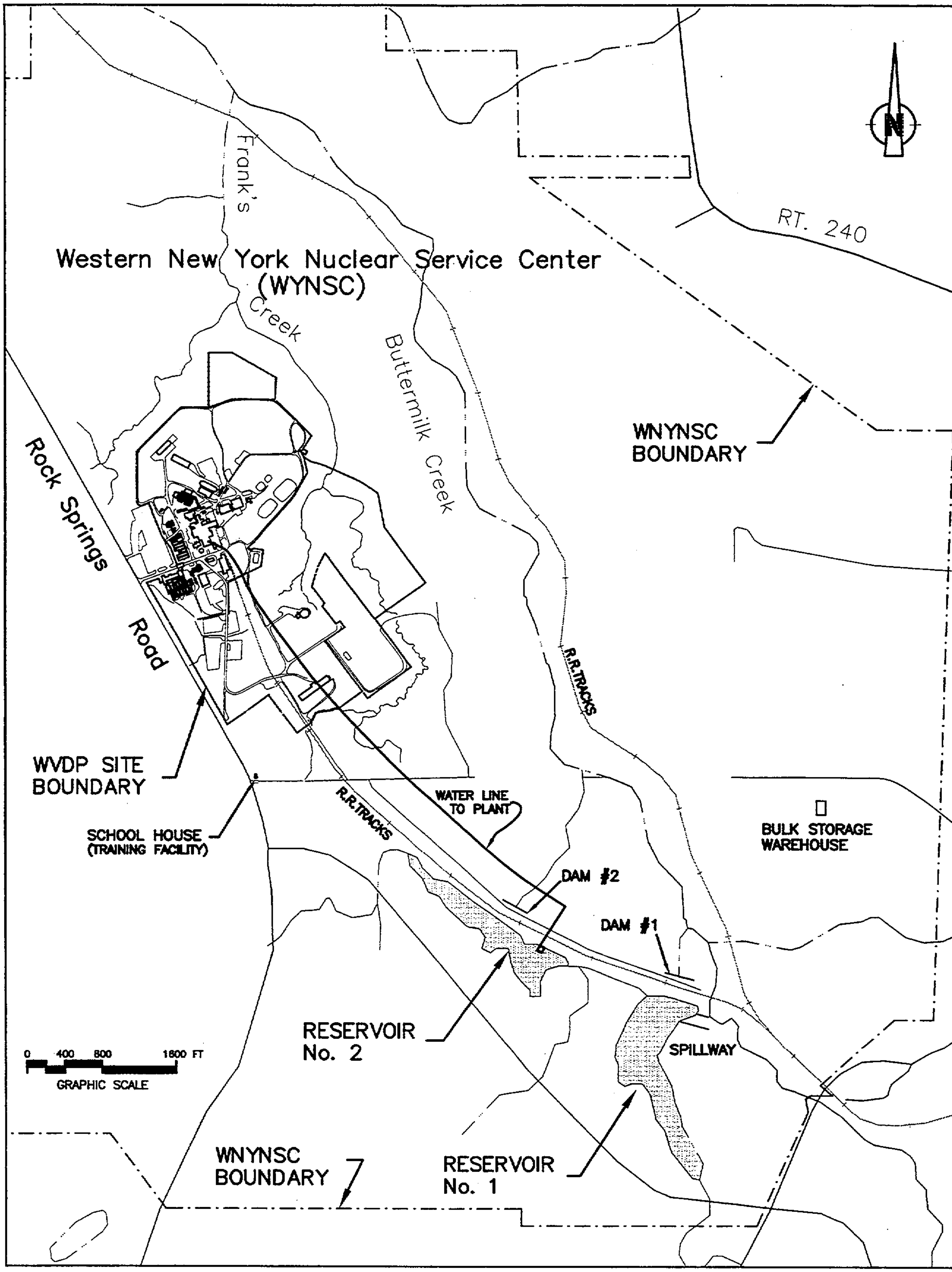
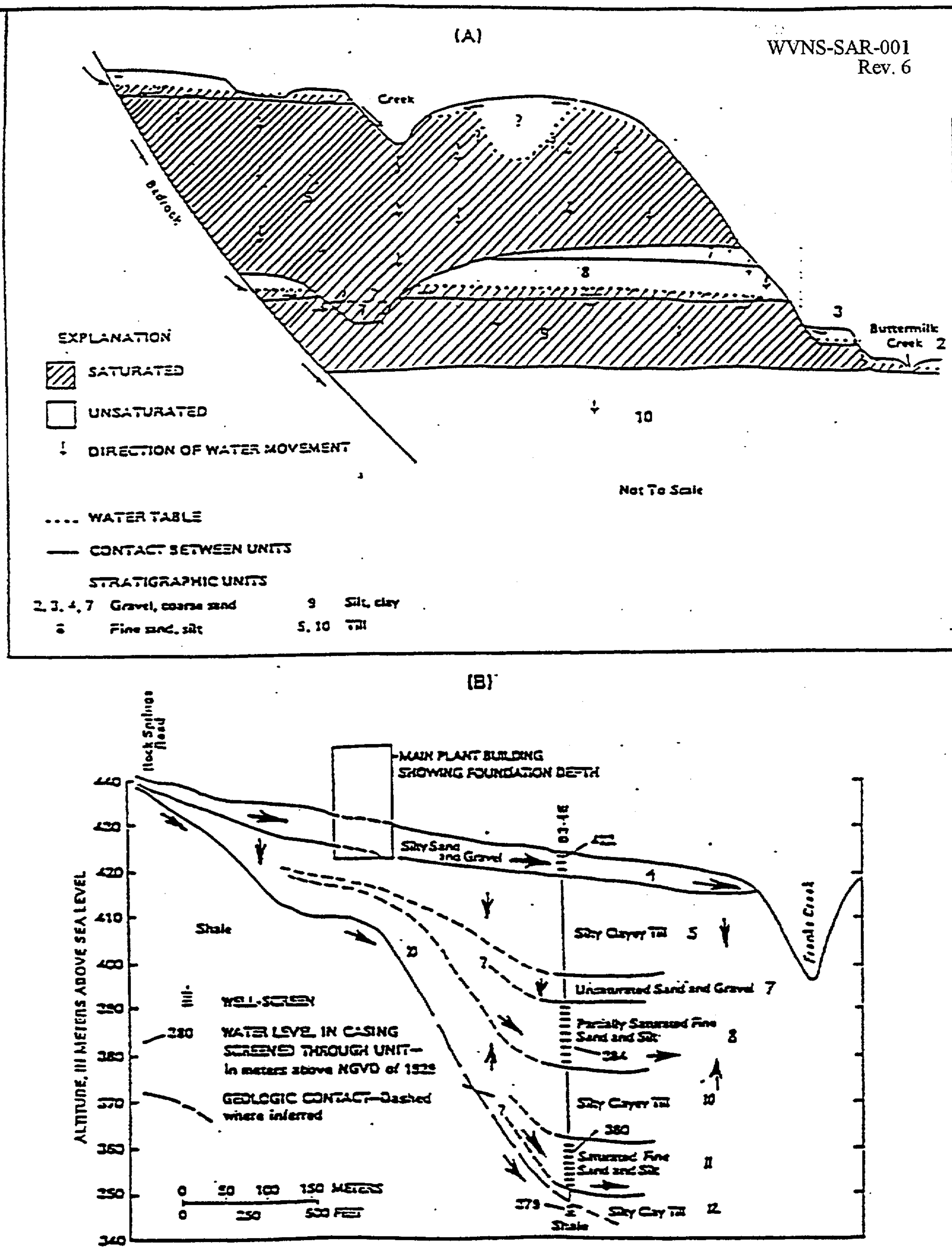


Figure A.3.4-4 Lake Water Supply System.



SCHEMATIZED GROUNDWATER FLOW PATTERNS BENEATH THE SOUTHERN (A) AND NORTHERN (B) SECTORS OF THE WVDP

SOURCE:
Bergeron, et al., 1987

FIGURE A.3.5-1

SR1-352.DWG

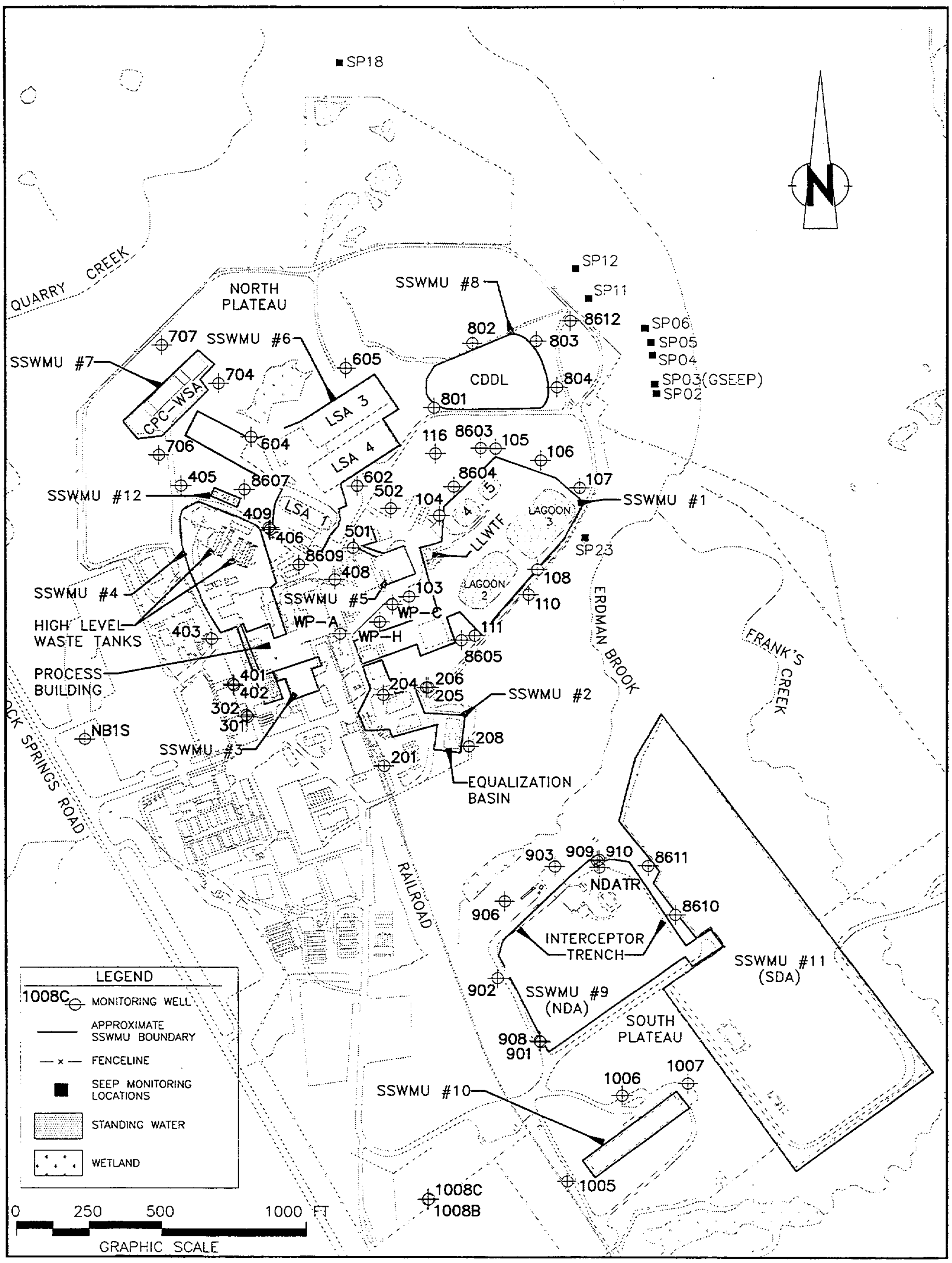


Figure A.3.5–2 WVDP Groundwater Monitoring Program Locations Sampled in 1997.

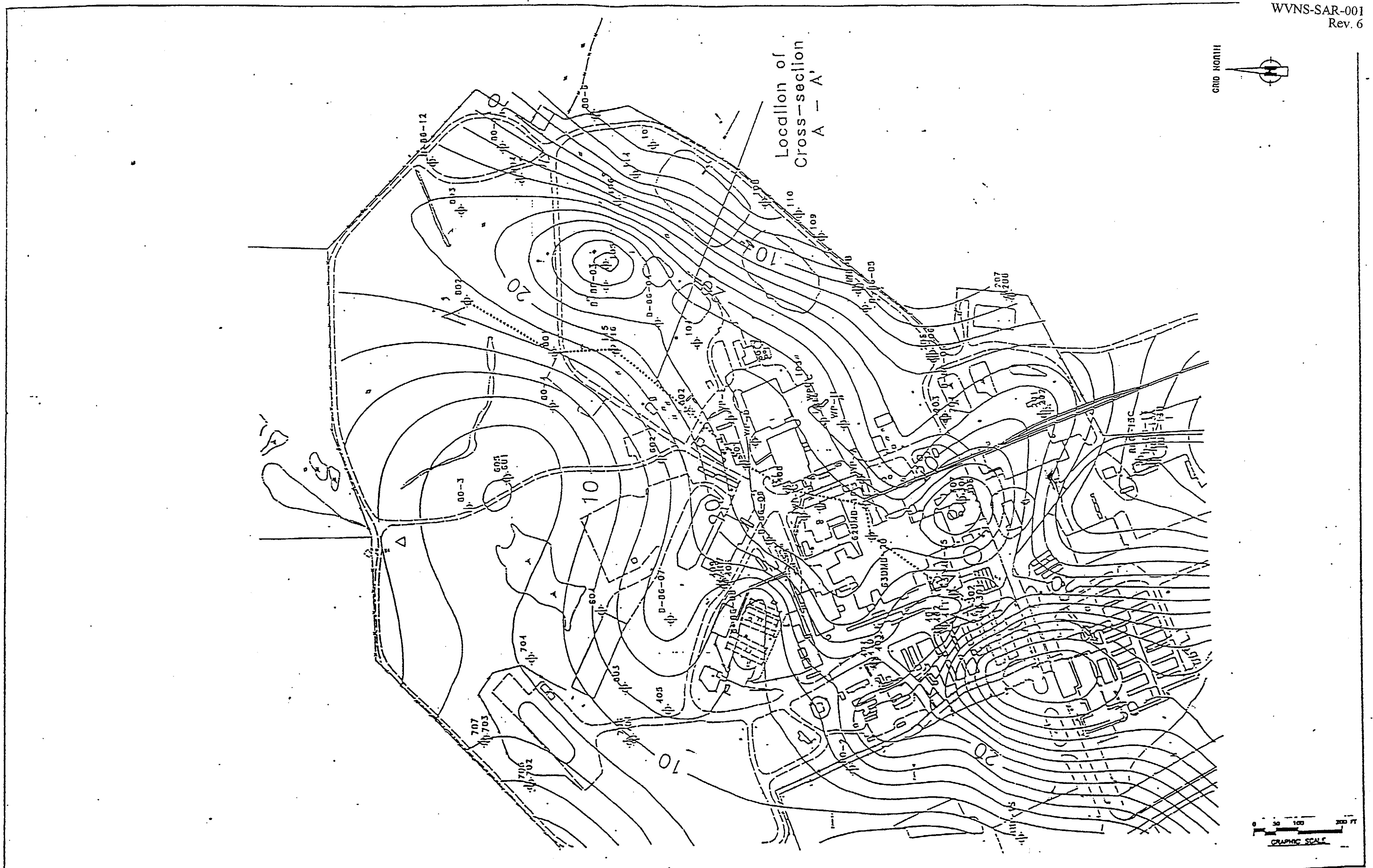


FIGURE A.3.5-3
Thickness of Surficial Sand and Gravel Layer – North Plateau
(C.I. = 2 feet)

SR1-354.DWG

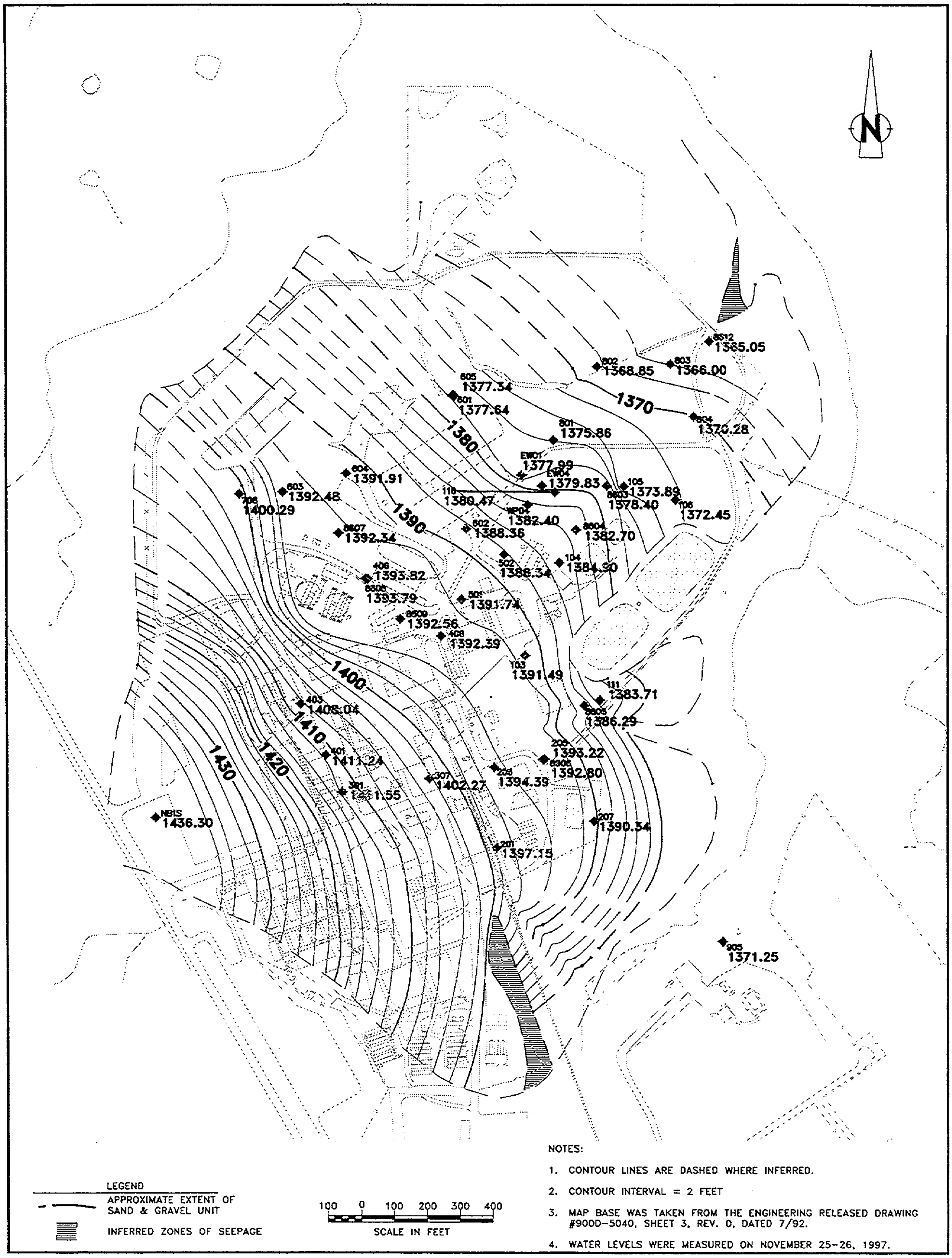
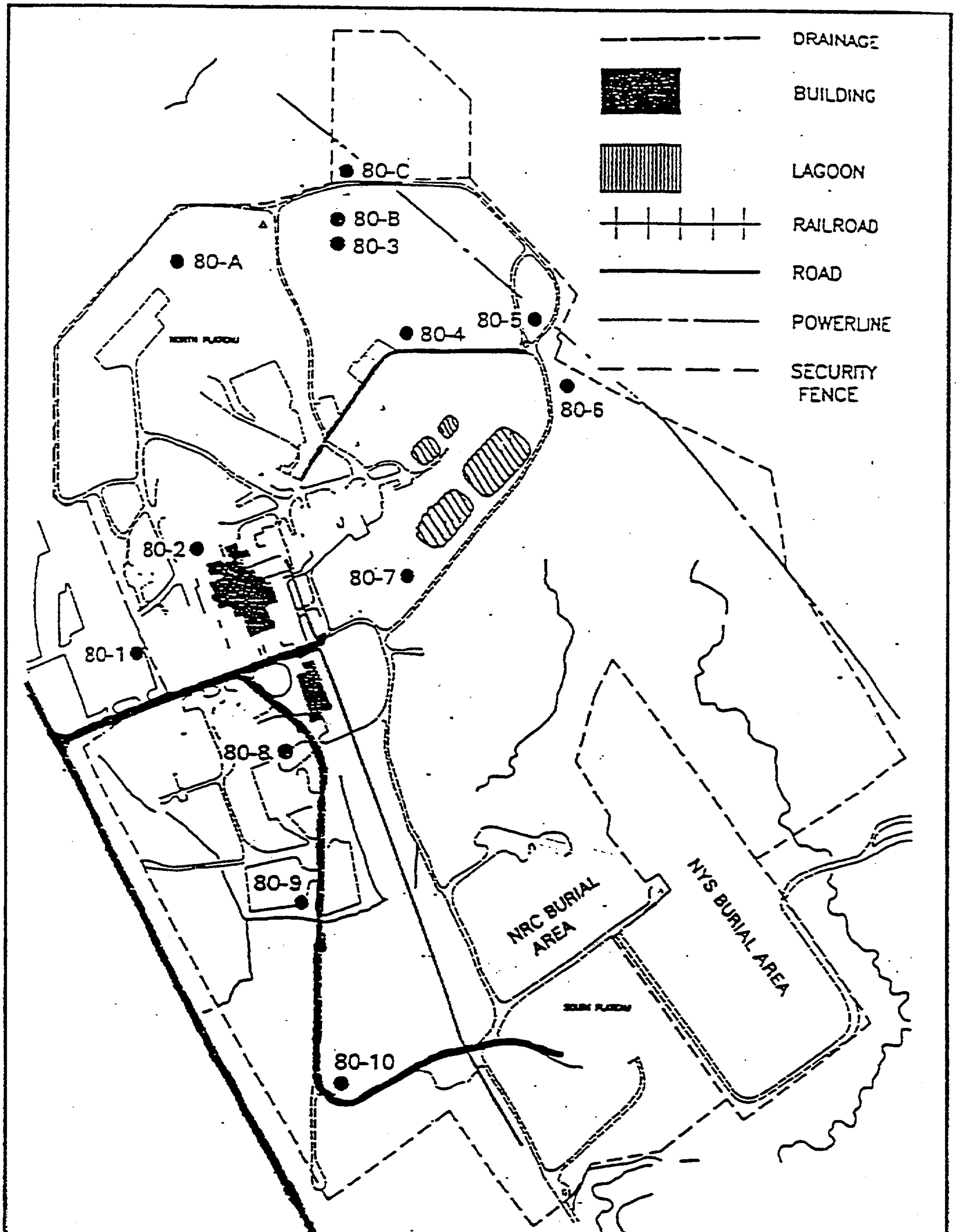


Figure A.3.5-4 Unconfined Groundwater Flow Within the Surficial Sand and Gravel Layer – North Plateau



LOCATION OF WELLS 80-1 THROUGH 80-8

FIGURE A.3.5-5

SR1-356.DWG

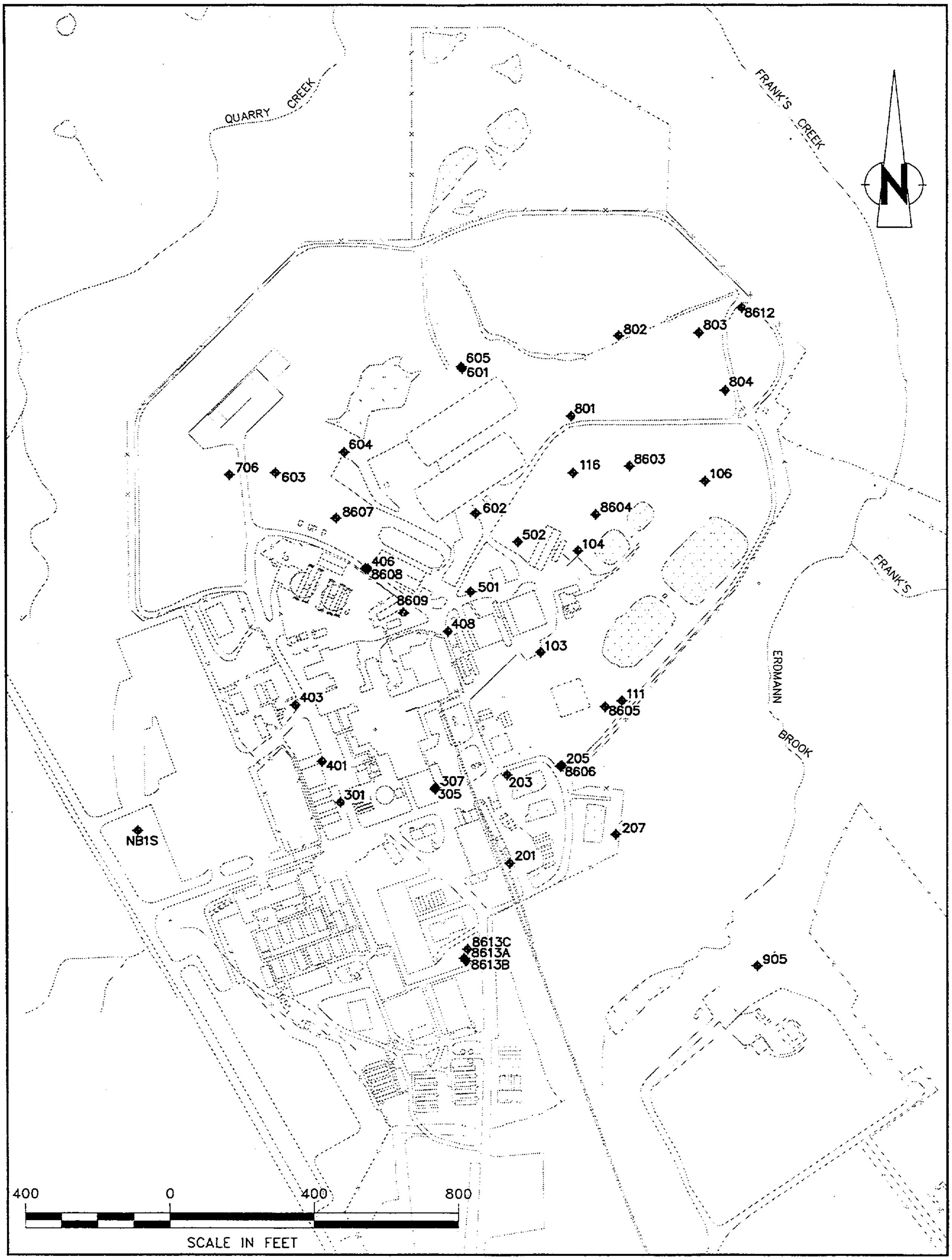


Figure A.3.5–6 Locations of Sand and Gravel Unit Wells (Slug–Tested Between 1992 and 1997).

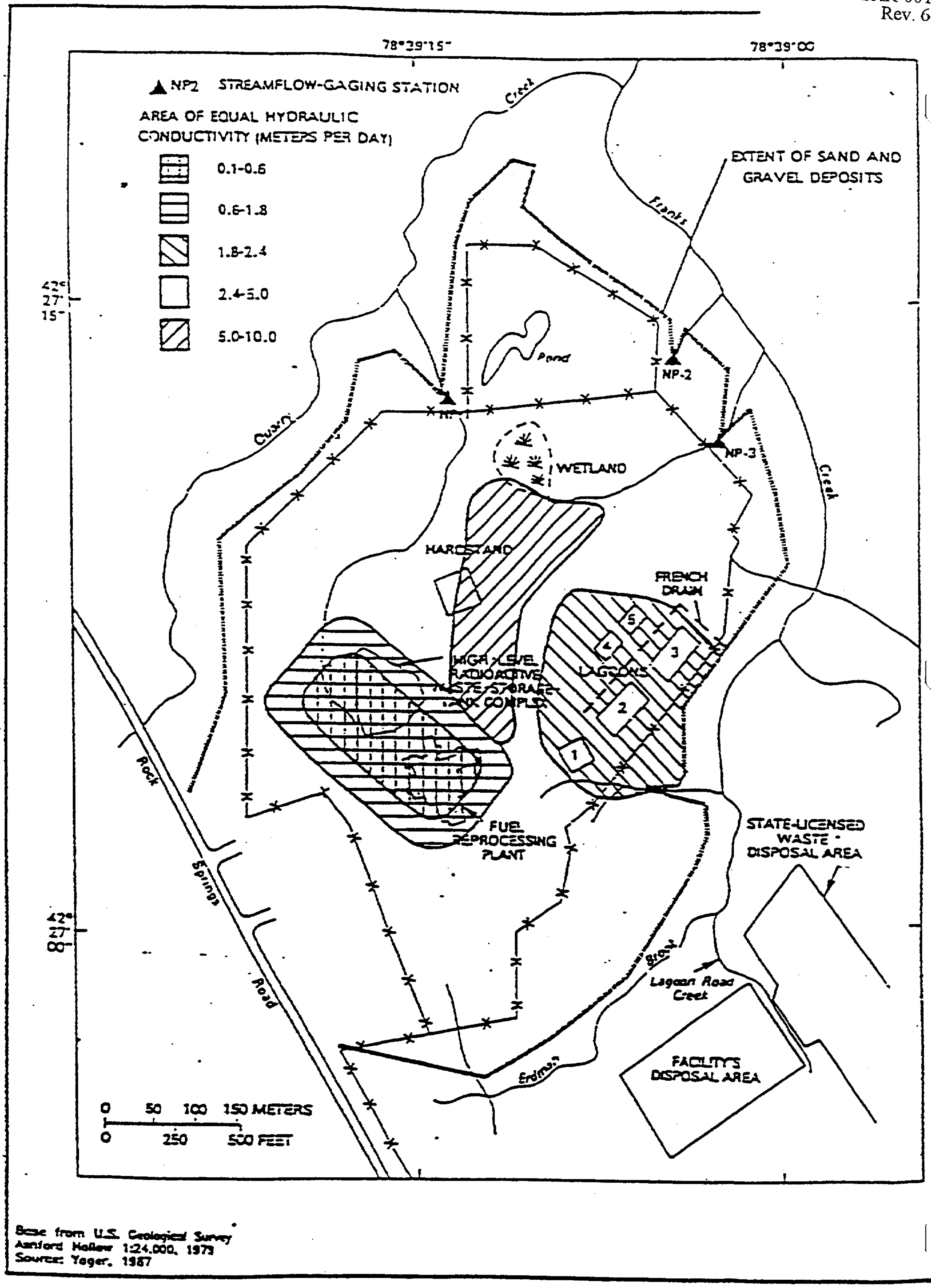
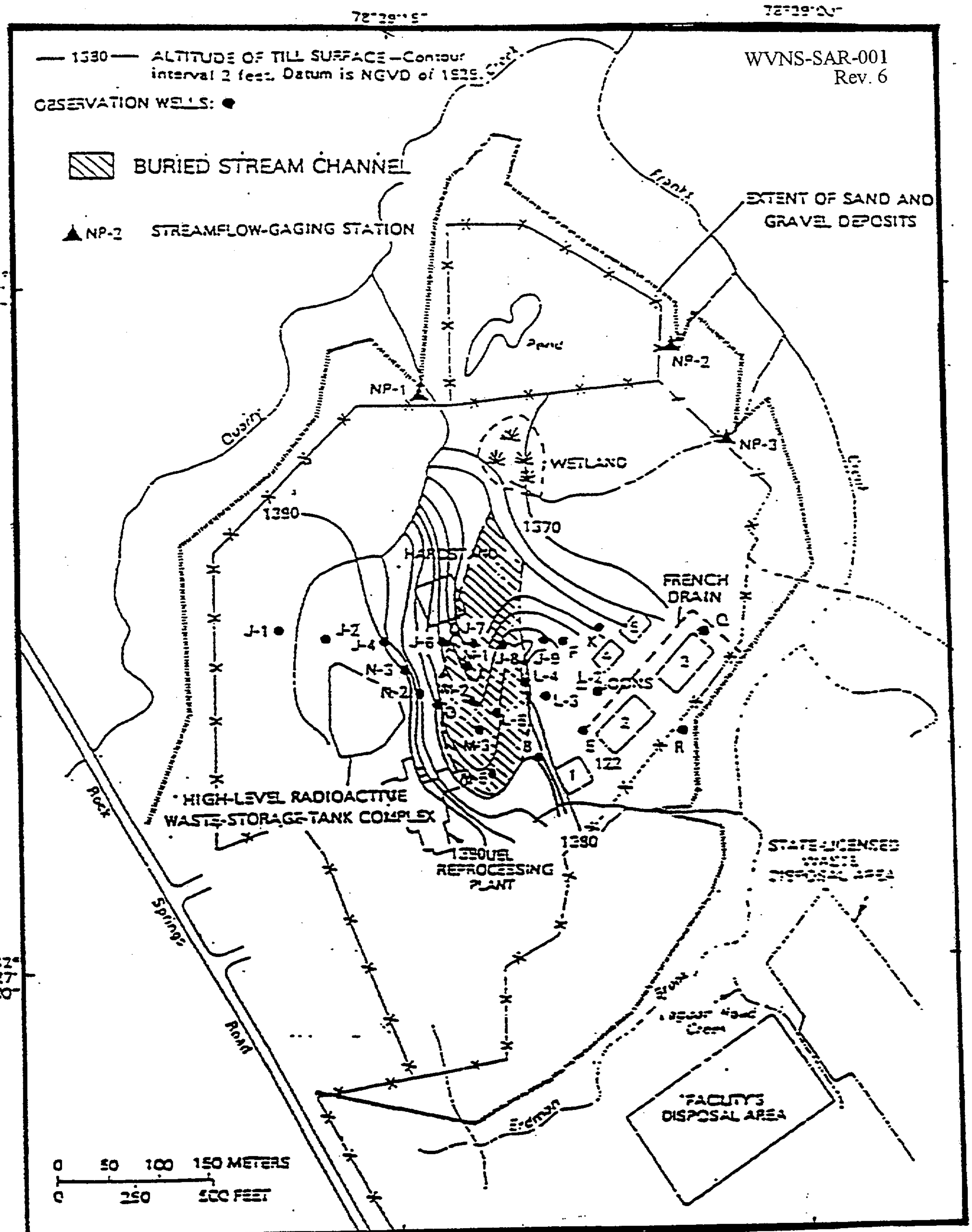


Figure A.3.5-7 Distribution of North Plateau Hydraulic Conductivities Assumed by USGS in 1985.



Base from U.S. Geological Survey Ashford Hollow 1979 1:24,000

Source: Modified from Yager 1987

LOCATION OF SUSPECTED BURIED CHANNEL
ON SURFACE OF LAVERY TILL

FIGURE A.3.5-8

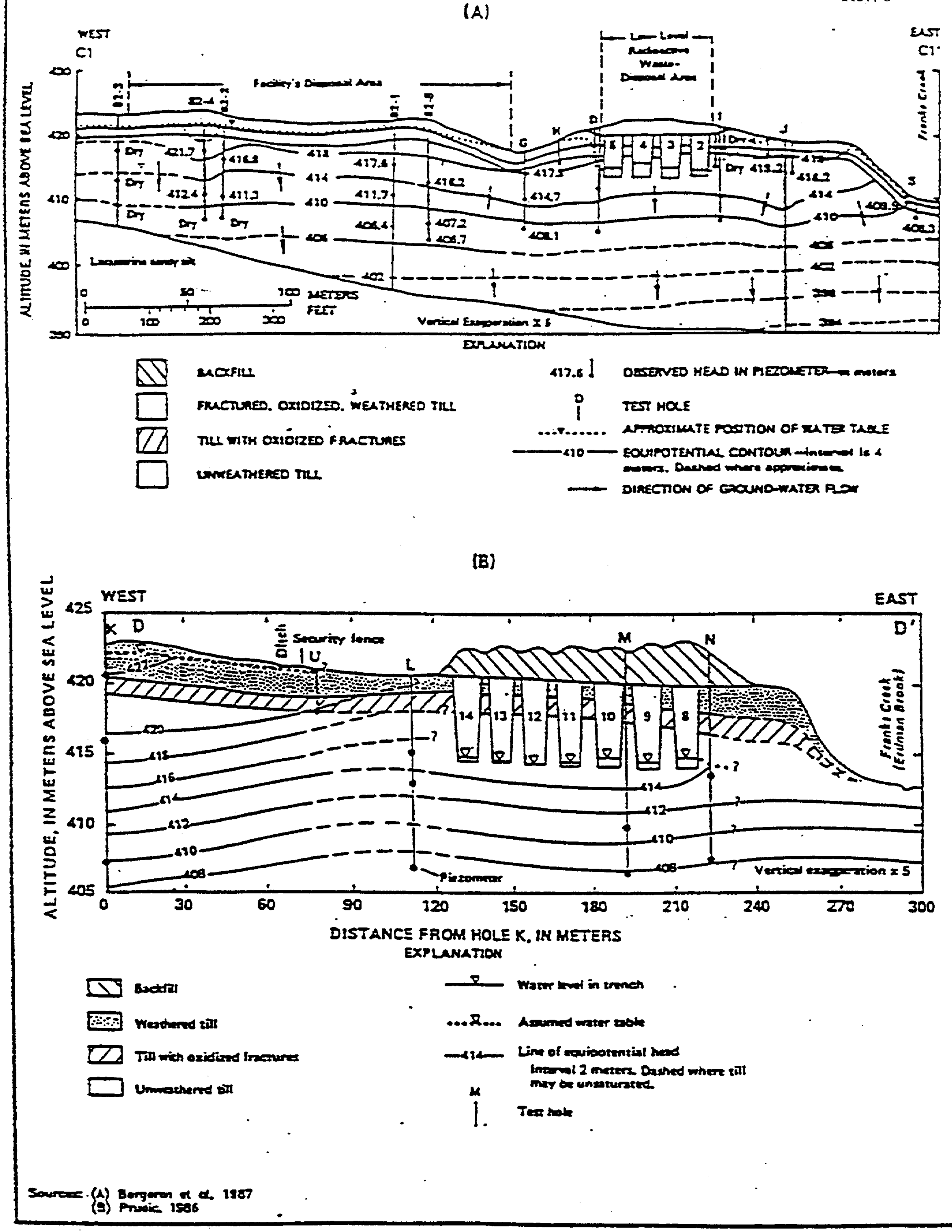


FIGURE A.3.5-9 Distribution on Hydraulic Head Across The South Plateau for Cross Sections C—C' (Feb. 1976) and D—D' (May 1983) Location of Cross Sections are on Figure A.3.5—10

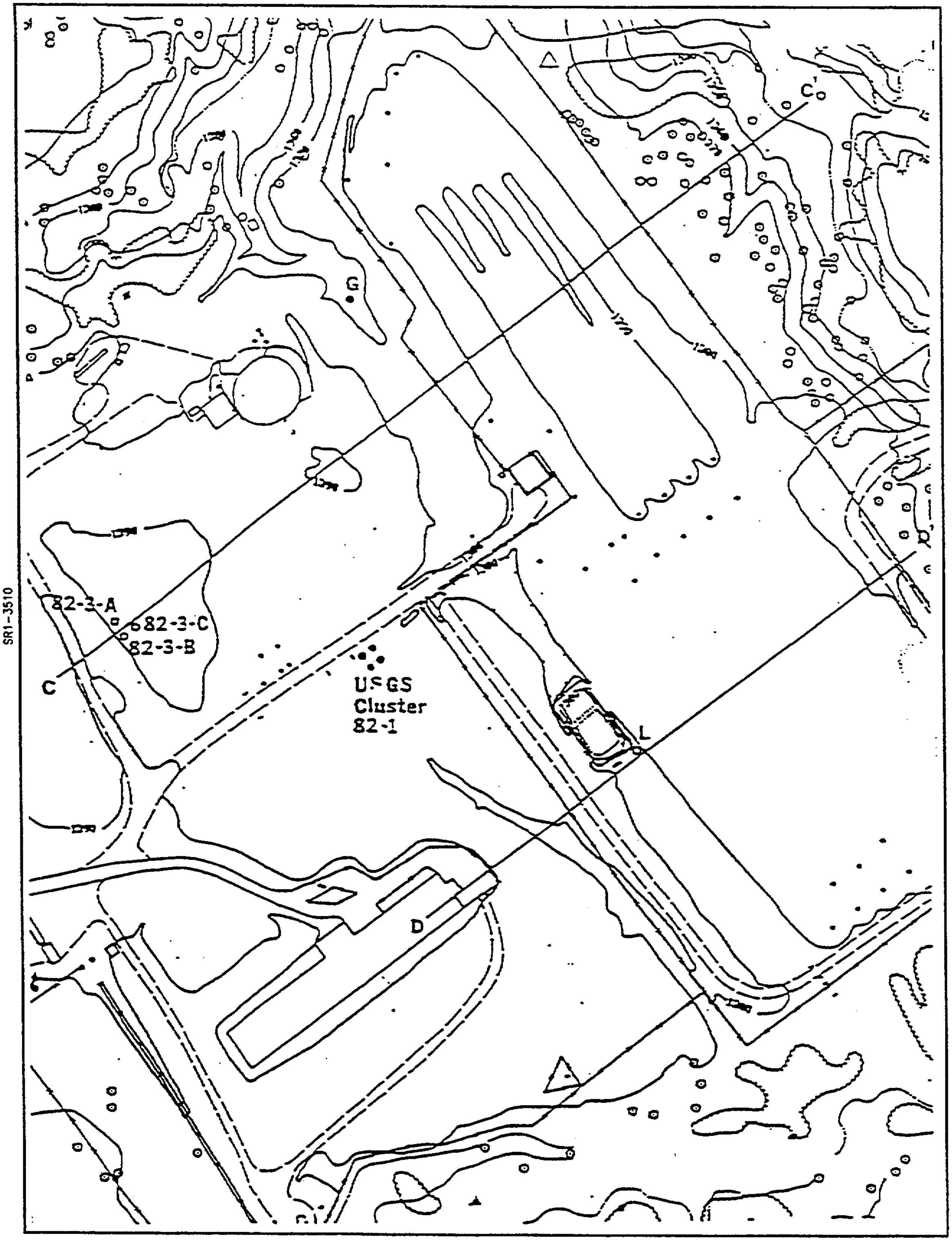


Figure A.3.5-10 Locations of Cross Sections C–C' and D–D' Shown in Figure A.3.5–9.

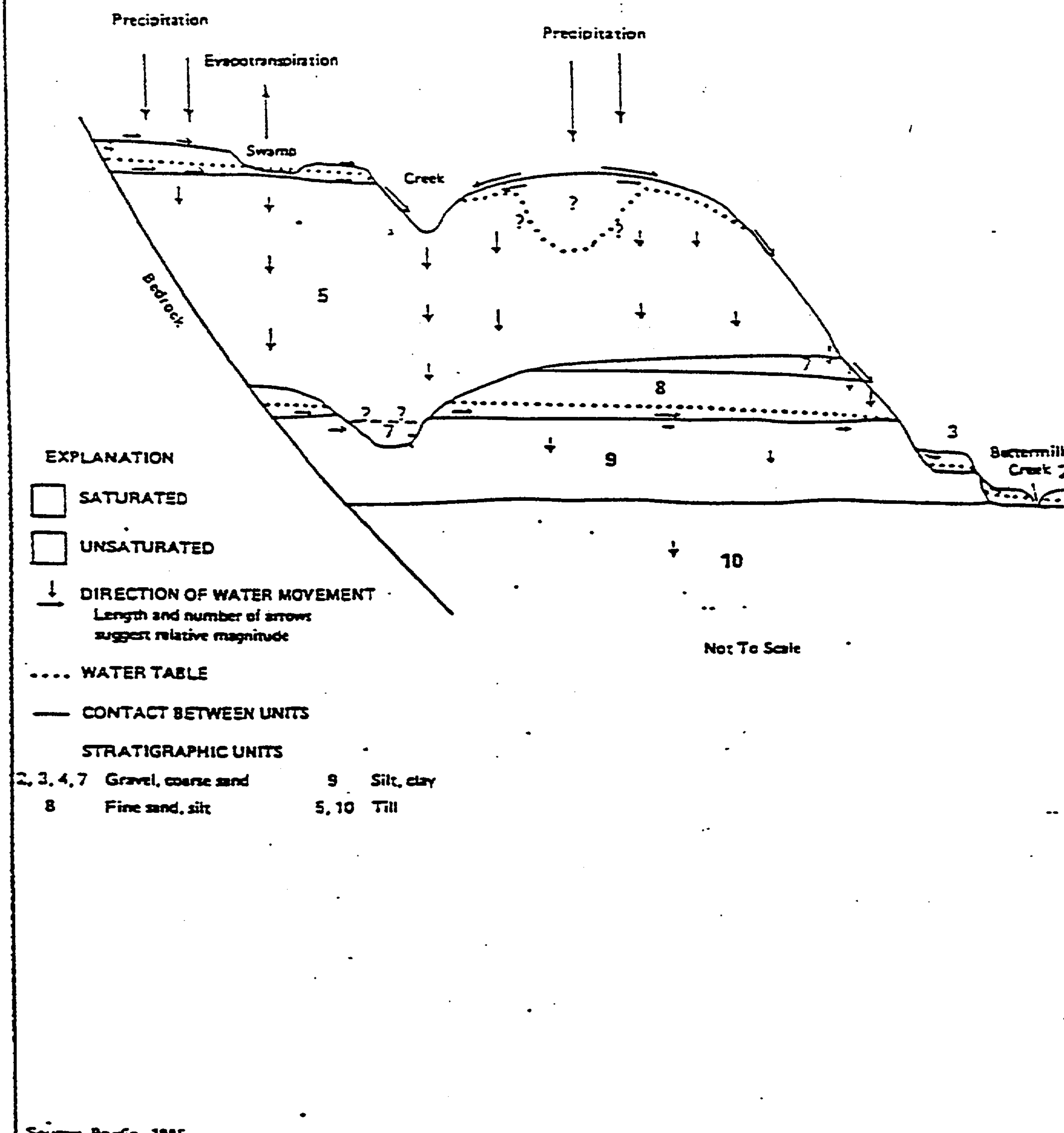
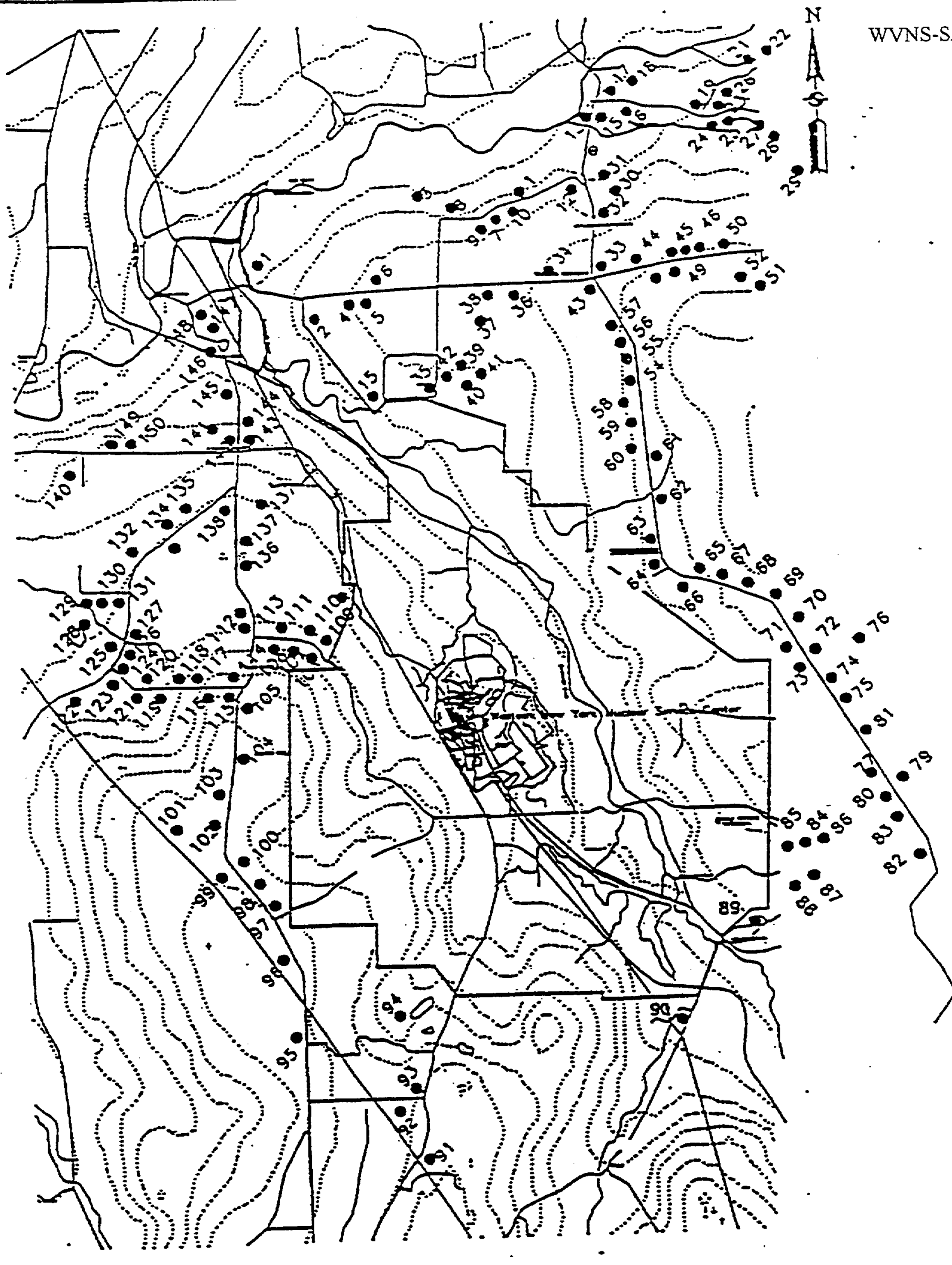


FIGURE A.3.5-11 Inferred Distribution of Saturated and Unsaturated Conditions in the South Plateau Subsurface (Idealized Cross Section)



LOCATIONS OF OFF-SITE WELLS INCLUDED IN GROUNDWATER USE SURVEY

FIGURE A.3.5-12

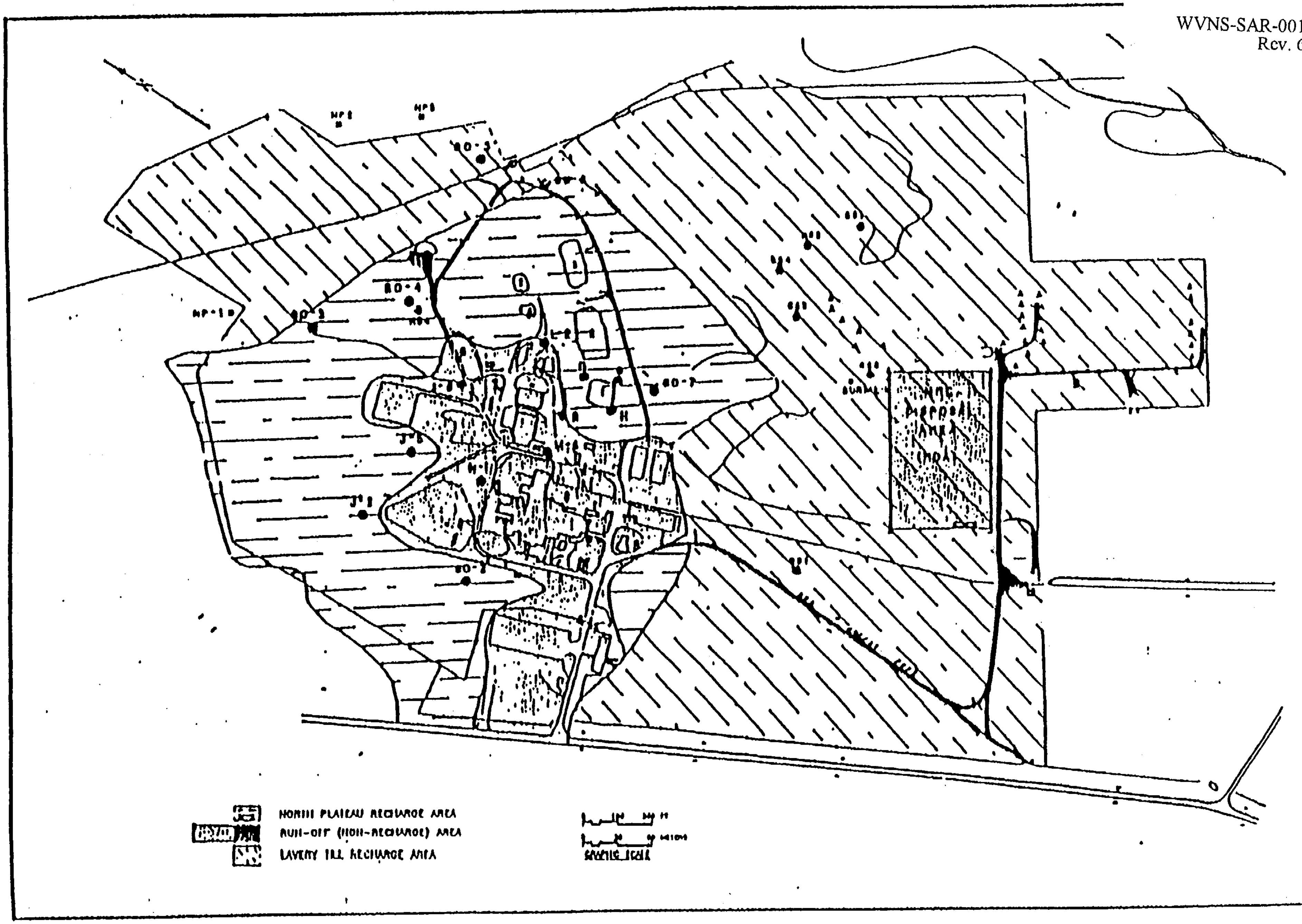
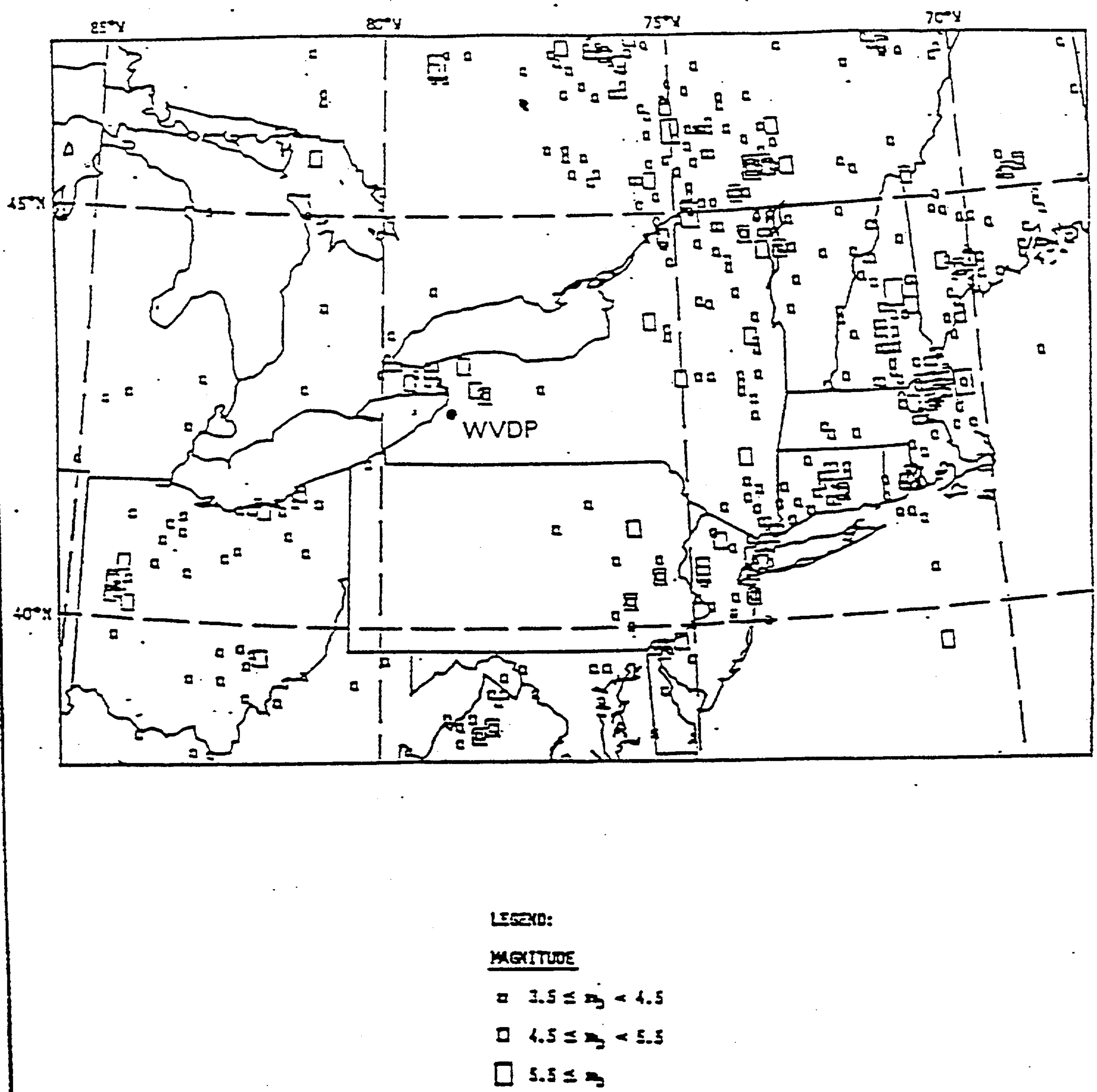
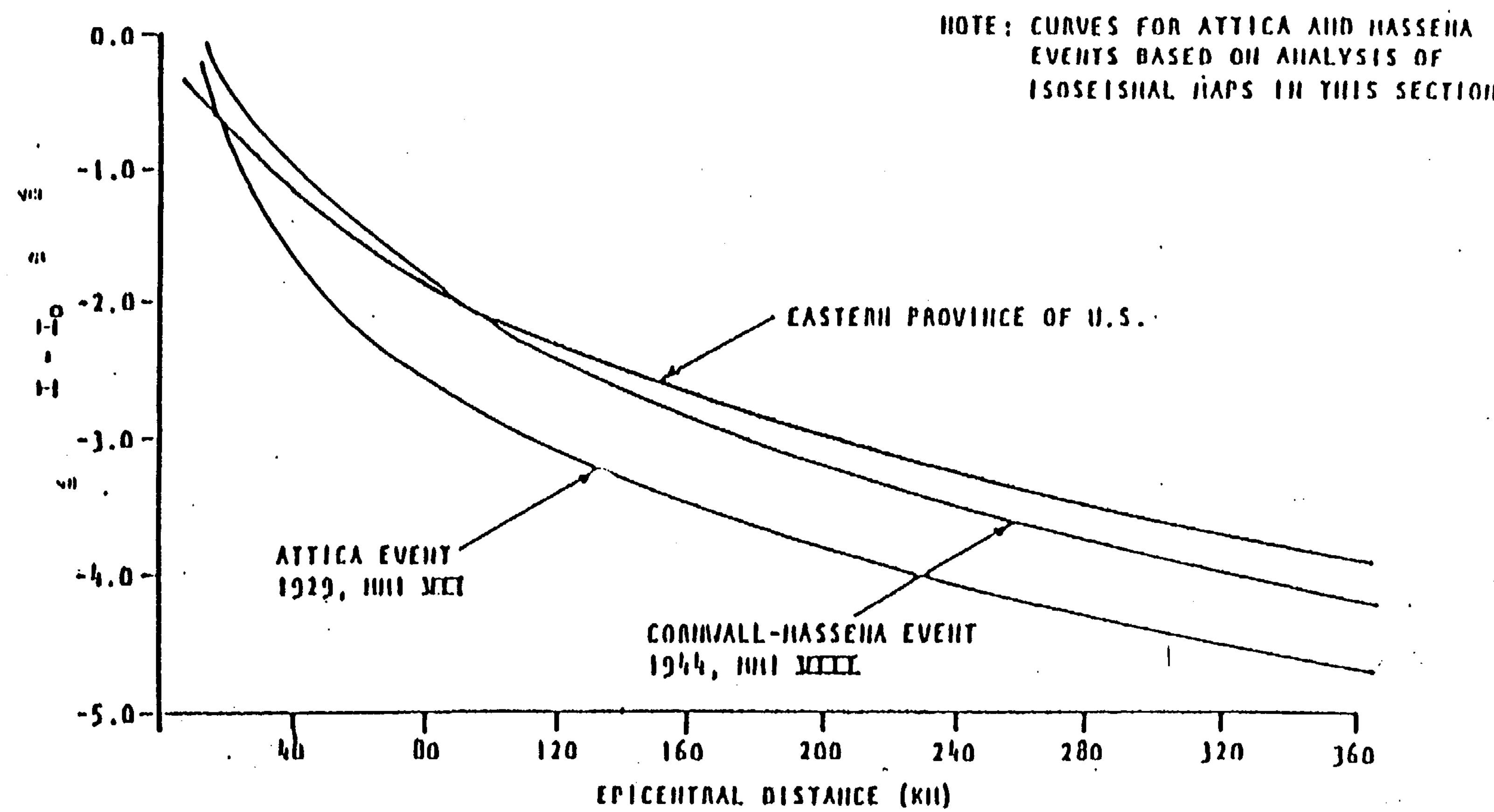


FIGURE A-5-13 Groundwater Recharge Areas at The WVDP



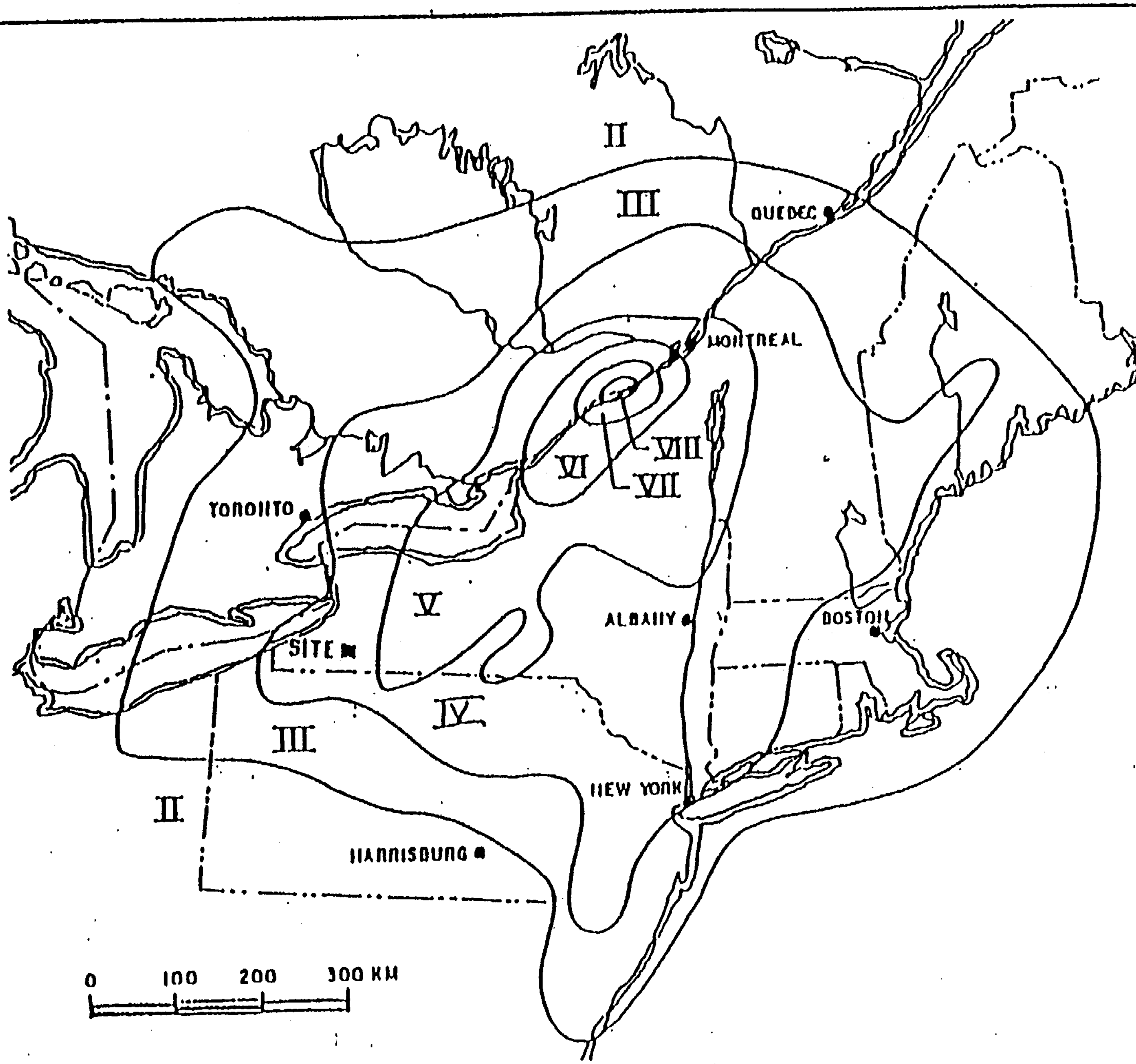
SEISMICITY IN NORTHEASTERN UNITED STATES

Figure A.3.6-1



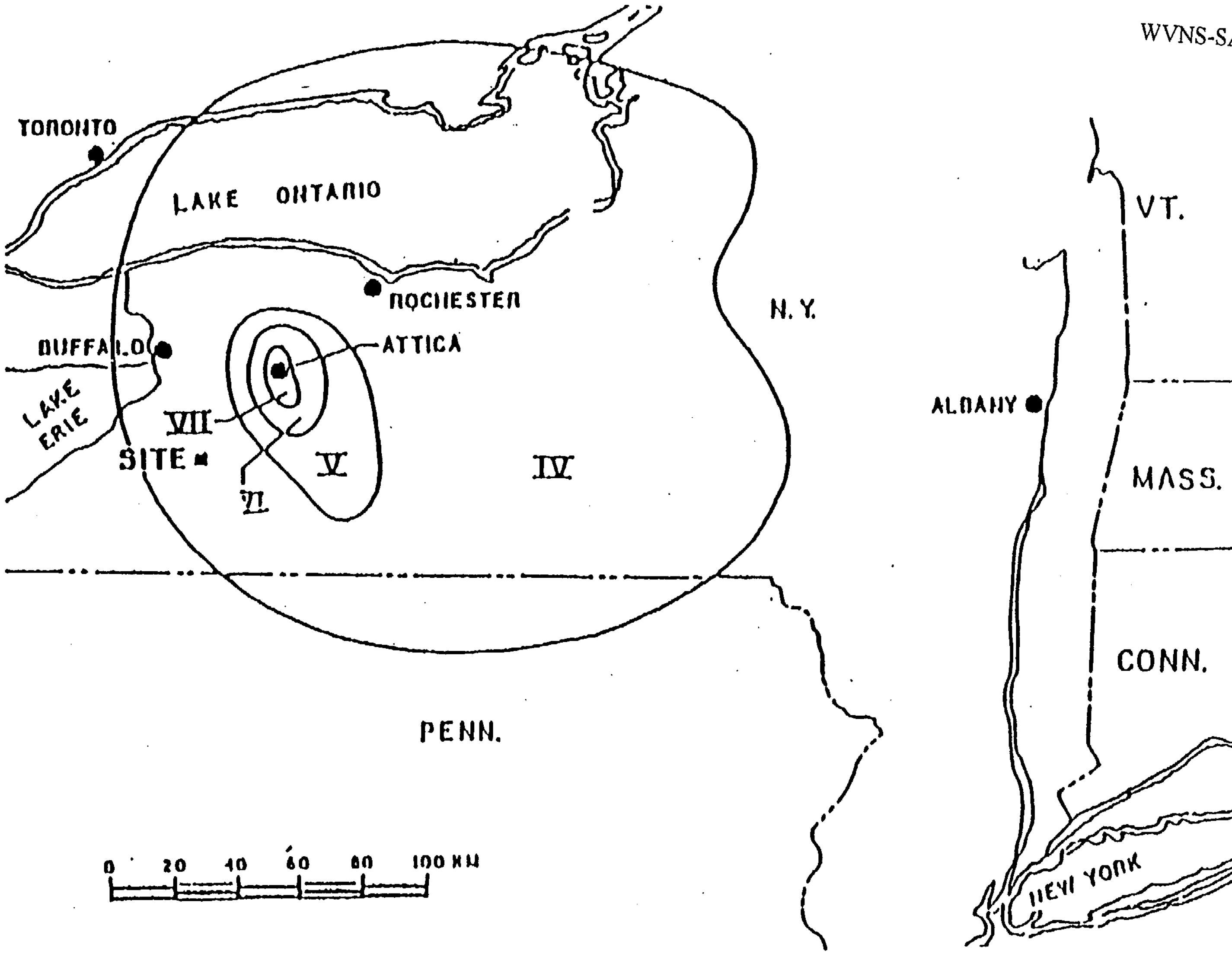
COMPARISON OF GENERAL EASTERN UNITED STATES ATTENUATION WITH DATA FOR SITE REGION

Figure A.3.6-2



ISOSEISMAL MAP OF THE CORNWALL-MASSENA EARTHQUAKE
SEPTEMBER 5,1944, MMI VIII

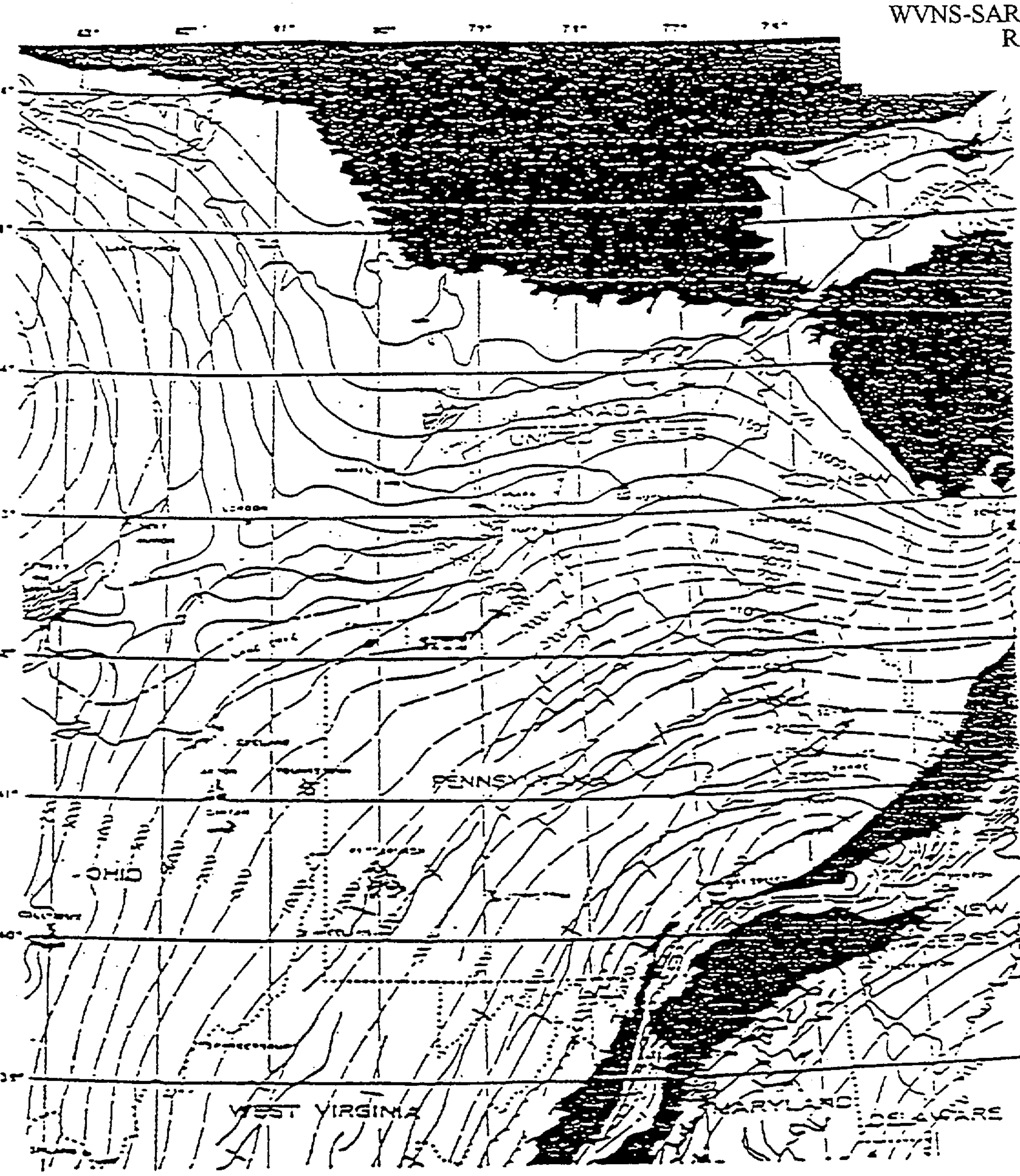
FIGURE A.3.6-3



ISOSEISMAL MAP OF THE ATTICA EARTHQUAKE
OF AUGUST 12,1929, MMI VIII

Figure A.3.6-4

WVNS-SAR-001
Rev. 6



REGIONAL TECTONIC MAP

50 25 0 50 100

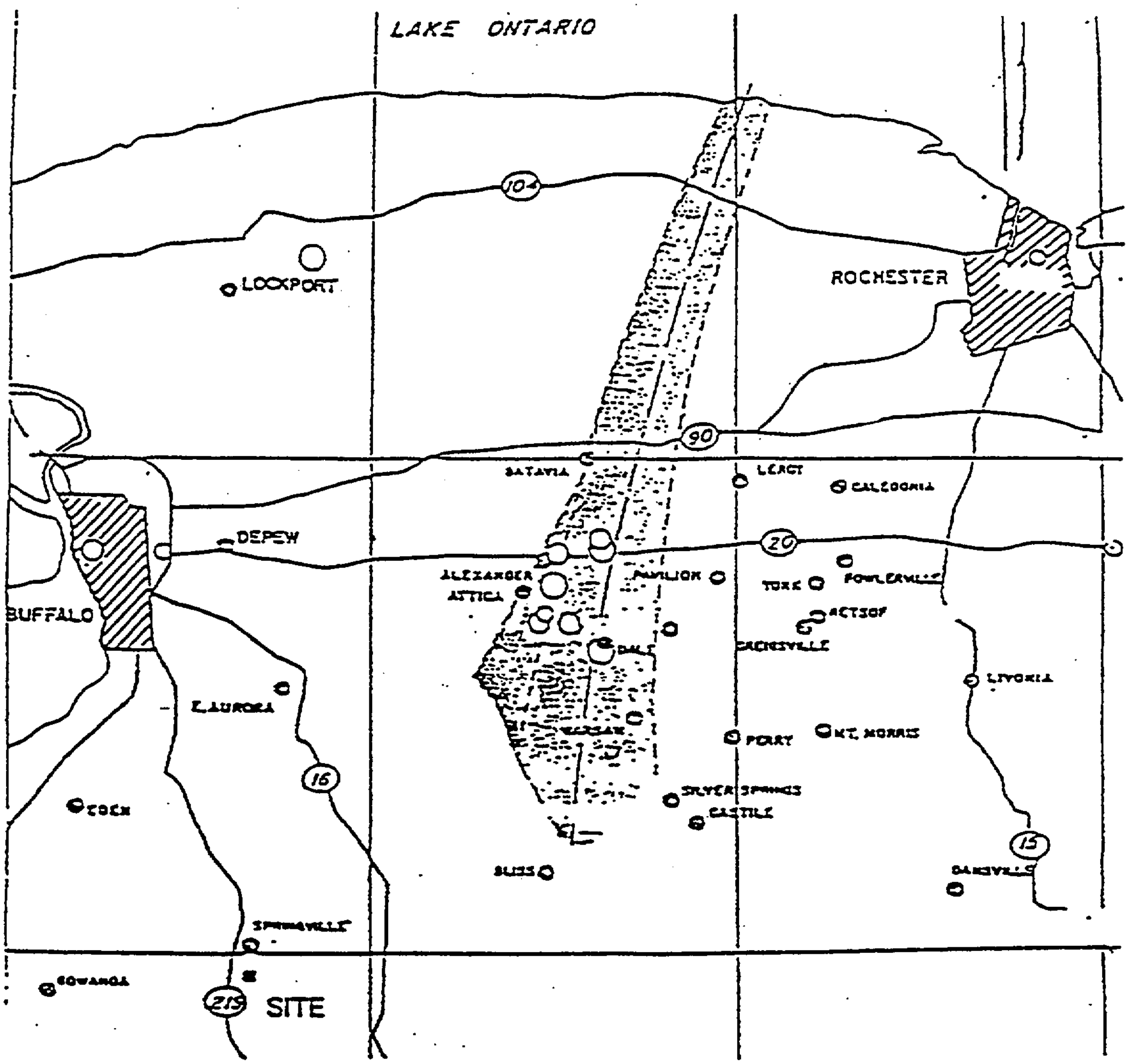
CONTOURS ON BASEMENT

REFERENCE:

THIS MAP WAS PREPARED FROM A PORTION OF THE U.S.G.S. "IFR WALL PLANNING CHART, EAST AND WEST, 1966"

MAJOR TECTONIC FEATURES WERE TAKEN FROM A PORTION OF THE "TECTONIC MAP OF THE UNITED STATES" BY U.S.G.S. AND A.A.P.G., 1962.

Figure A.3.6-5 Regional Tectonic Map



CLARENDON-LINDEN FAULT AND
ASSOCIATED EARTHQUAKES, 1975 INTERPRETATION

KEY:

CLARENDON -LINDEN FAULT AND

POSTULATED RELATED STRUCTURE

INTENSITY

○ 8-6 8-6

○ 5-3 5-3

○ 2-0 2-0

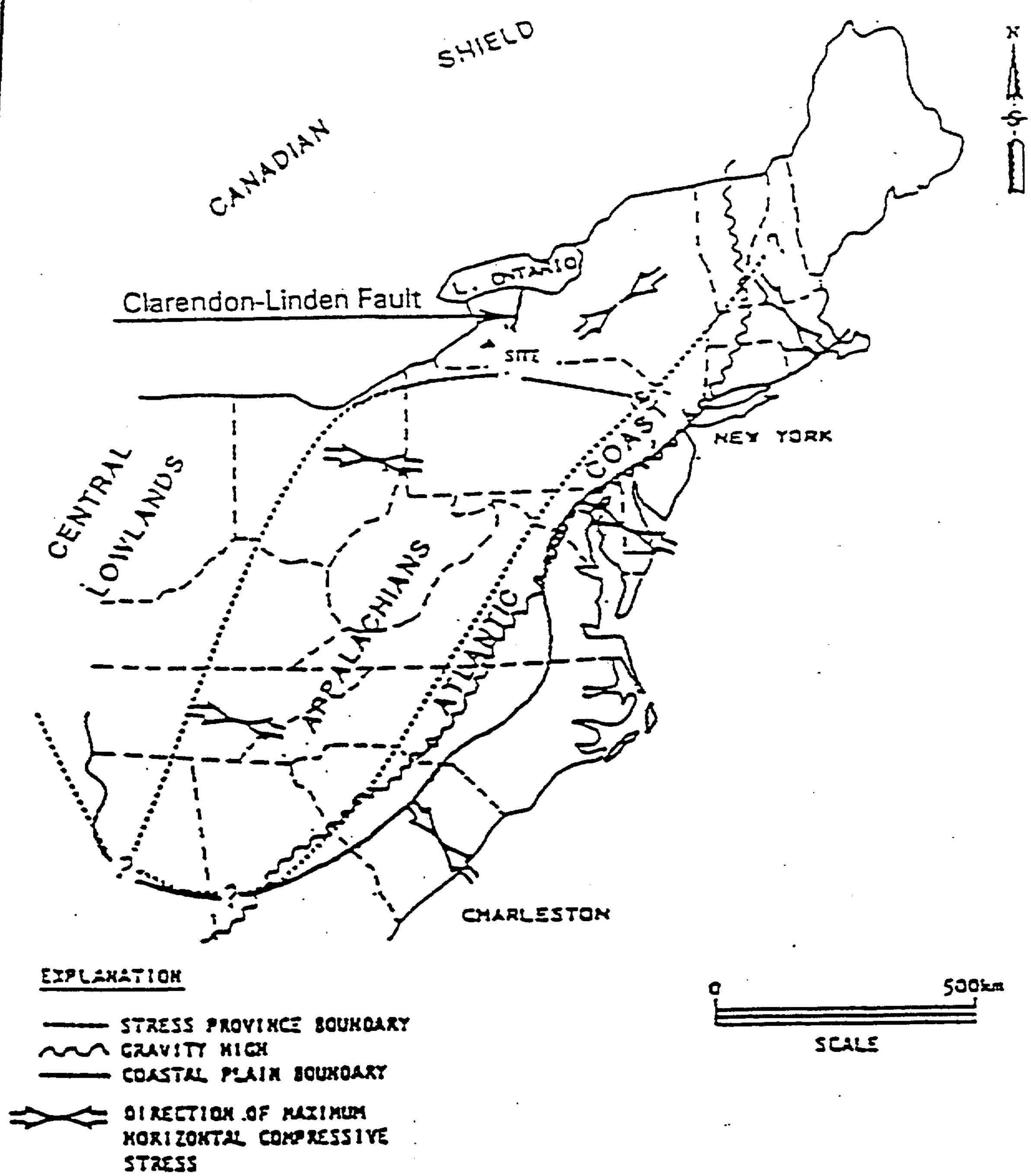
SCALE IN MILES

0 10

VAN TYNE-N.Y. GEOLOGICAL SURVEY OPEN
FILE REPORT APRIL /75

FIGURE A.3.6-6

Filename



SOURCE:
Reference: Zoback and Zoback, 1980

STRESS PROVINCES

Figure A.3.6-7

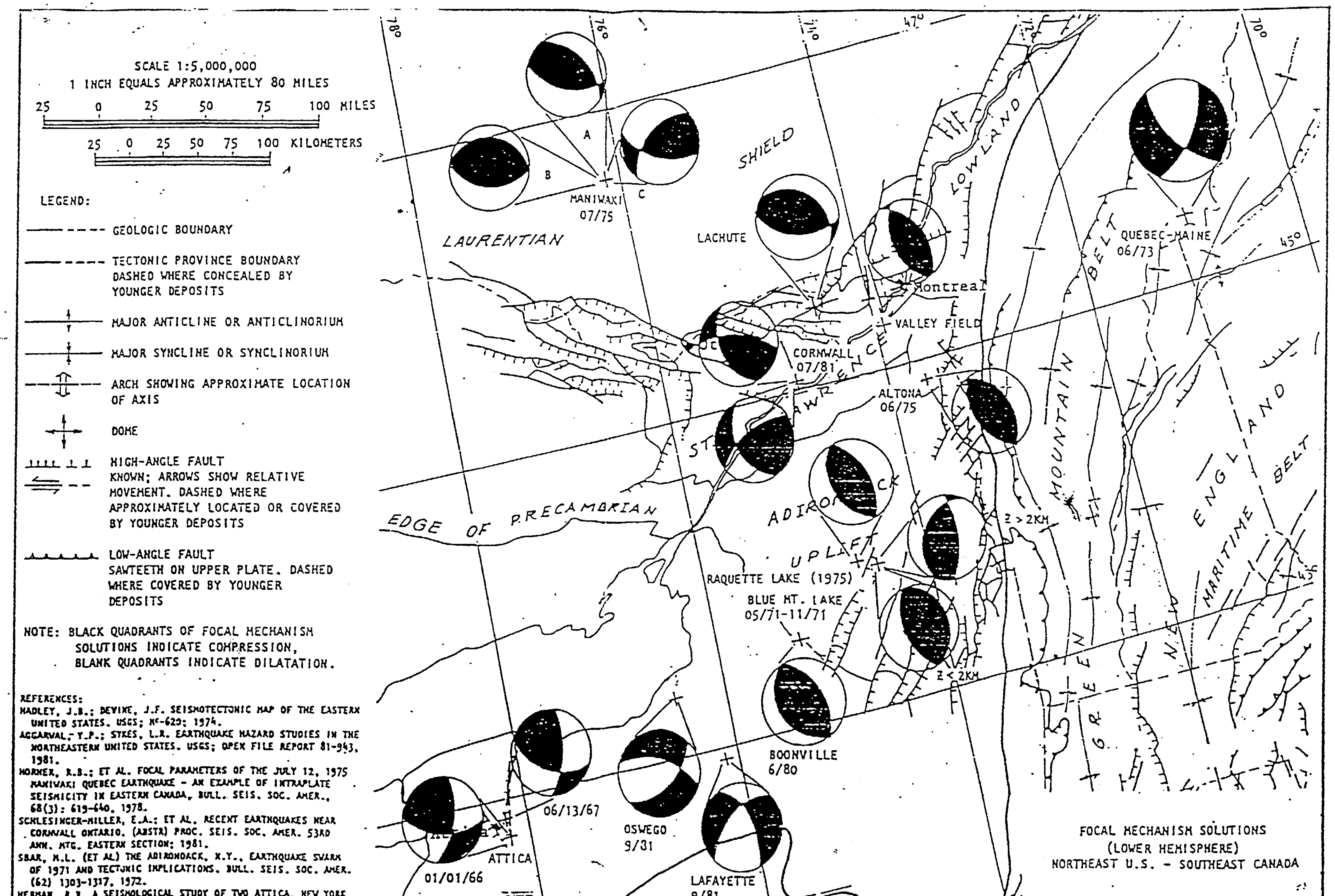
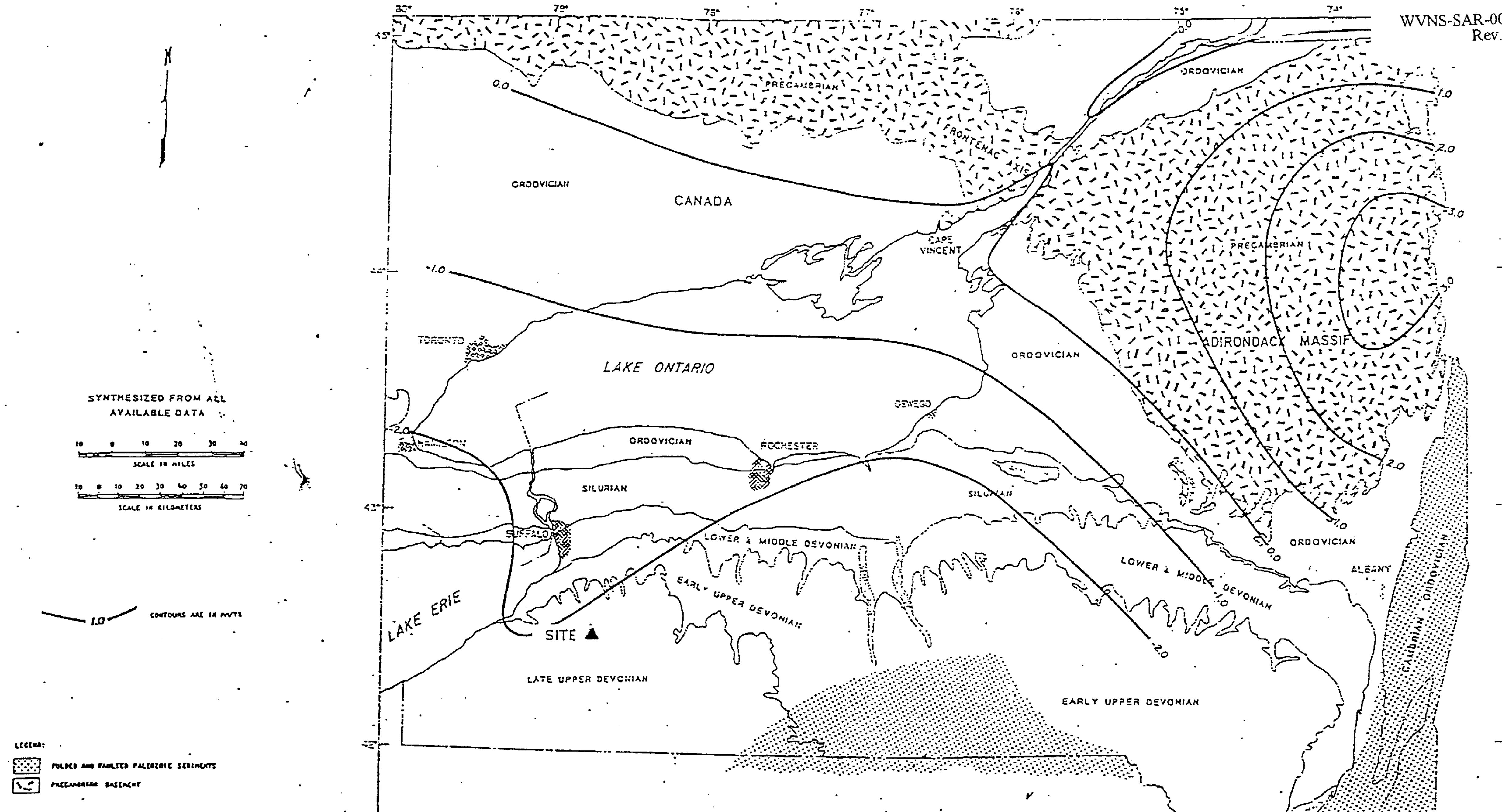

SCALE 1:5,000,000
1 INCH EQUALS APPROXIMATELY 80 MILES
25 0 25 50 75 100 MILES
25 0 25 50 75 100 KILOMETERS
LEGEND:
GEOLOGIC BOUNDARY
TECTONIC PROVINCE BOUNDARY DASHED WHERE CONCEALED BY YOUNGER DEPOSITS
MAJOR ANTICLINE OR ANTICLINORIUM
MAJOR SYNCLINE OR SYNCLINORIUM
ARCH SHOWING APPROXIMATE LOCATION OF AXIS
DOME
HIGH-ANGLE FAULT KNOWN; ARROWS SHOW RELATIVE MOVEMENT. DASHED WHERE APPROXIMATELY LOCATED OR COVERED BY YOUNGER DEPOSITS
LOW-ANGLE FAULT SAWTEETH ON UPPER PLATE. DASHED WHERE COVERED BY YOUNGER DEPOSITS
NOTE: BLACK QUADRANTS OF FOCAL MECHANISM SOLUTIONS INDICATE COMPRESSION, BLANK QUADRANTS INDICATE DILATATION.
REFERENCES:
HADLEY, J.B.; DEVINE, J.F. SEISMOTECTONIC MAP OF THE EASTERN UNITED STATES. USGS; MF-620; 1974.
AGGARVAL, Y.P.; SYKES, L.R. EARTHQUAKE HAZARD STUDIES IN THE NORTHEASTERN UNITED STATES. USGS; OPEN FILE REPORT 81-943. 1981.
HORNER, R.B.; ET AL. FOCAL PARAMETERS OF THE JULY 12, 1975 MANIWAKI QUEBEC EARTHQUAKE - AN EXAMPLE OF INTRAPLATE SEISMICITY IN EASTERN CANADA. BULL. SEIS. SOC. AMER., 68(3): 619-640. 1978.
SCHLESINGER-MILLER, E.A.; ET AL. RECENT EARTHQUAKES NEAR CORNWALL ONTARIO. (ABSTR) PROC. SEIS. SOC. AMER. 53RD ANN. MTG. EASTERN SECTION; 1981.
SBAR, M.L. (ET AL) THE ADIRONDACK, N.Y., EARTHQUAKE SWARM OF 1971 AND TECTONIC IMPLICATIONS. BULL. SEIS. SOC. AMER. (62) 1303-1317, 1972.
HERMAN, R.B. A SEISMOLOGICAL STUDY OF TWO ATTICA, NEW YORK EARTHQUAKES. BULL. SEIS. SOC. AMER. 1978, 68(3), P 641-651.
78°
76°
74°
72°
70°
47°
45°
A
B
C
MANIWAKI
07/75
SHIELD
LAURENTIAN
LACHUTE
LOWLAND
Montreal
QUEBEC-MAINE
06/73
VALLEY FIELD
CORNWALL
07/81
ST. LAWRENCE
ALTONA
06/75
EDGE OF PRECAMBRIAN
ADIRONDACK
UPLIFT
MOUNTAIN
BELT
GREEN
NEW ENGLAND
MARITIME BELT
Z > 2KM
Z < 2KM
RAQUETTE LAKE (1975)
BLUE MT. LAKE
05/71-11/71
BOONVILLE
6/80
06/13/67
OSWEGO
9/81
LAFAYETTE
9/81
ATTICA
01/01/66
SITE
FOCAL MECHANISM SOLUTIONS
(LOWER HEMISPHERE)
NORTHEAST U.S. - SOUTHEAST CANADA

FIGURE A.3.6-8



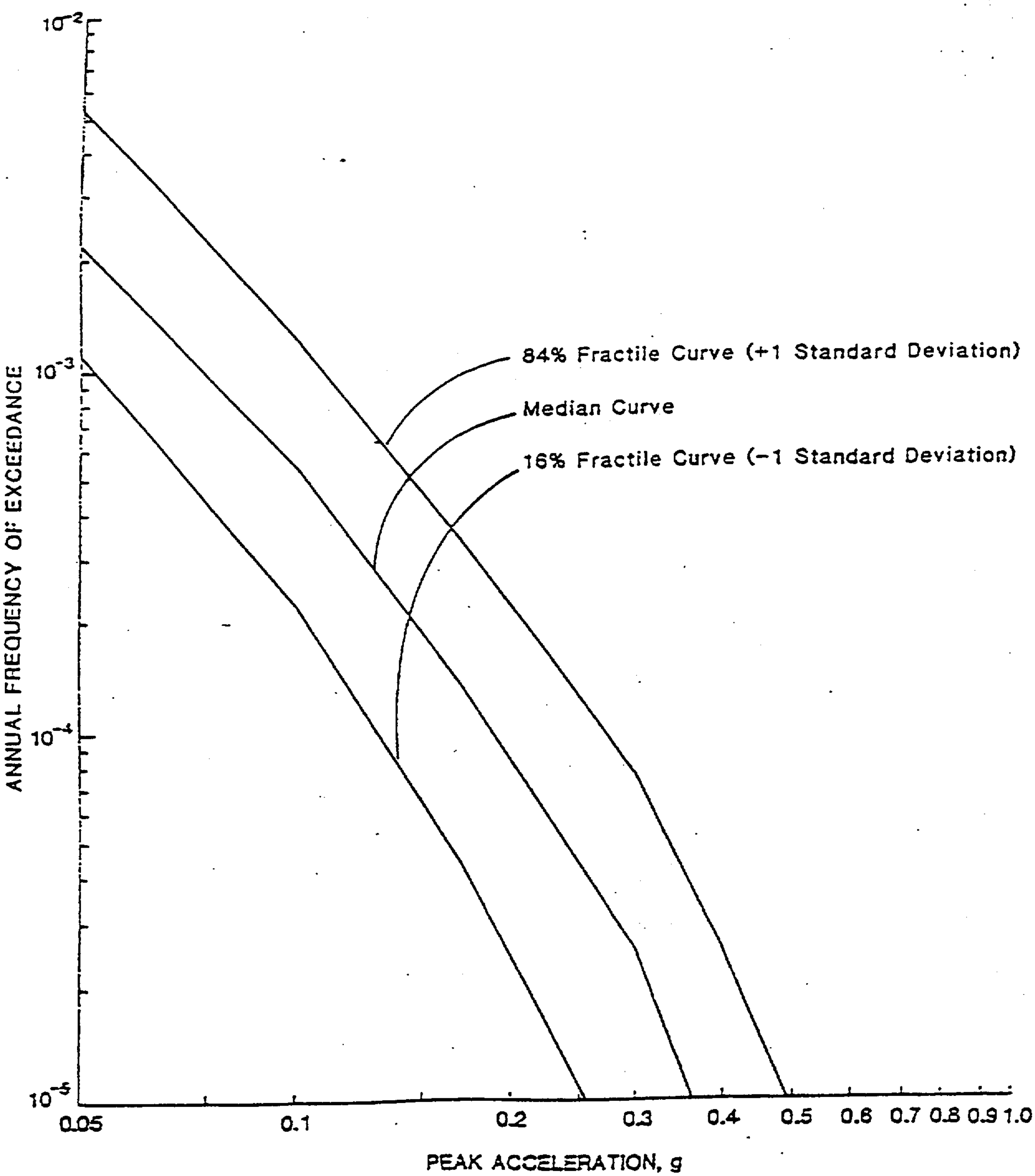
REFERENCES:

BROUGHTON, J.G. et al., 1966. GEOLOGY OF NEW YORK - A SHORT ACCOUNT EDUCATIONAL LEAFLET No. 20 NEW YORK STATE MUSEUM AND SCIENCE SERVICE

GEOLOGICAL SURVEY OF CANADA (1969) GEOLOGICAL MAP OF CANADA No. 1250 A

INTERPRETATION OF VERTICAL CRUSTAL VELOCITY FOR LAKE ONTARIO REGION RELATIVE TO CAPE VINCENT, N.Y.

FIGURE A.3.6-9



Fractile Seismic Hazard Curves

Figure A.3.6-10

Filename

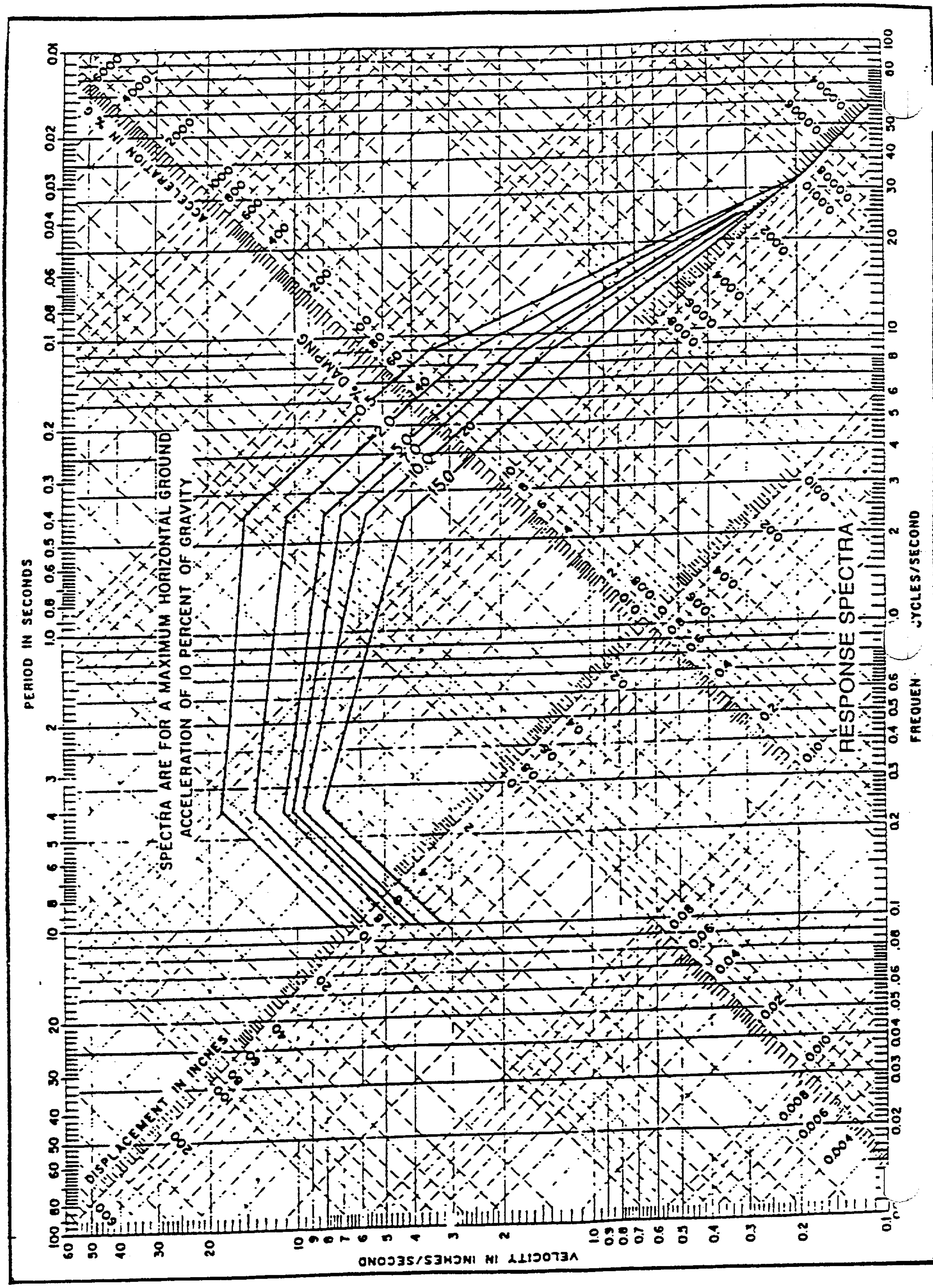
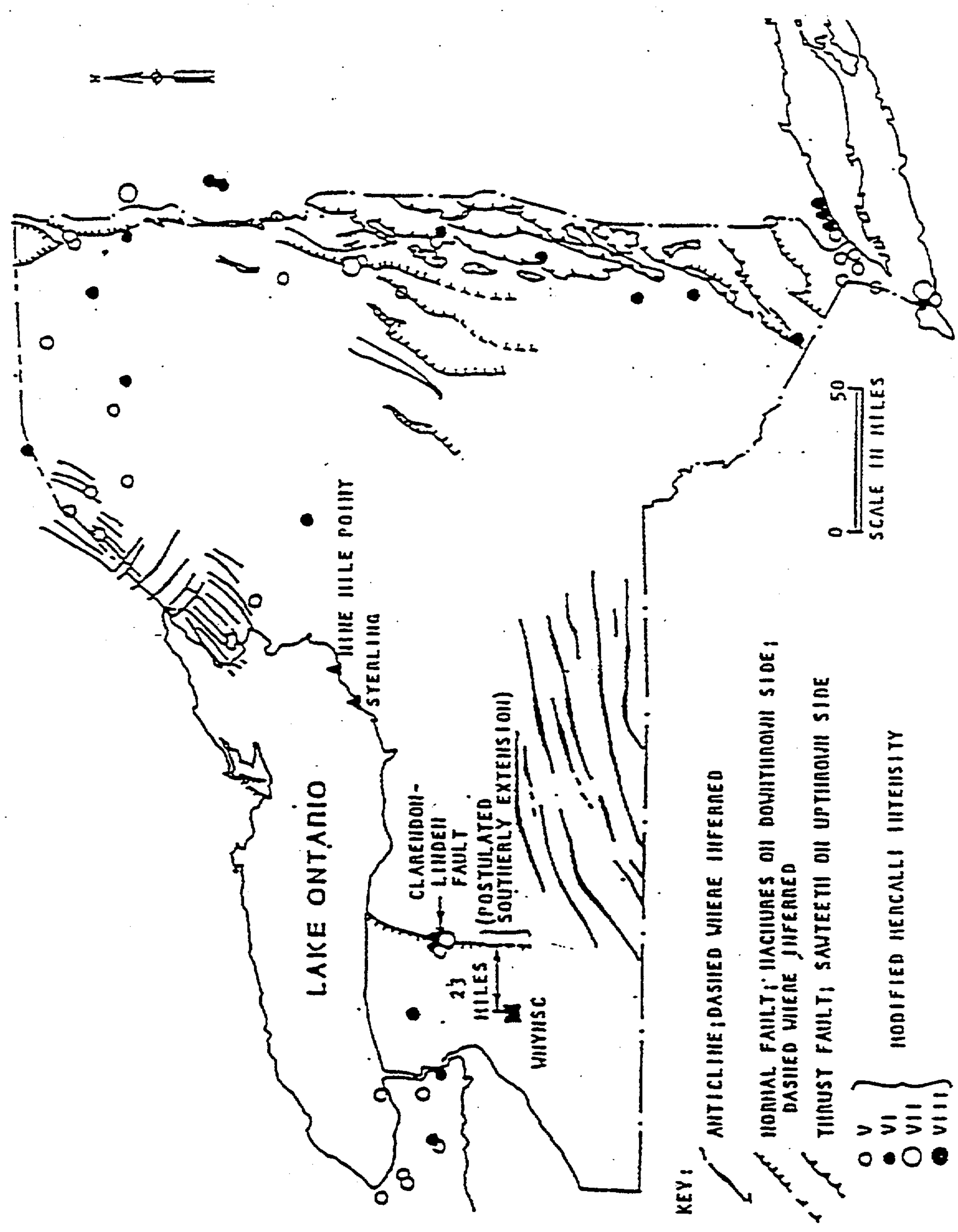


FIGURE A.3.6-11 Design Basis Earthquake - Response Spectra

Filename



GENERALIZED SEISMO-TECTONIC MAP
OF NEW YORK
SHOWING HISTORICAL SEISMICITY

FIGURE A.3.6-12

SR1-3613.DWG

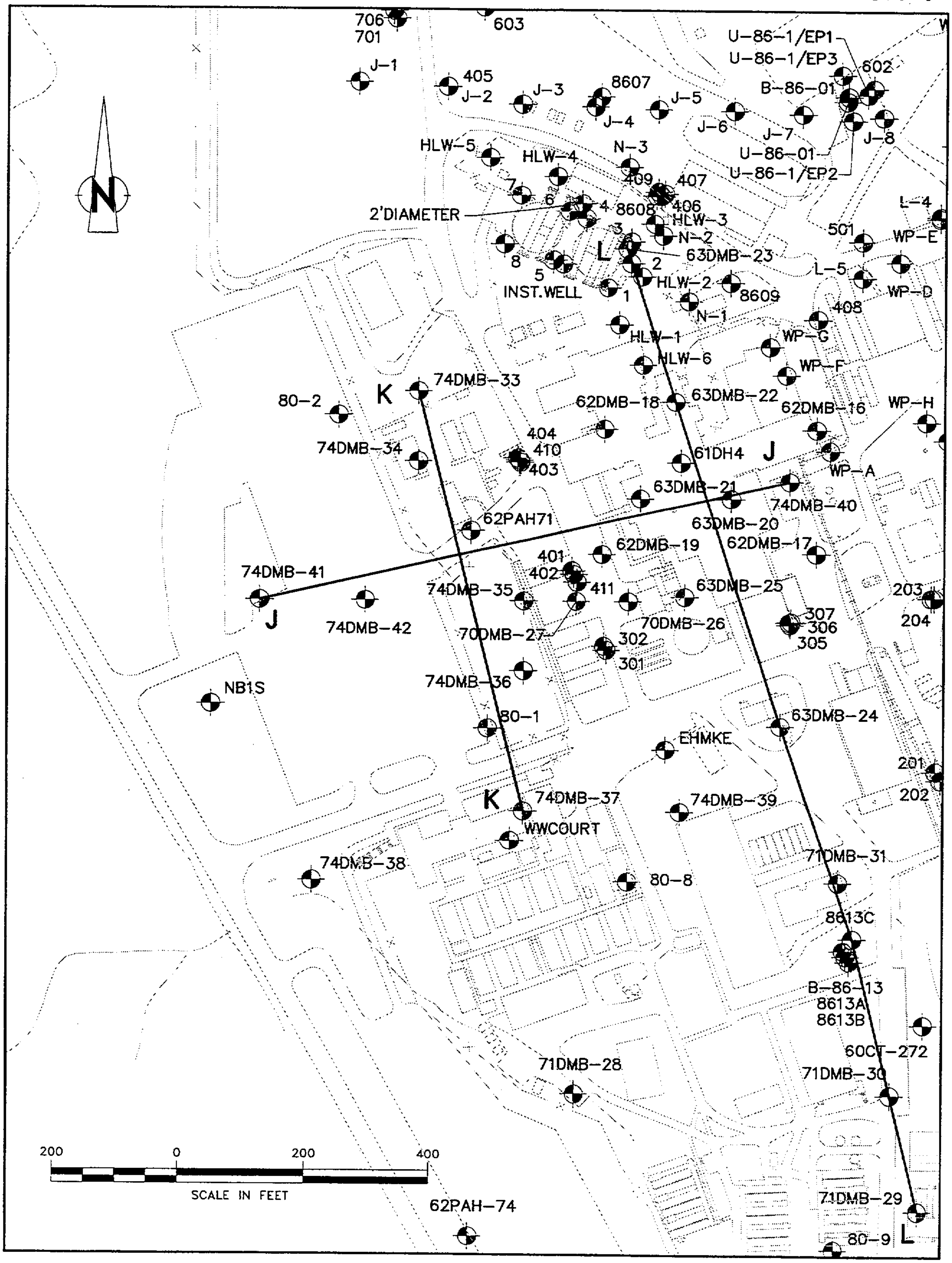


Figure A.3.6-13 Plot Plan Showing Locations of Drill Holes and Surface Sections (Reprocessing Plant Area).

SR1-3614.DWG

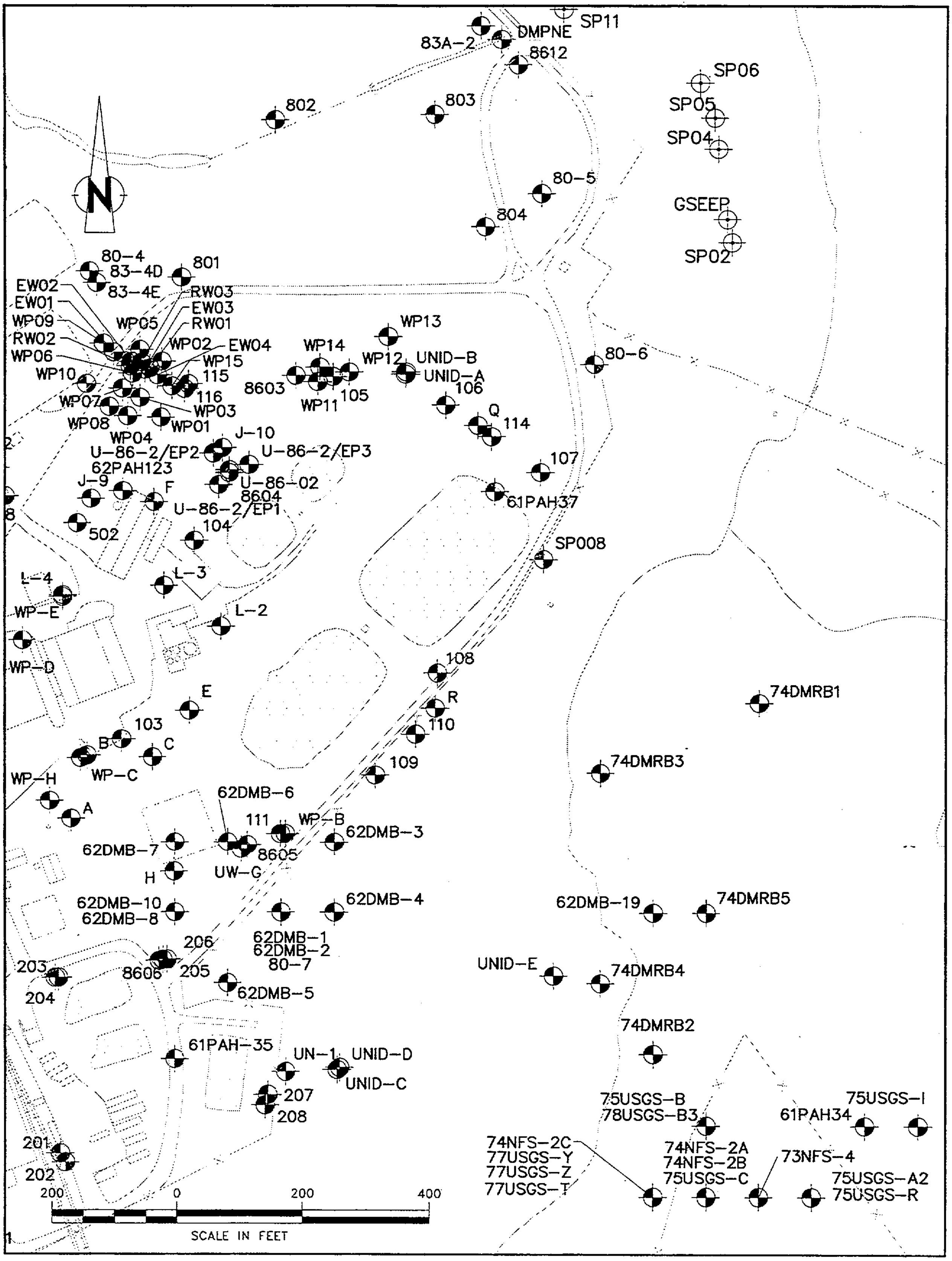


Figure A.3.6-14 Plot Plan Showing Locations of Drill Holes (Low Level Waste Treatment Facility Area)

SR1-3615.DWG

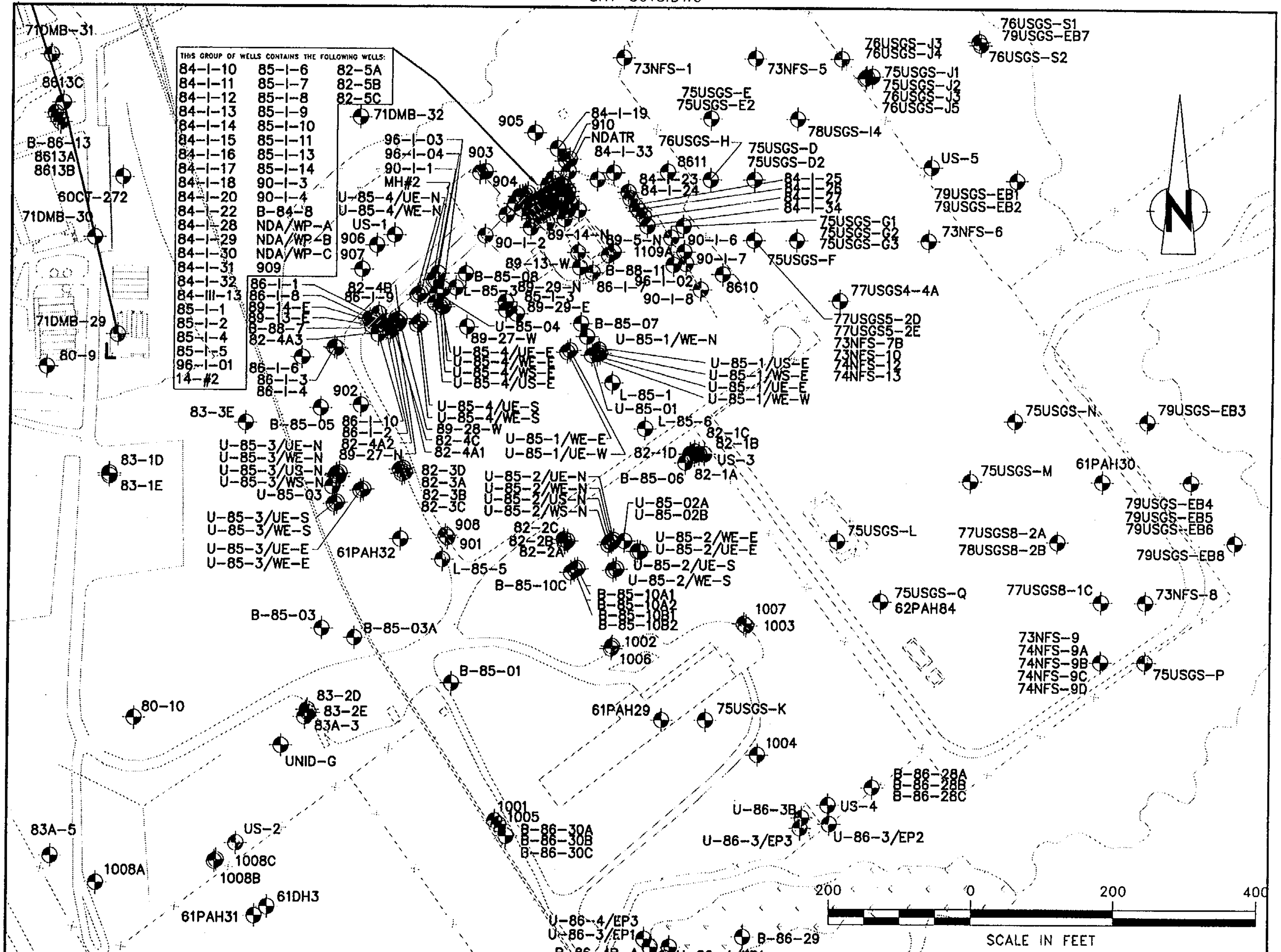


Figure A.3.6-15 Plot Plan Showing Locations of Drill Holes (Waste Disposal Areas)

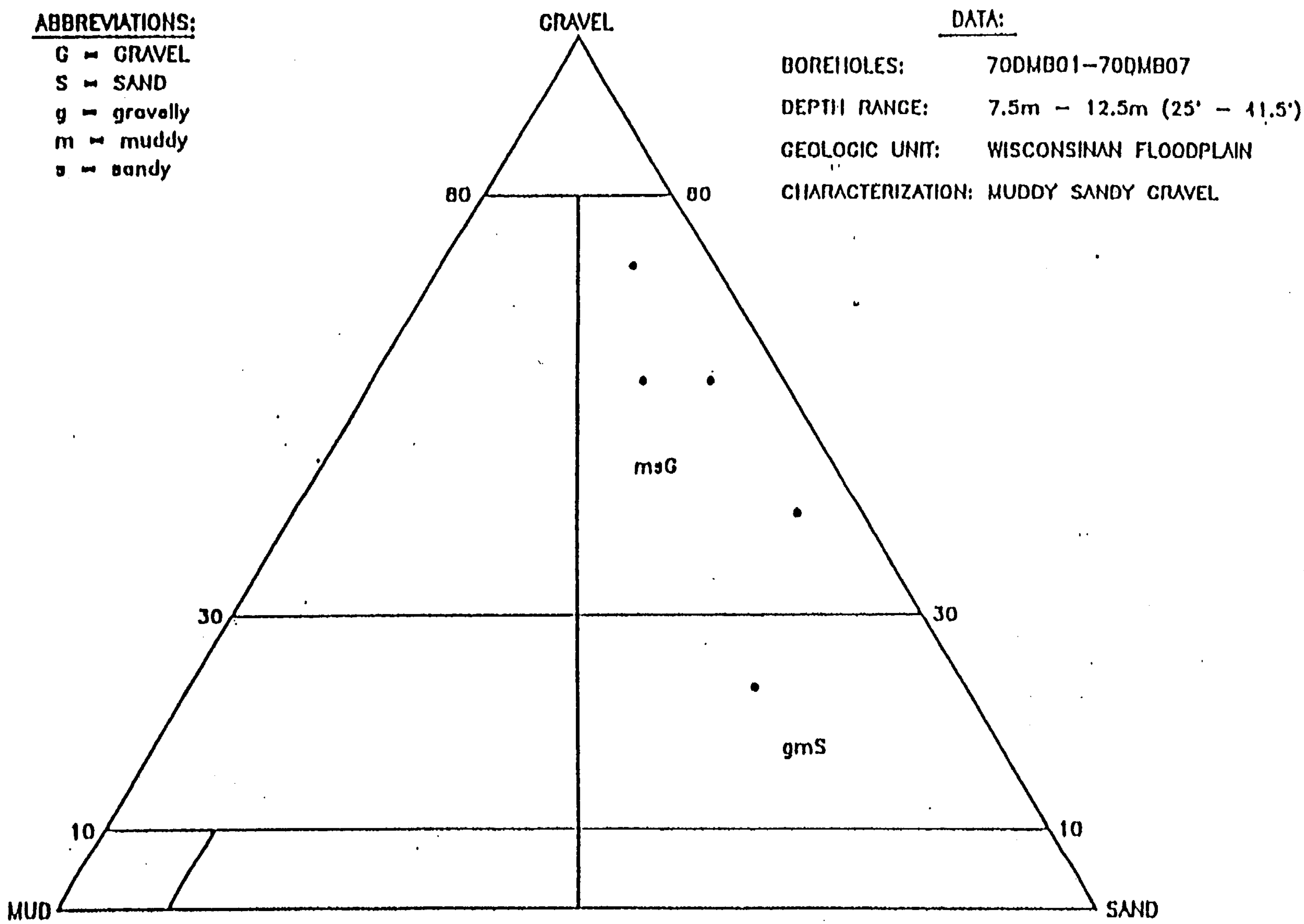


FIGURE A.3.6-16a Particle-Size Distribution-1

SR13616B.DWG

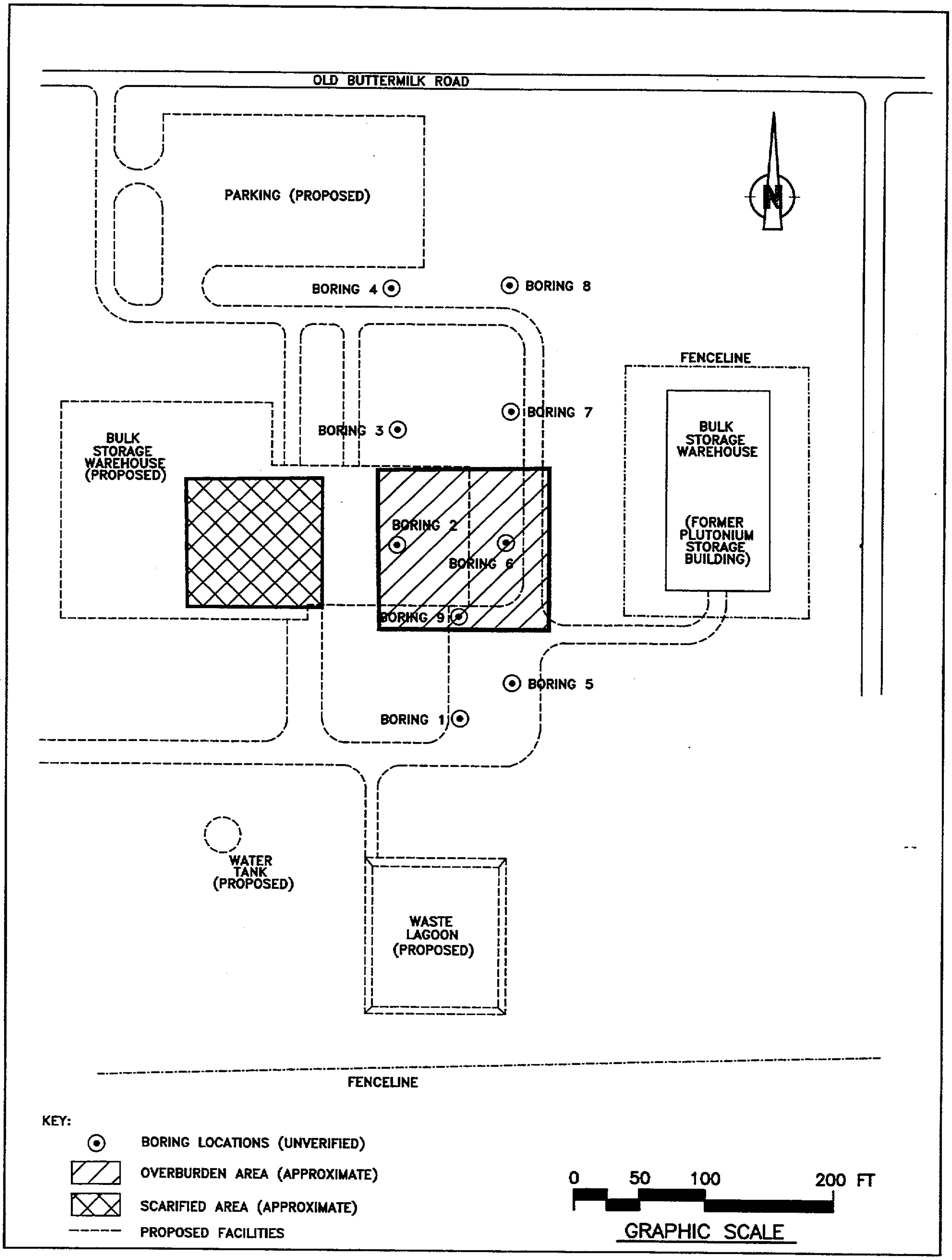


Figure A.3.6–16b Locations of Boreholes Indicated in FIGURE A.3.6–16a

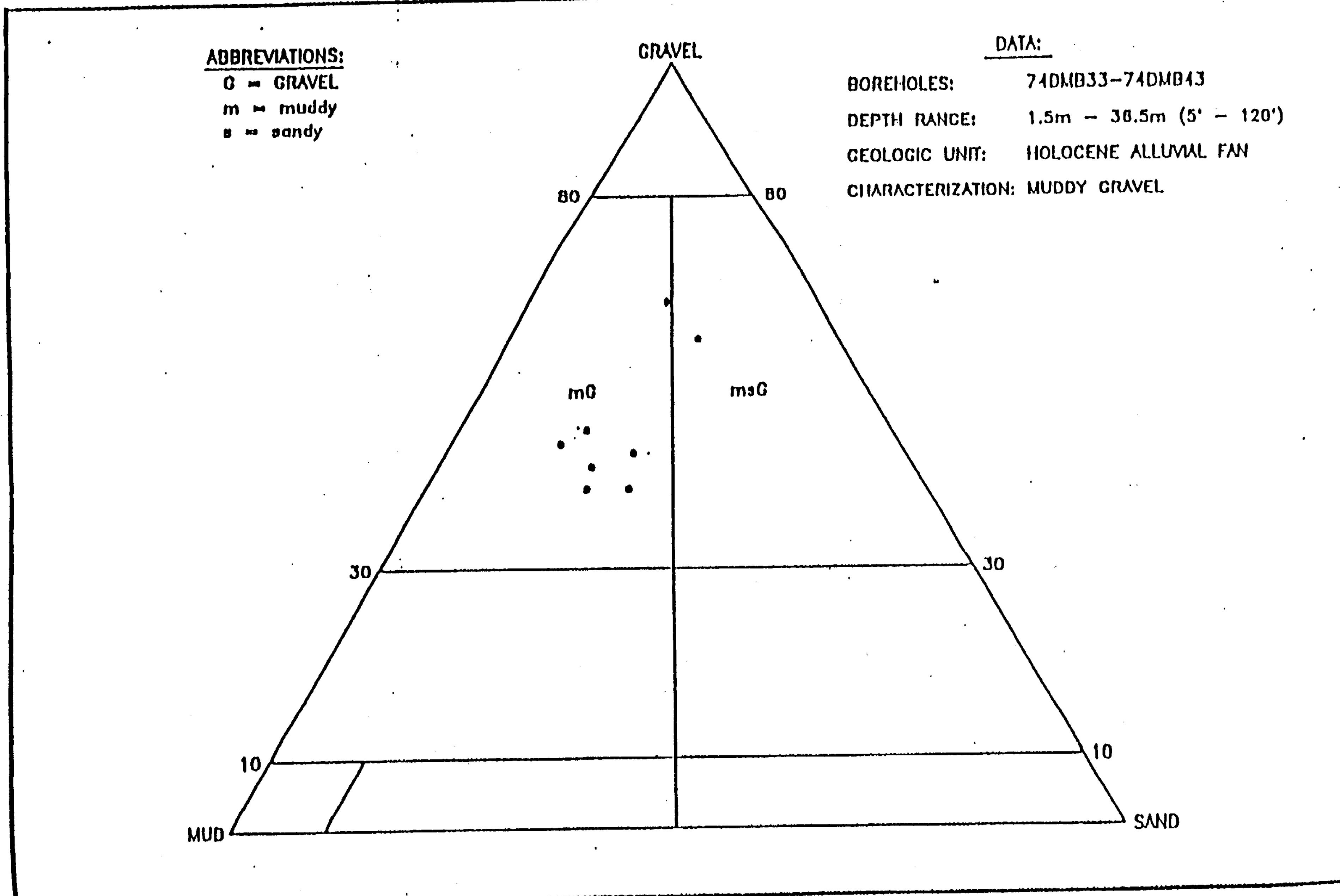


FIGURE A.3.6-17a Particle-Size Distribution-2

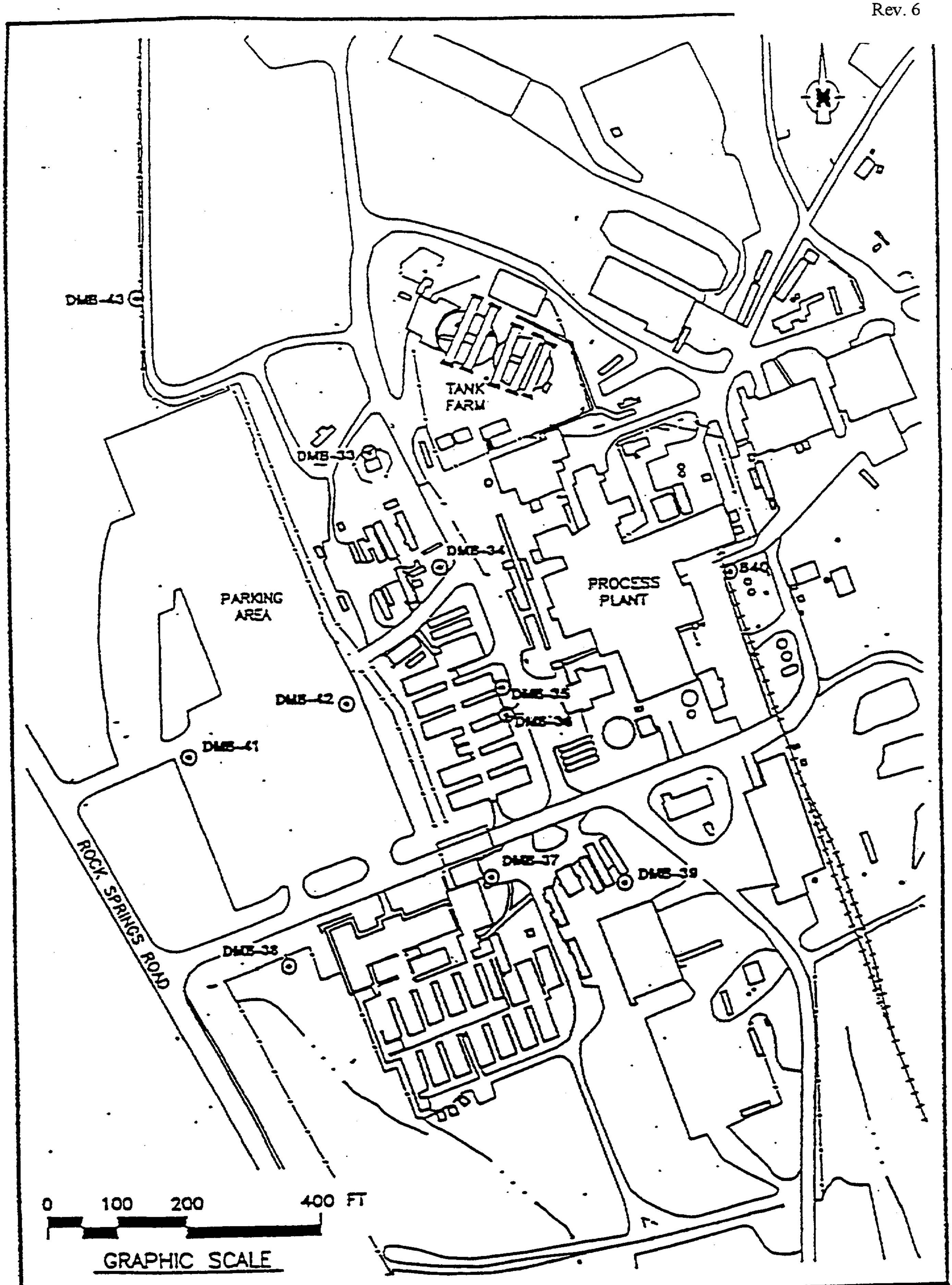


FIGURE A.3.6-17b Locations of Boreholes Indicated in FIGURE A.3.6-17a

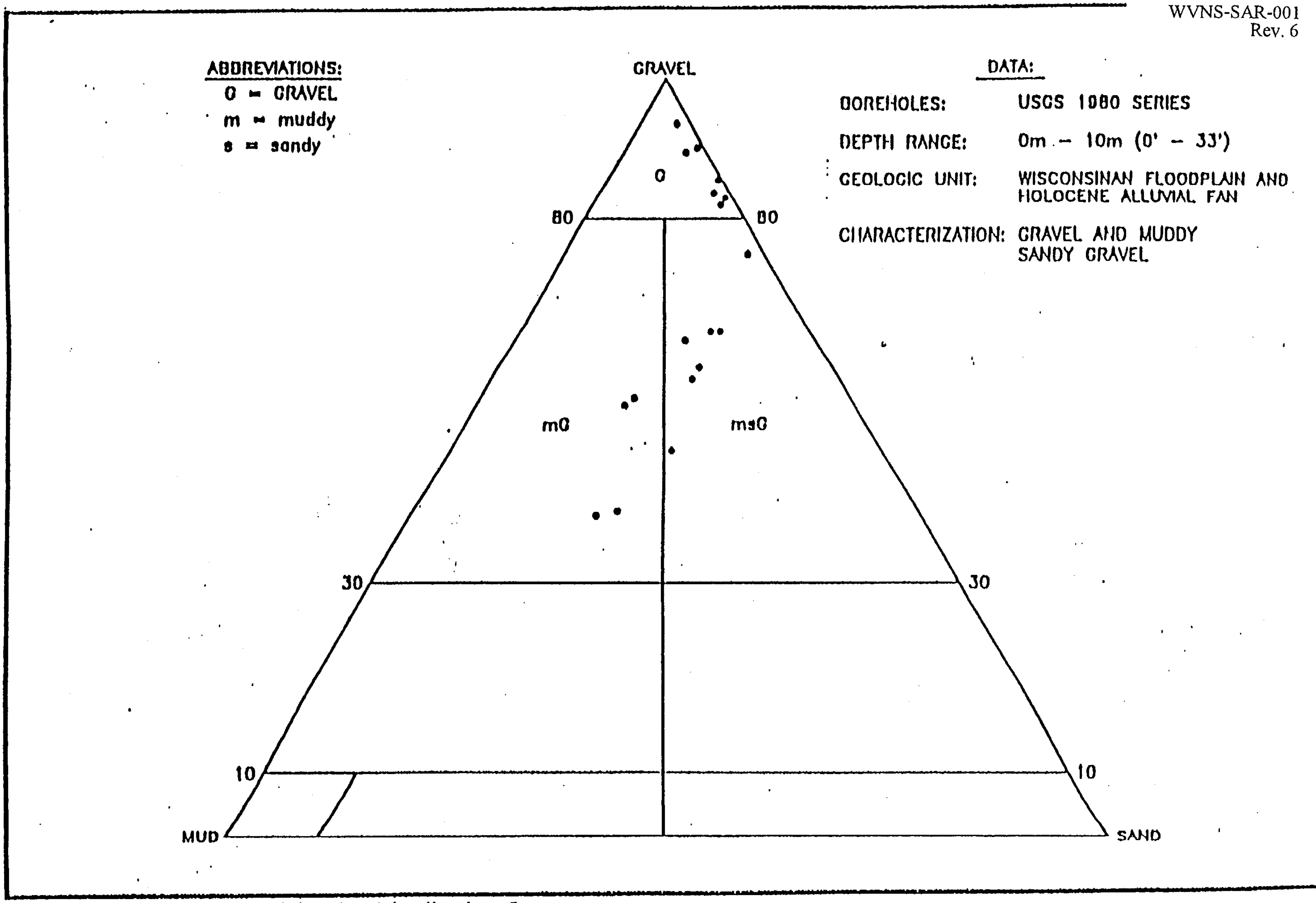


FIGURE A.3.6-18A Particle-Size Distribution-3

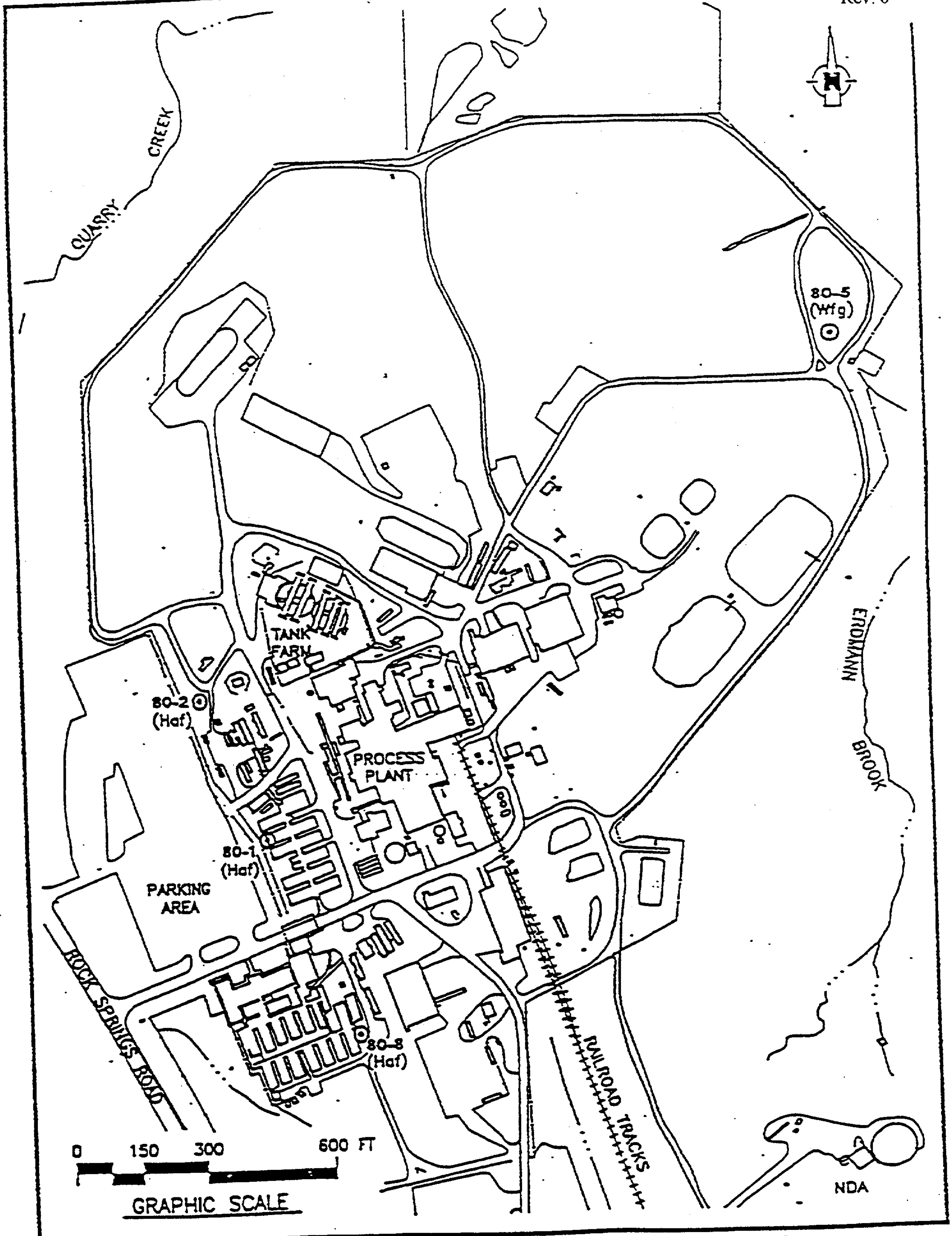


FIGURE A.3.6-18b Locations of Boreholes Indicated in FIGURE A.3.6-18a

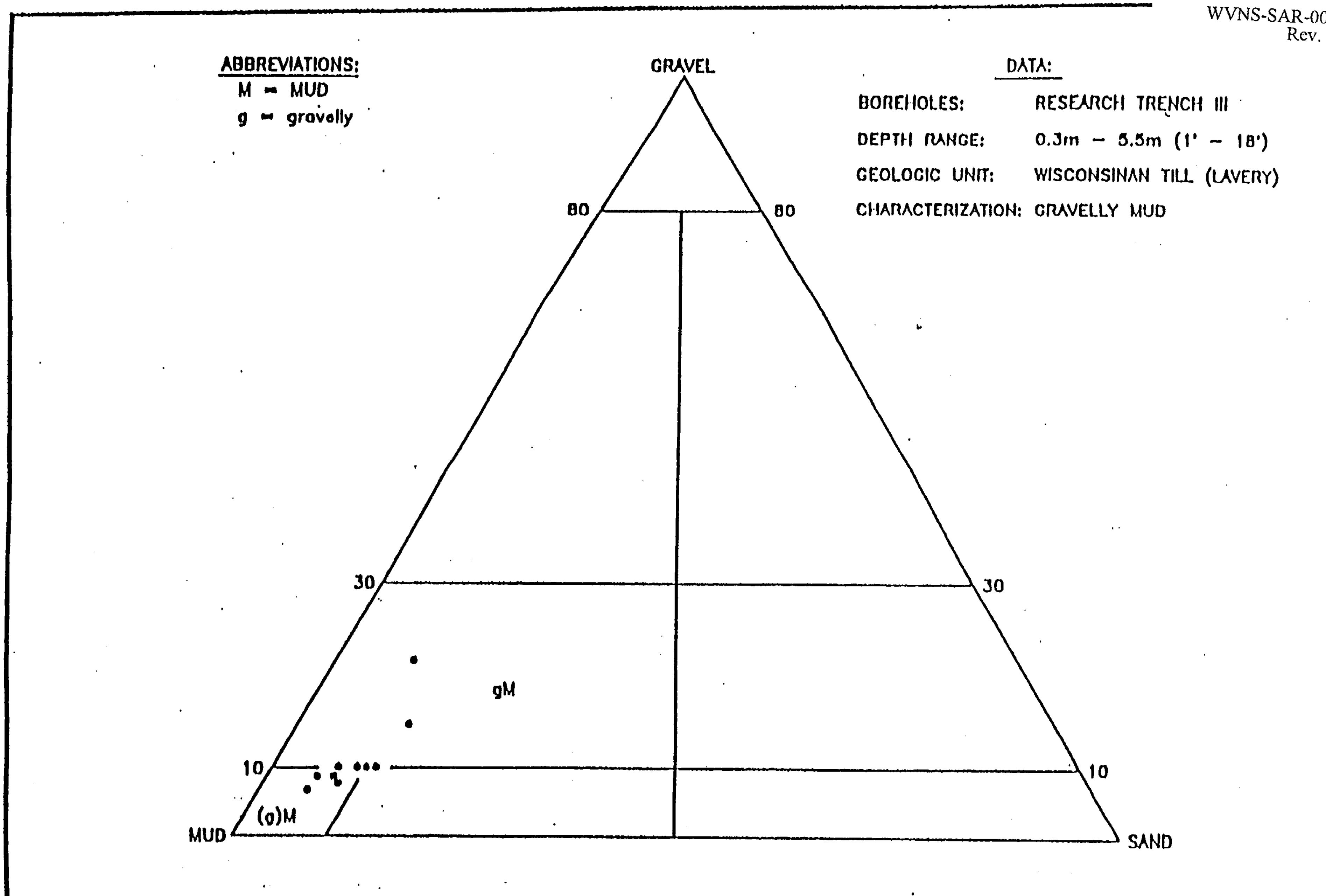


FIGURE A.3.6-19a Particle-Size Distribution-4

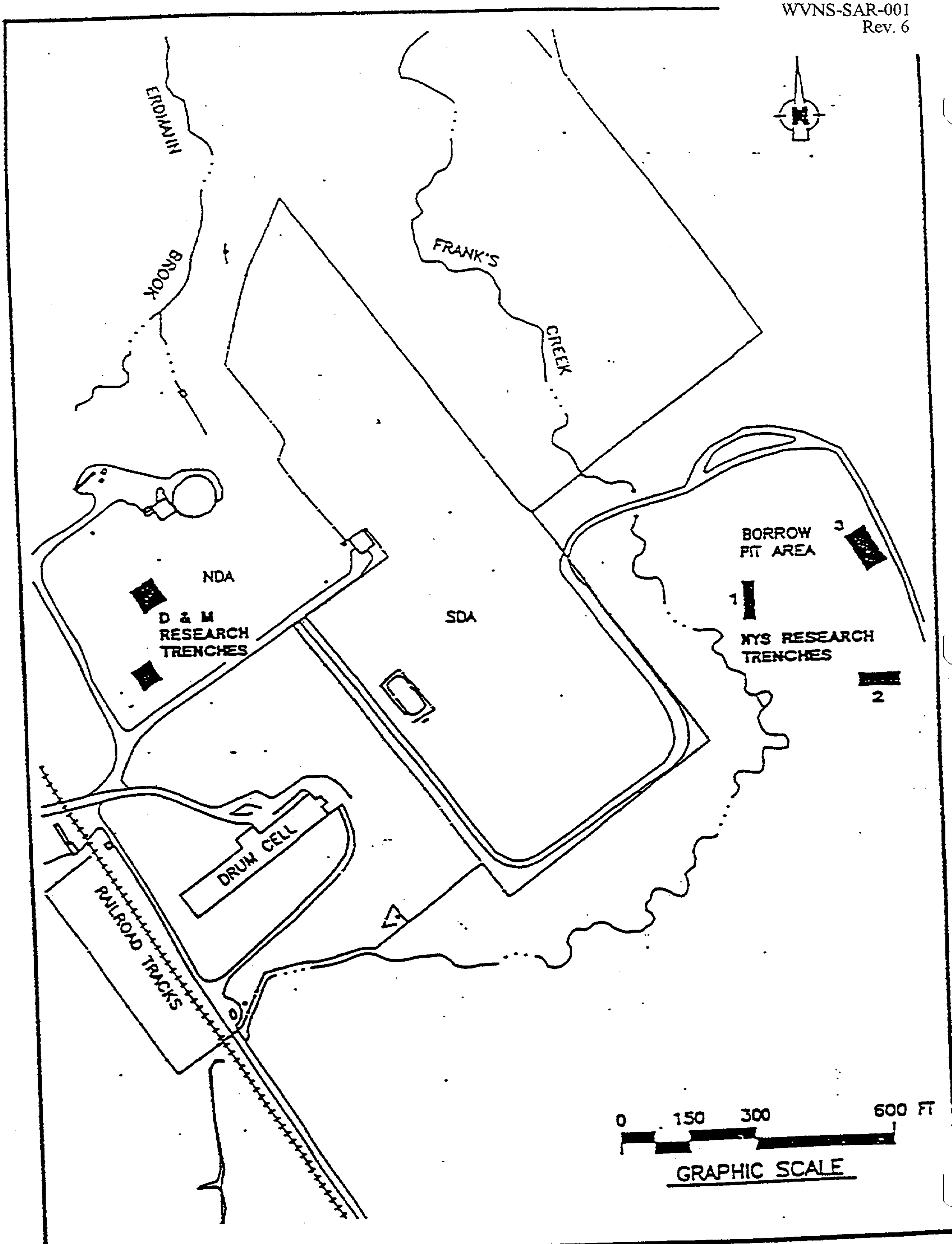


FIGURE A.3.6-19b Locations of Boreholes Indicated in FIGURE A.3.6-19a

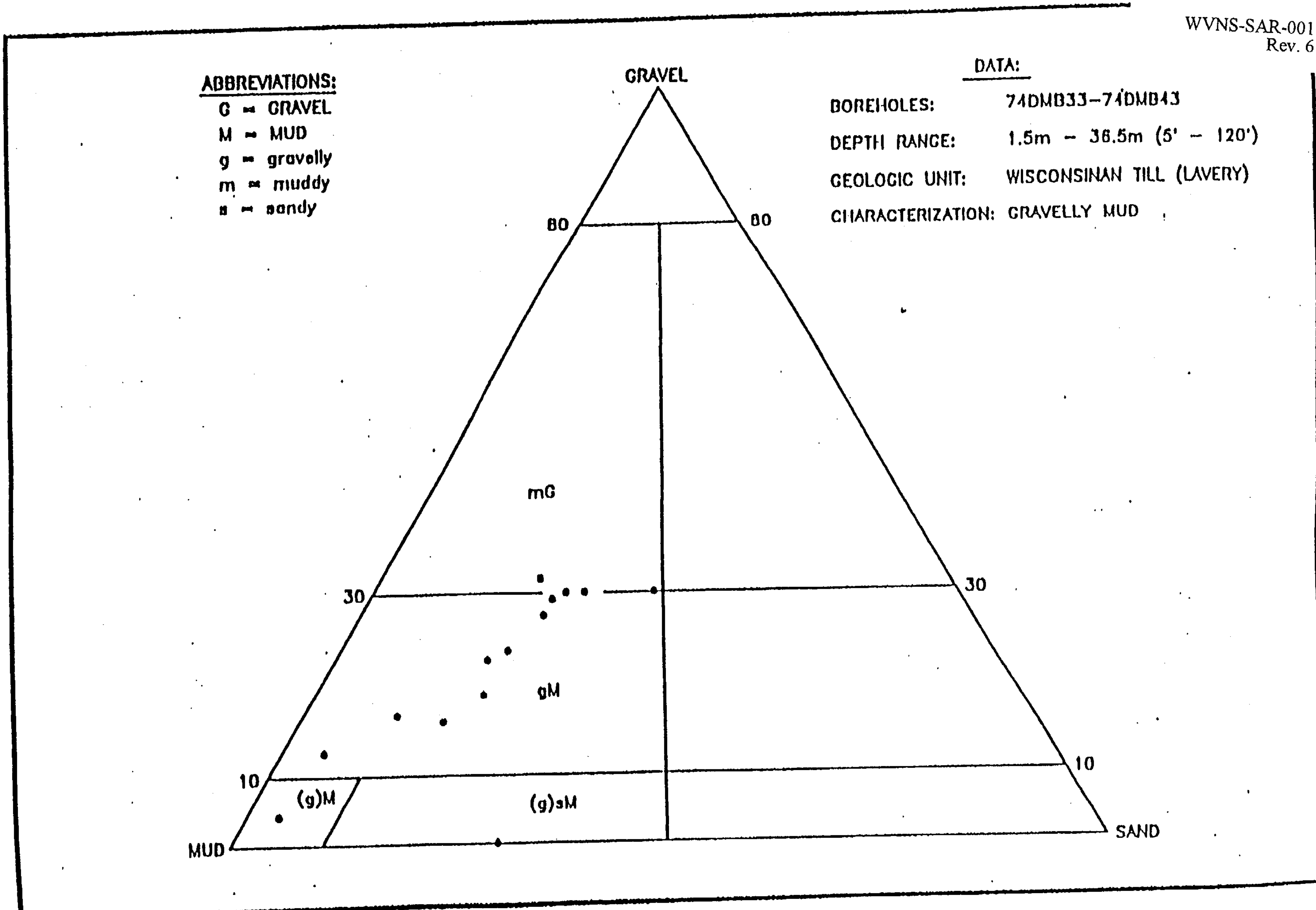


FIGURE A.3.6-20a Particle-Size Distribution-5

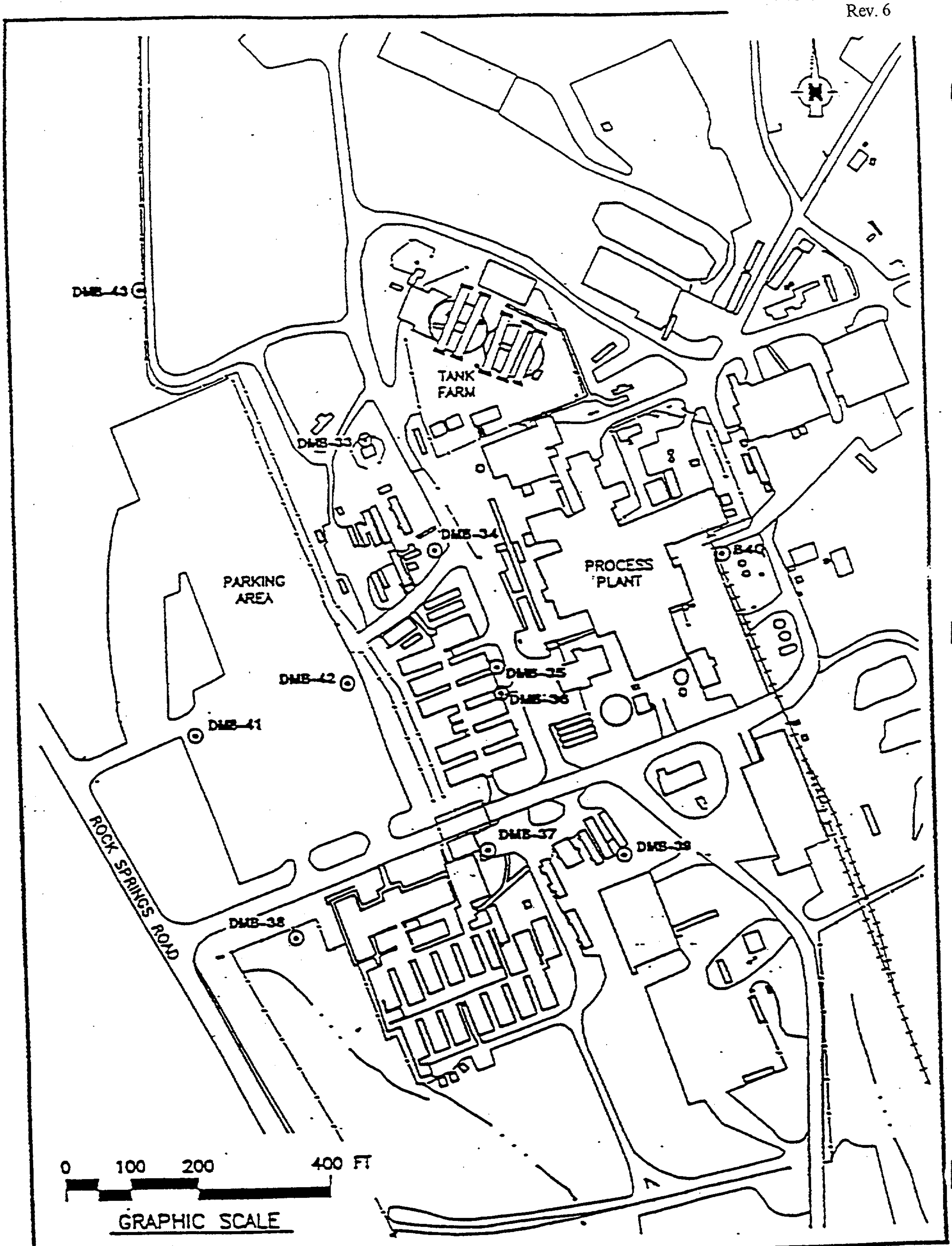


FIGURE A.3.6-20b Locations of Boreholes Indicated in FIGURE A.3.6-20a

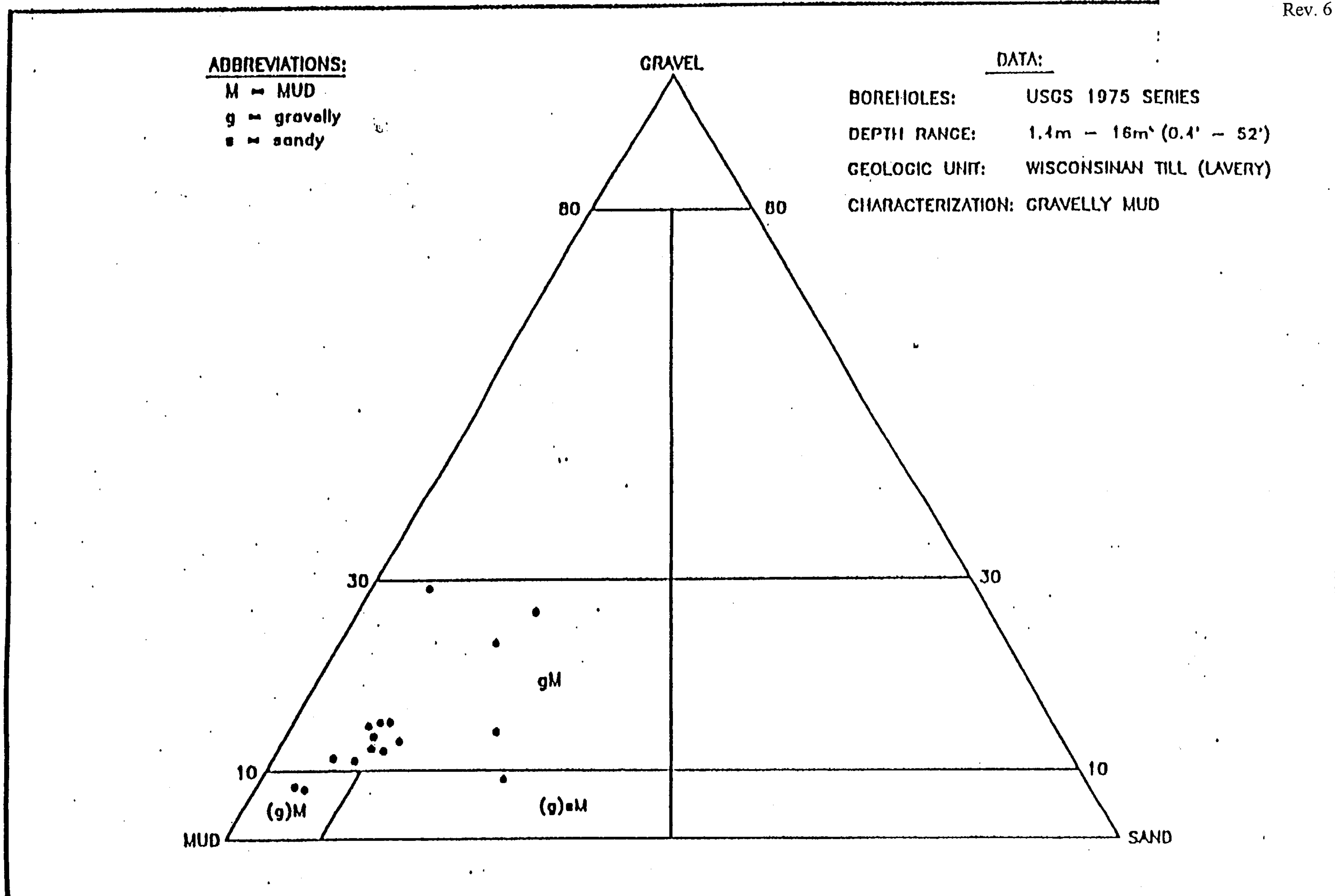


FIGURE A.3.6-21a Particle-Size Distribution-6

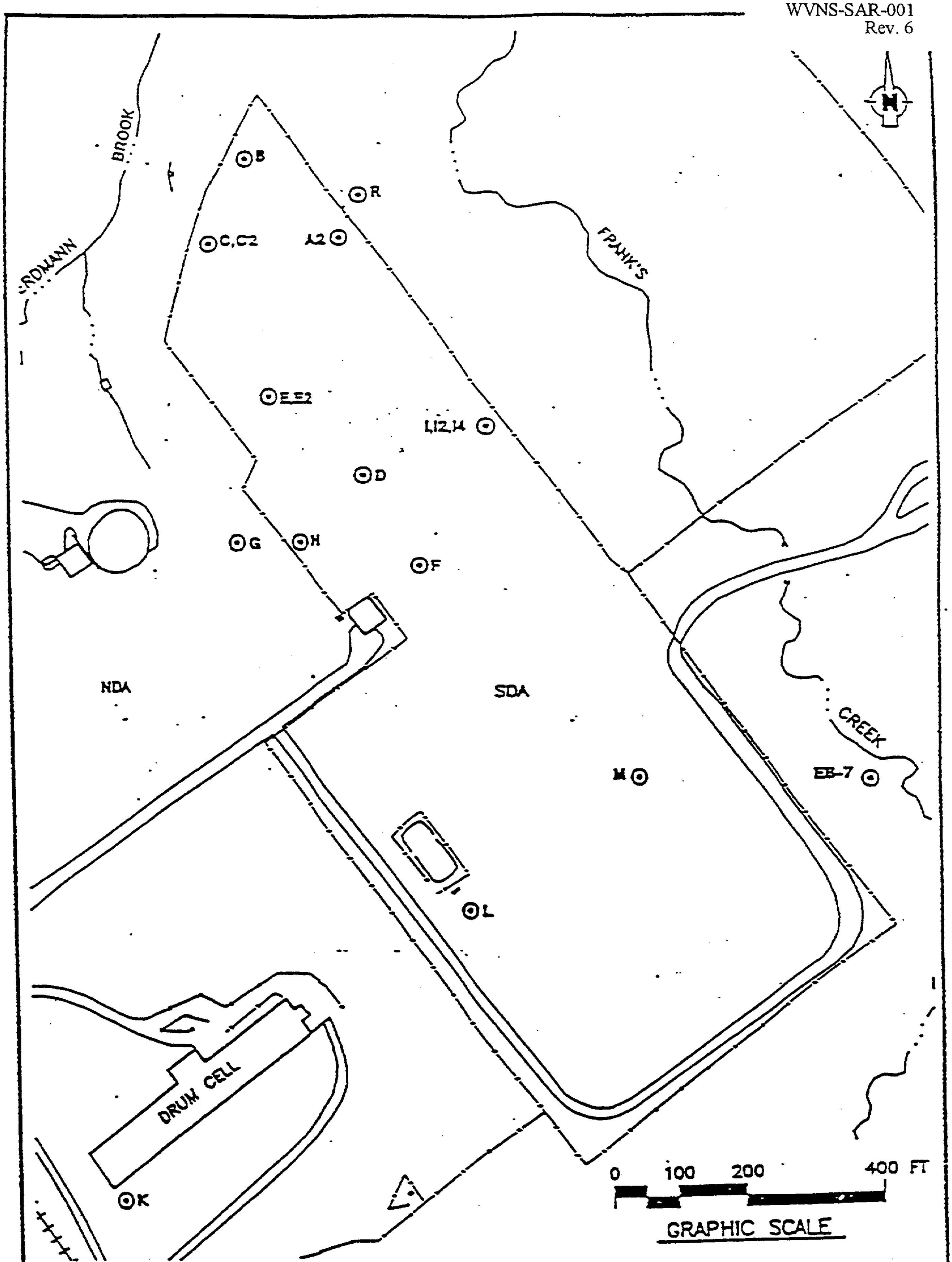


FIGURE A.3.6-21b Locations of Boreholes Indicated in FIGURE A.3.6-21a

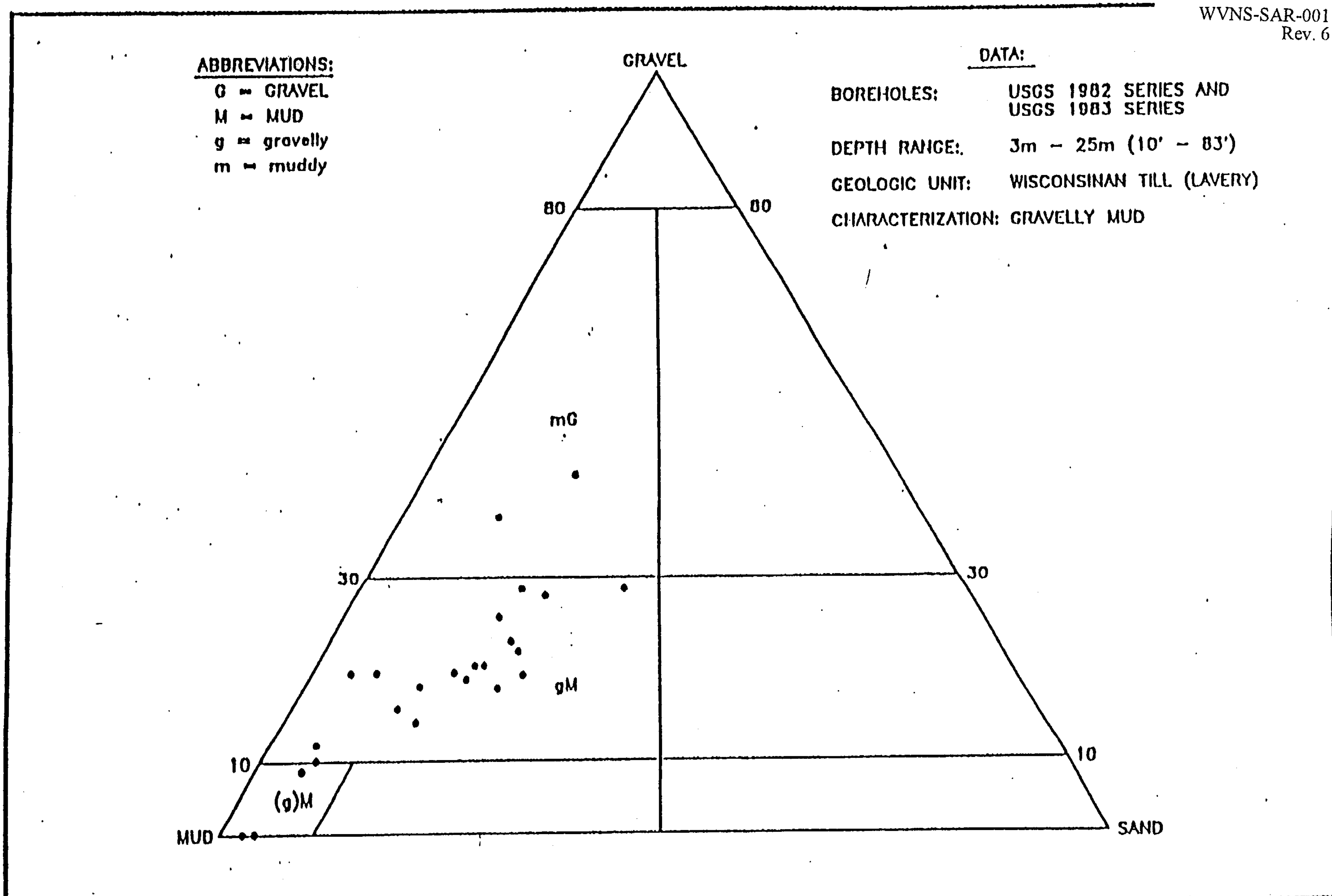


FIGURE A.3.6-22a Particle-Size Distribution-7

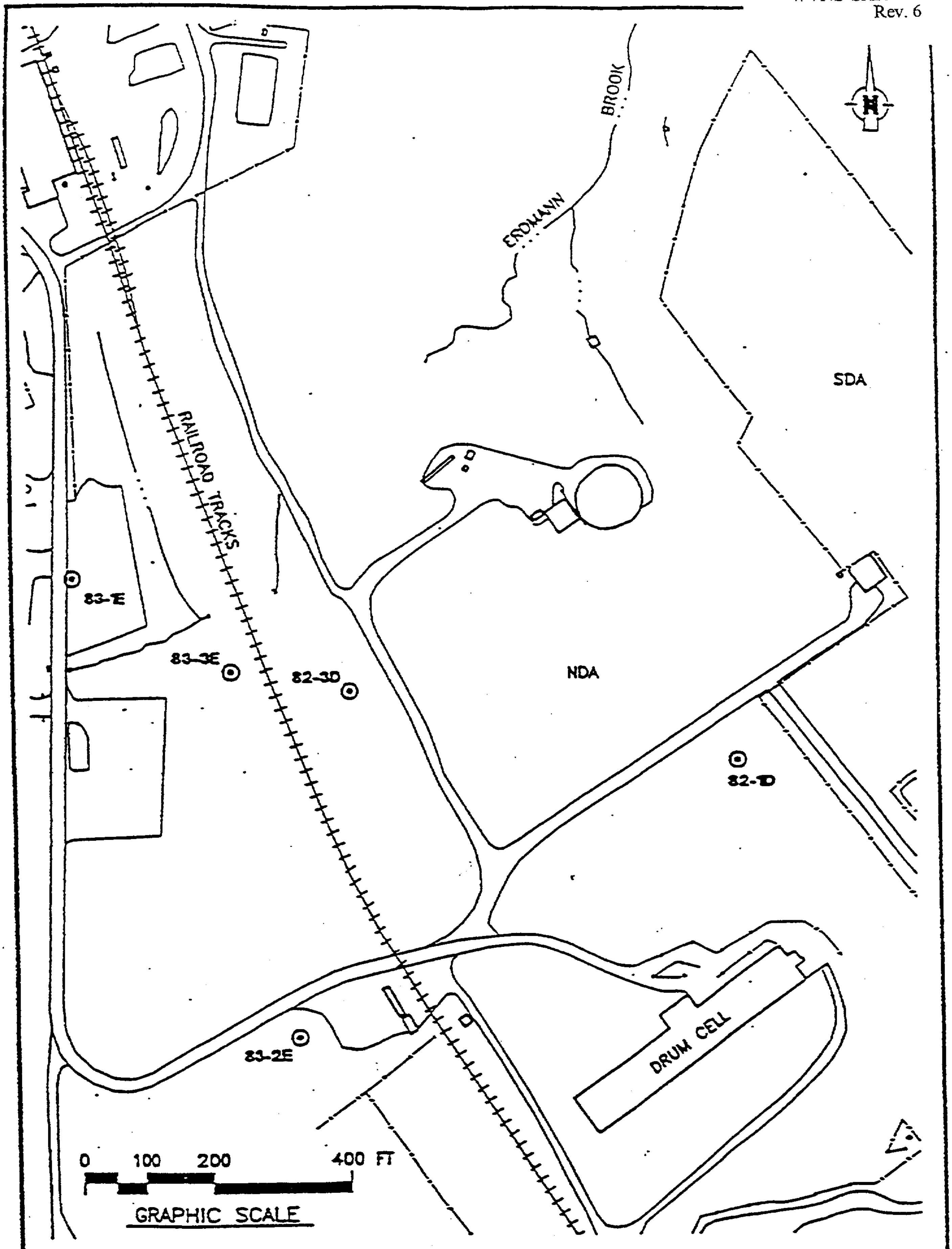


FIGURE A.3.6-22b Locations of Boreholes Indicated in FIGURE A.3.6-22a

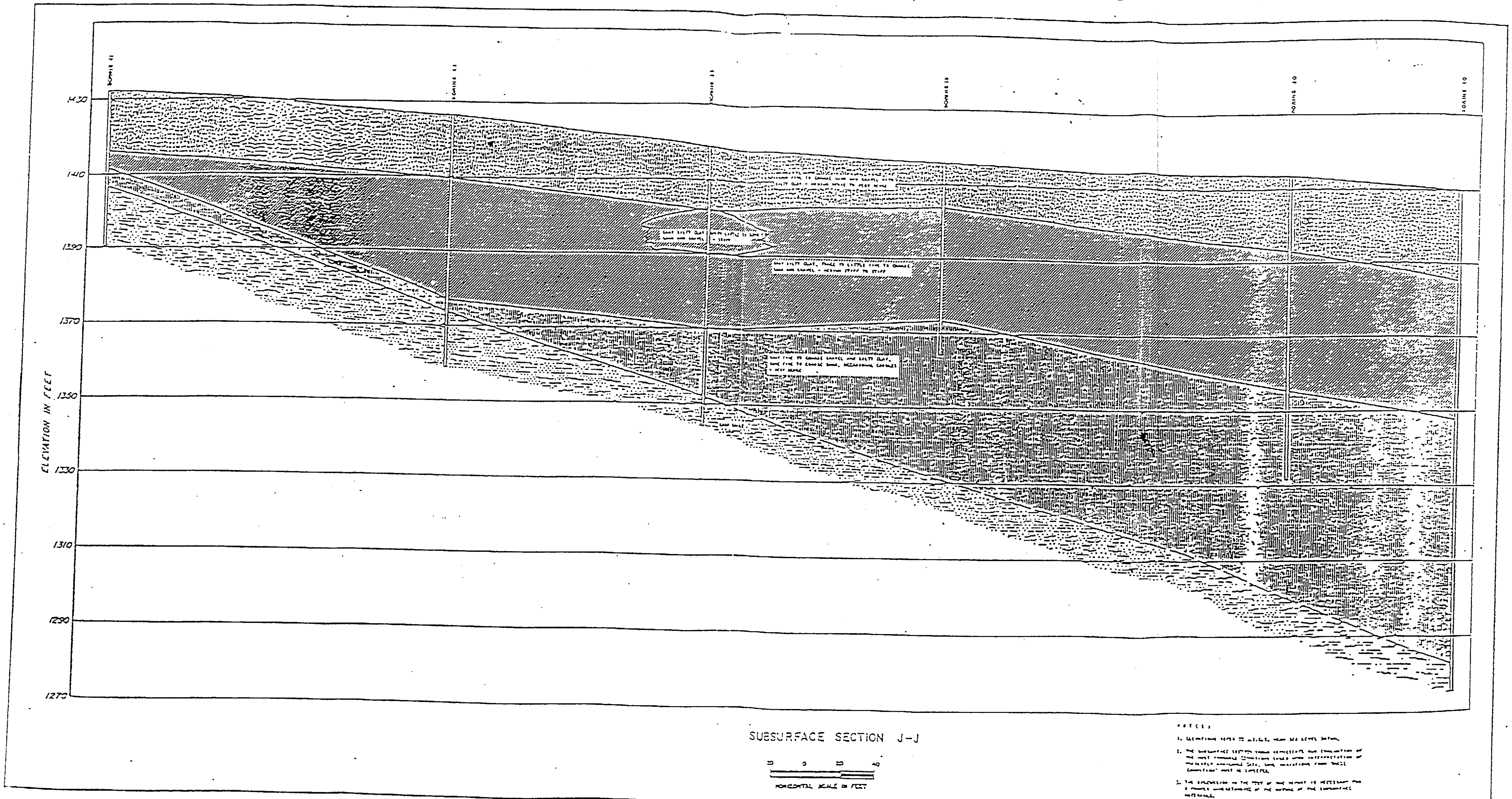
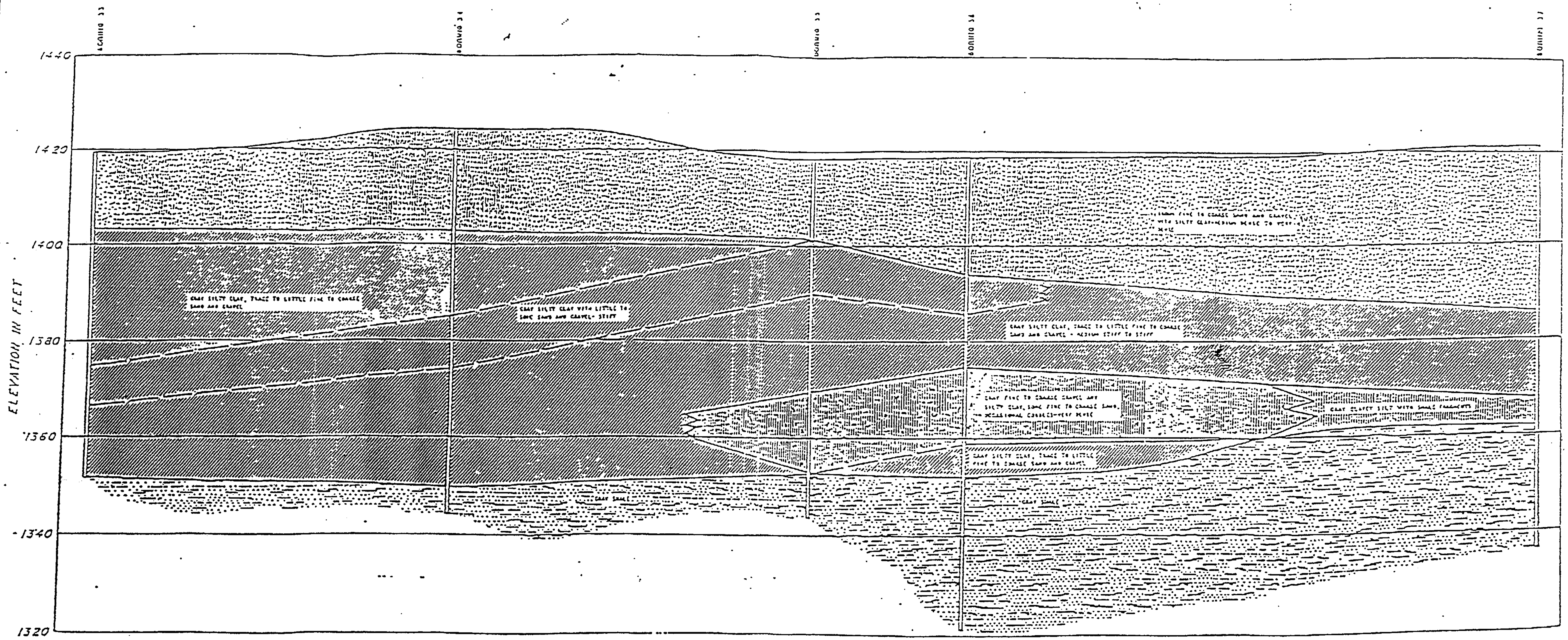


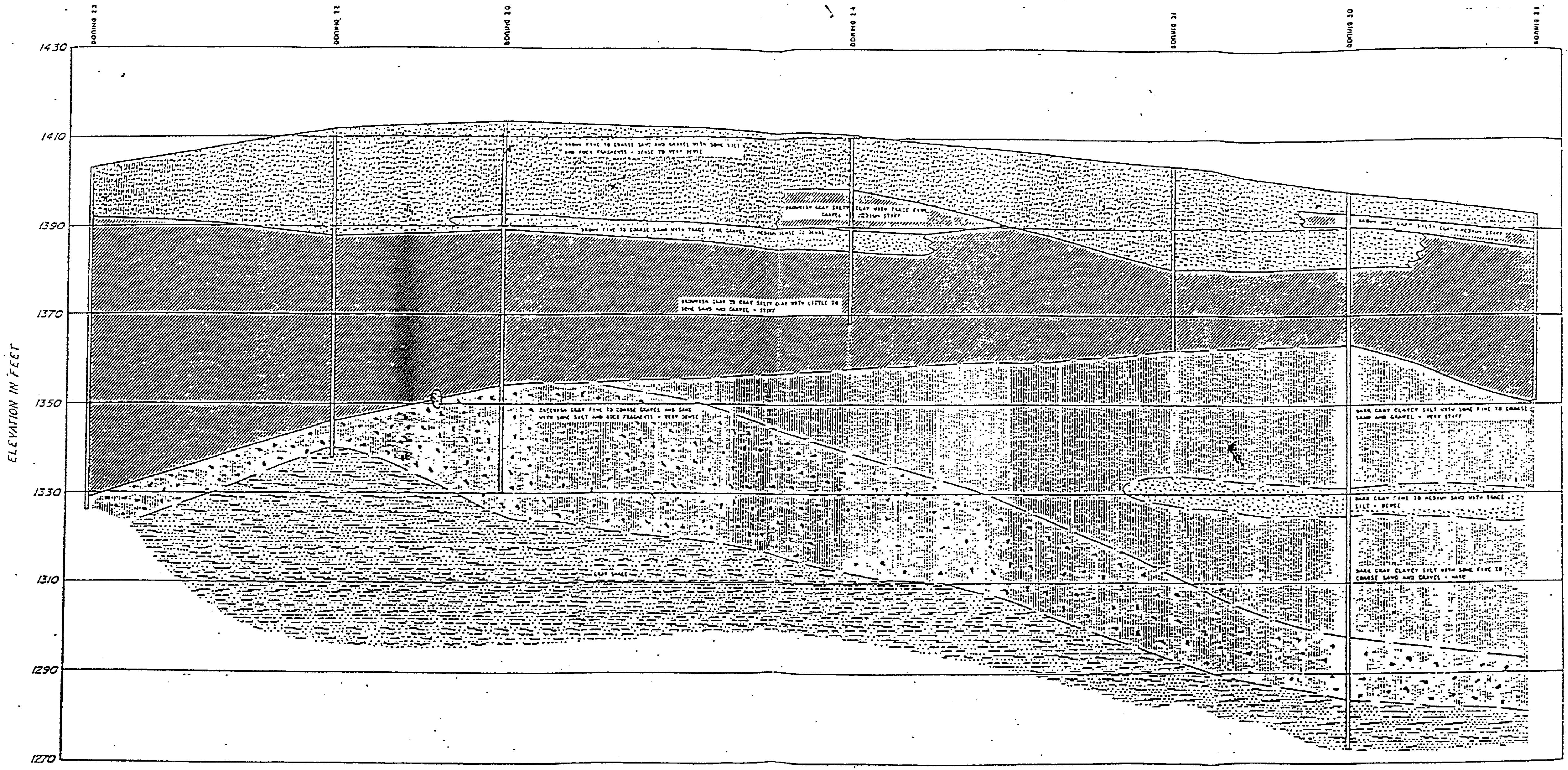
FIGURE A.3.6-23



SUBSURFACE SECTION K-K

HORIZONTAL SCALE IN FEET

FIGURE A.3.6-24



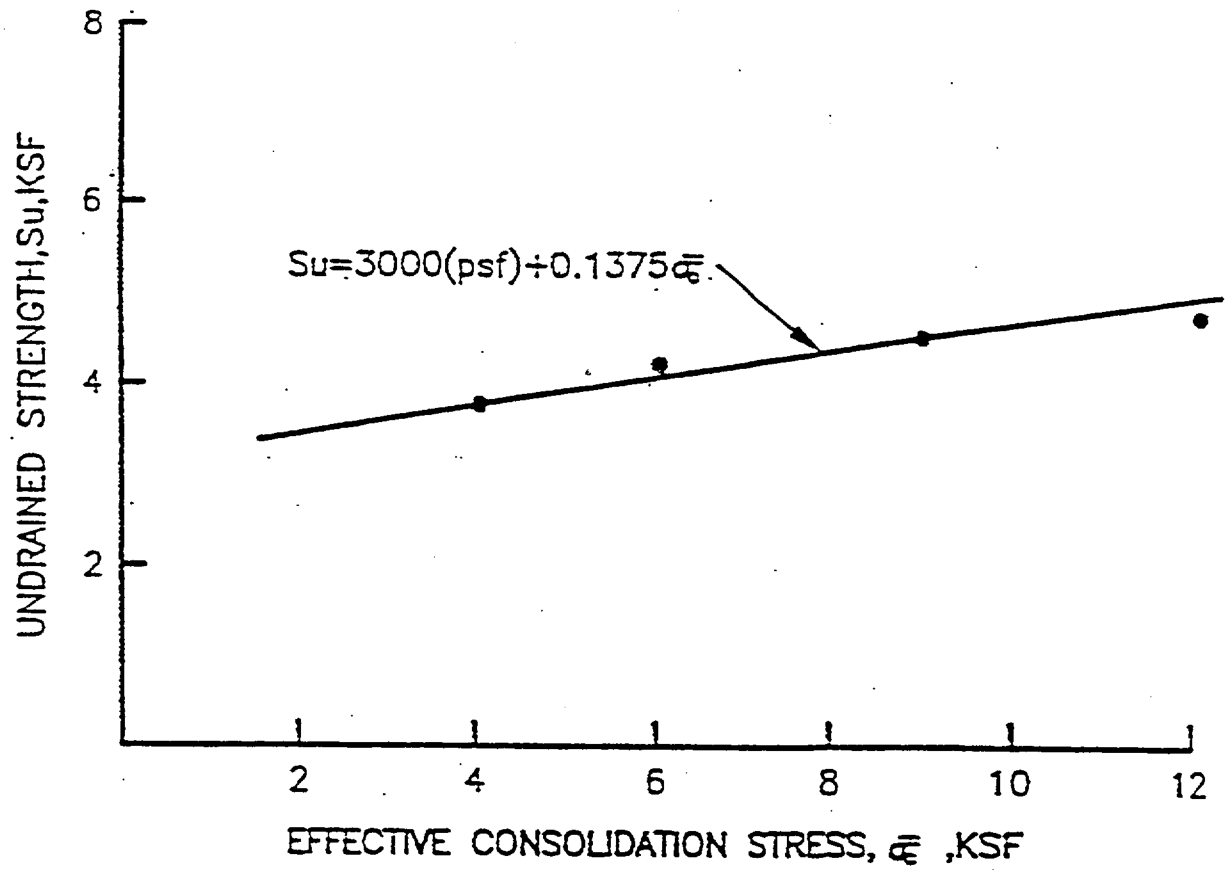
SUBSURFACE SECTION L-L

40 0 40 80
HORIZONTAL SCALE IN FEET

NOTES:

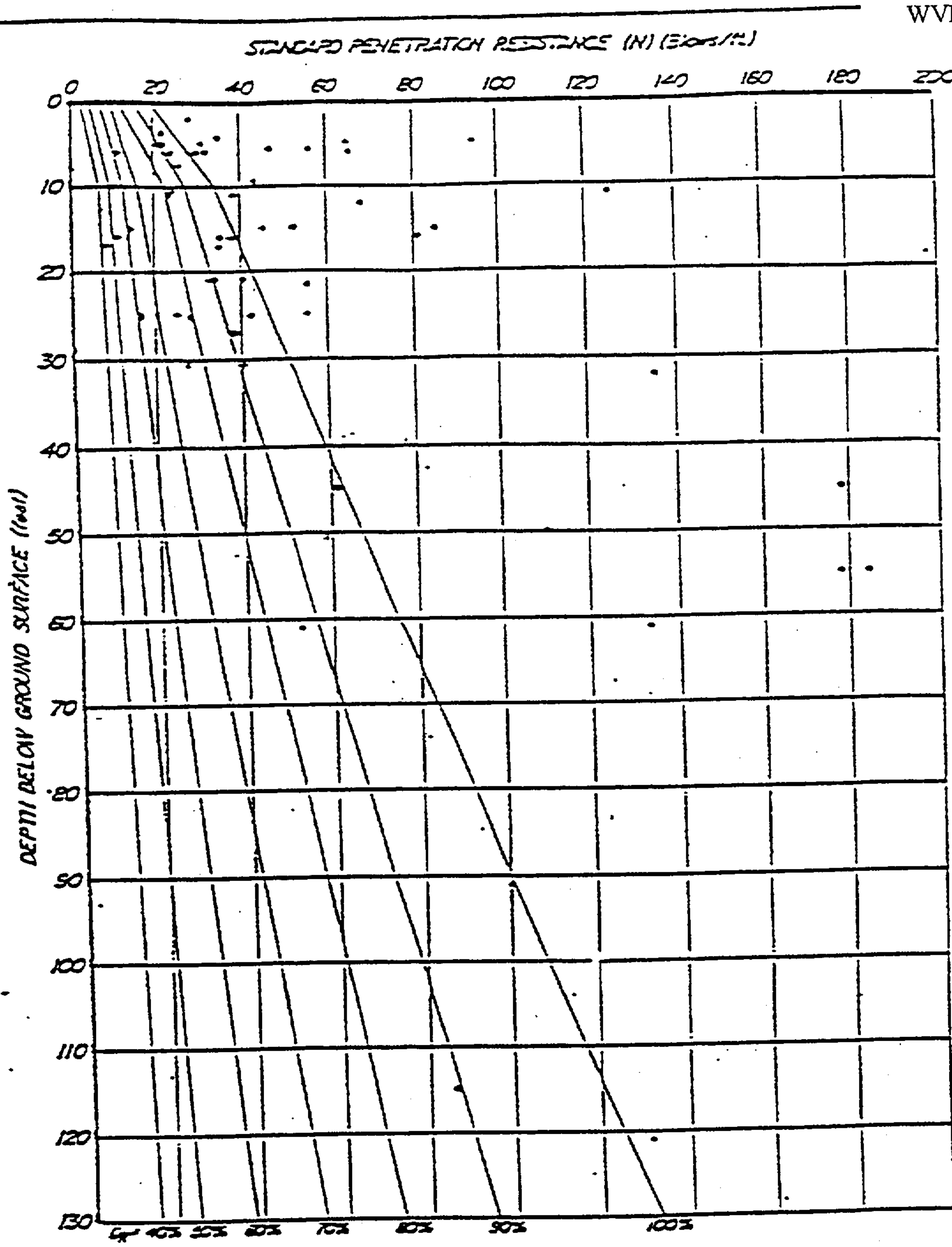
1. ELEVATIONS REFER TO U.S.G.S. MEAN SEA LEVEL DATUM.
2. THE SUBSURFACE SECTION SHOWN REPRESENTS OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3. THE DISCUSSION IN THE TEXT OF THE REPORT IS NECESSARY FOR A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

FIGURE A.3.6-25



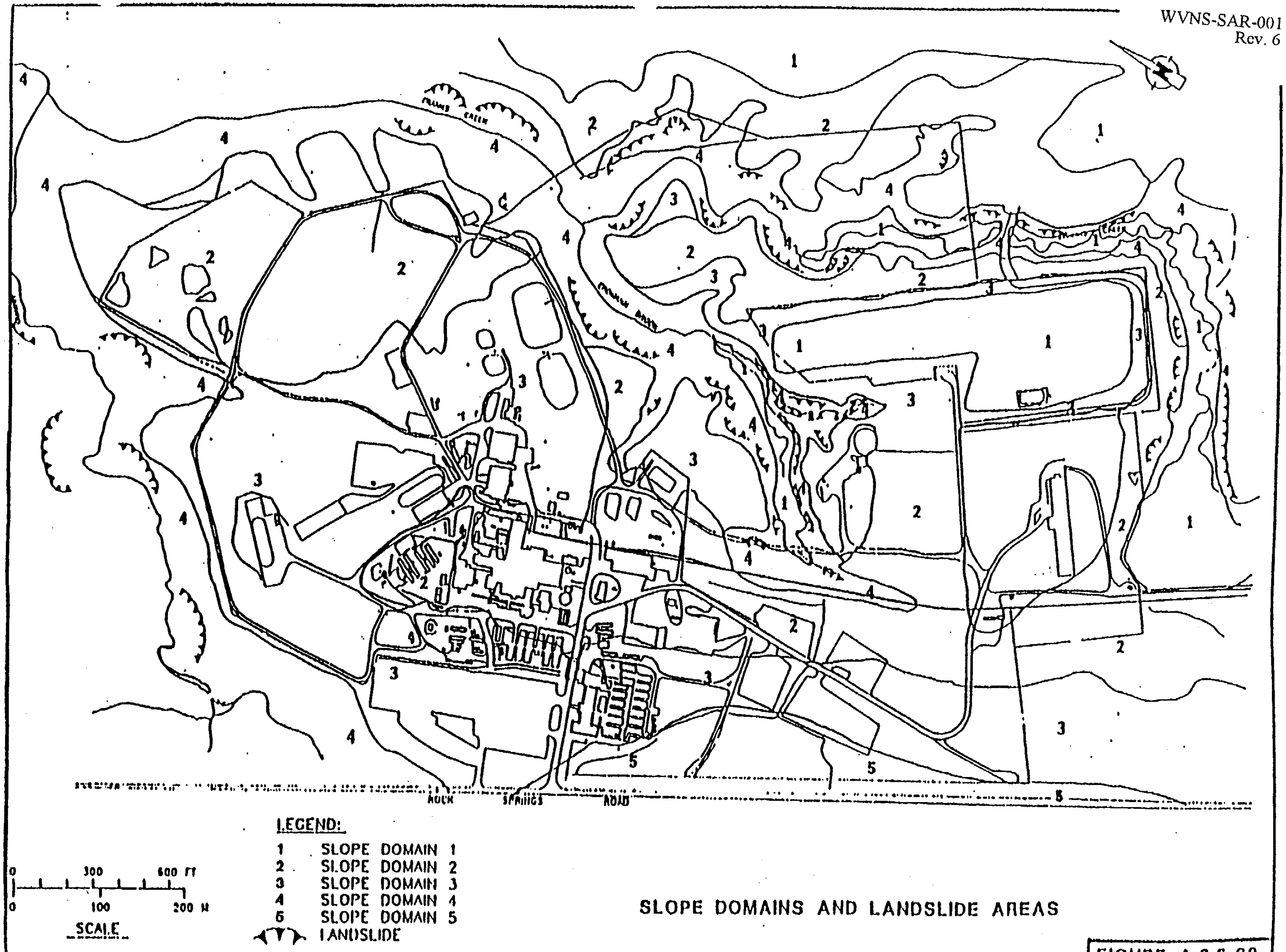
CONFINING STRESS VERSUS
UNDRAINED SHEAR STRENGTH
CIU TESTS – CL SOILS

FIGURE A.3.6-26



CORRELATION BETWEEN RELATIVE DENSITY AND STANDARD PENETRATION RESISTANCE

FIGURE A.3.6-27



SLOPE DOMAINS AND LANDSLIDE AREAS

FIGURE A.3.6-28

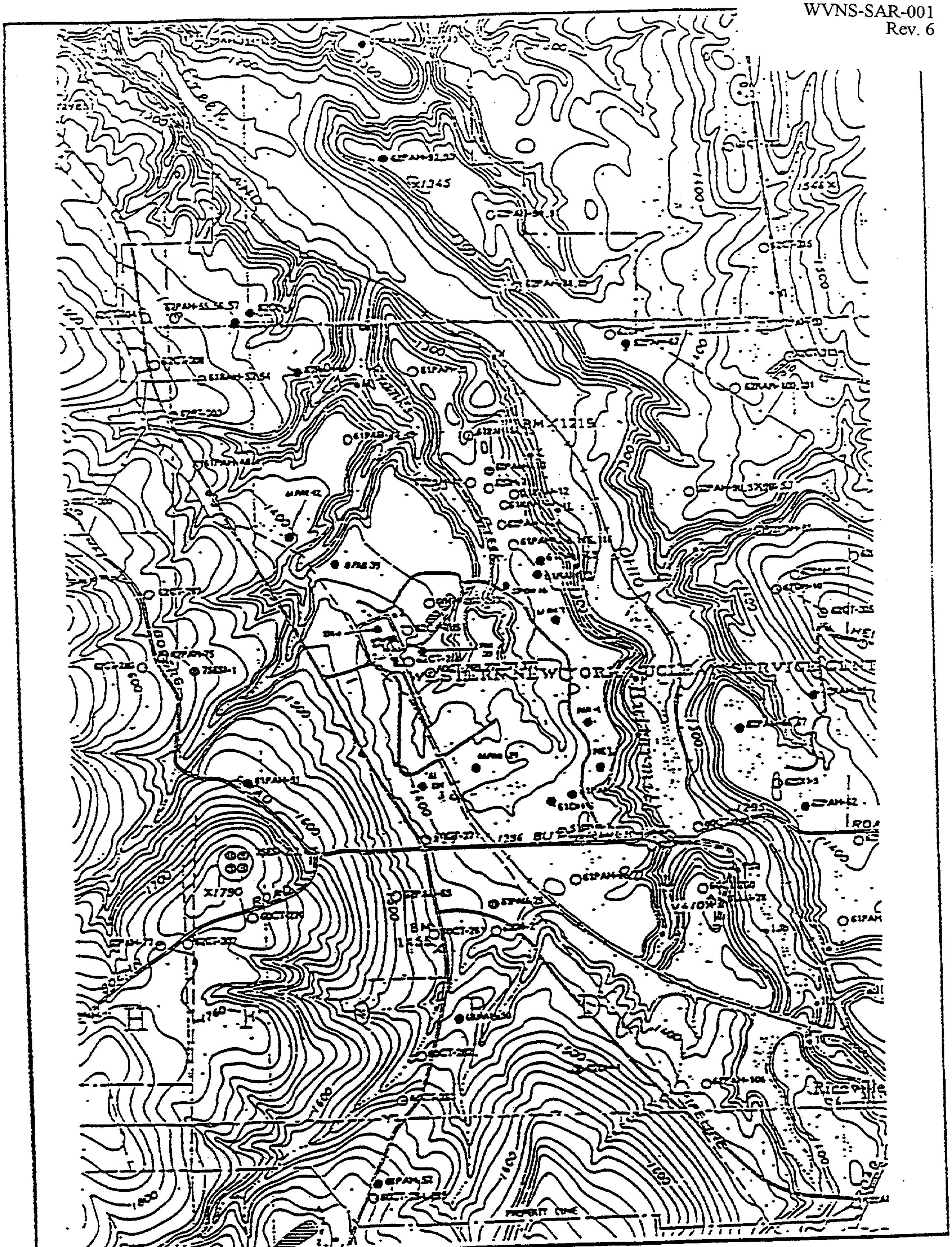


FIGURE A.3.6-29 Locations of Boreholes Listed in Tables A.3.6-7, -8, and -14

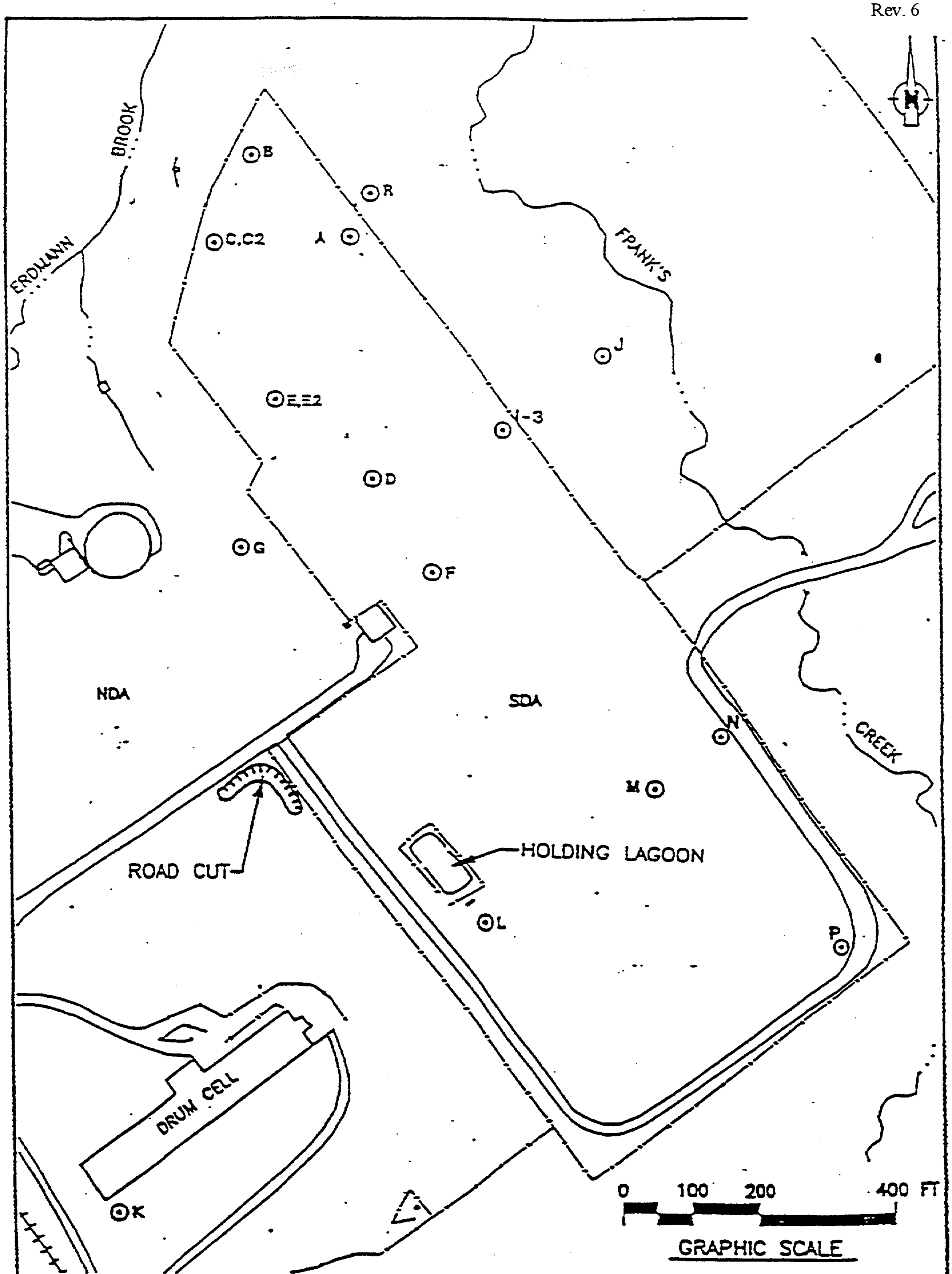
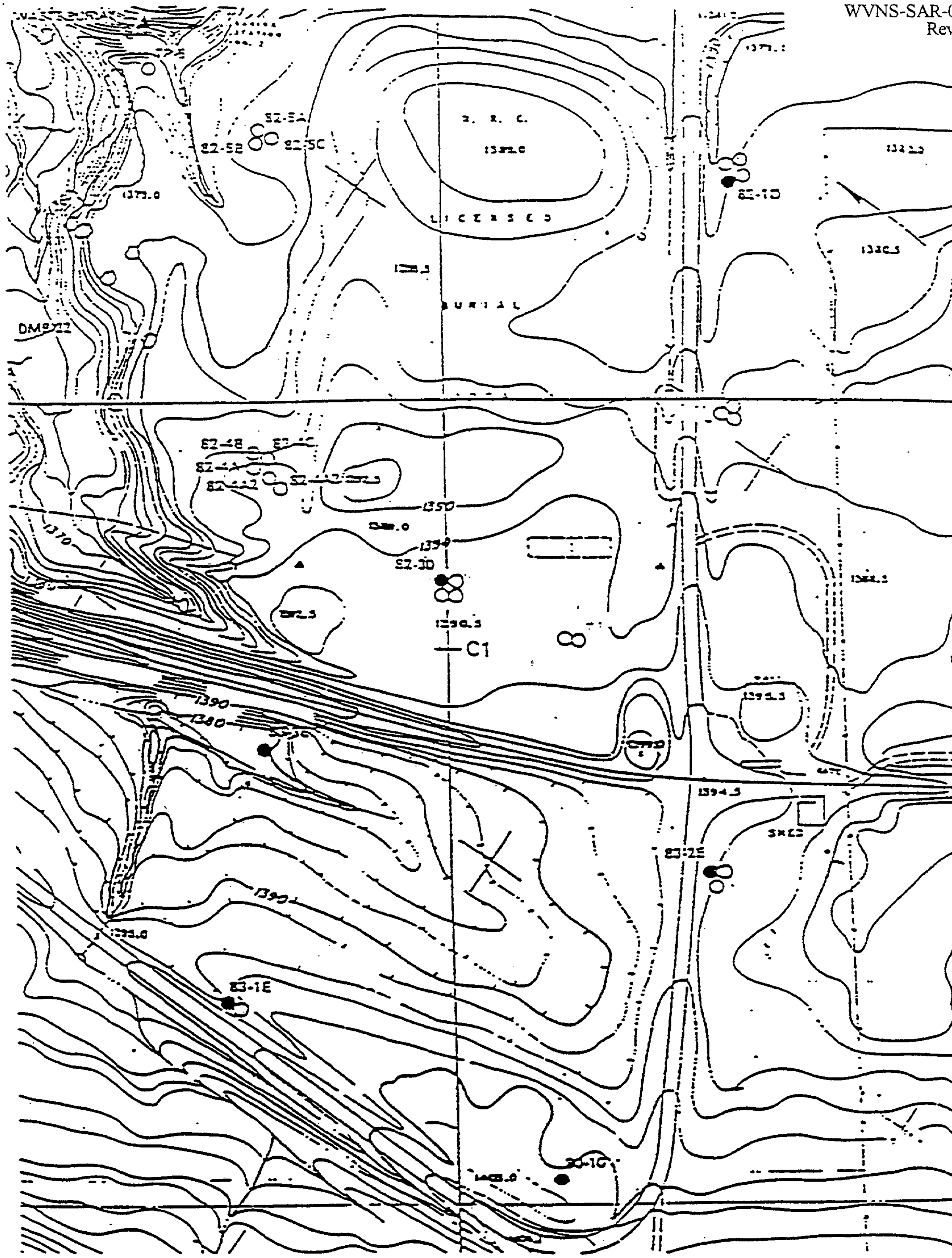
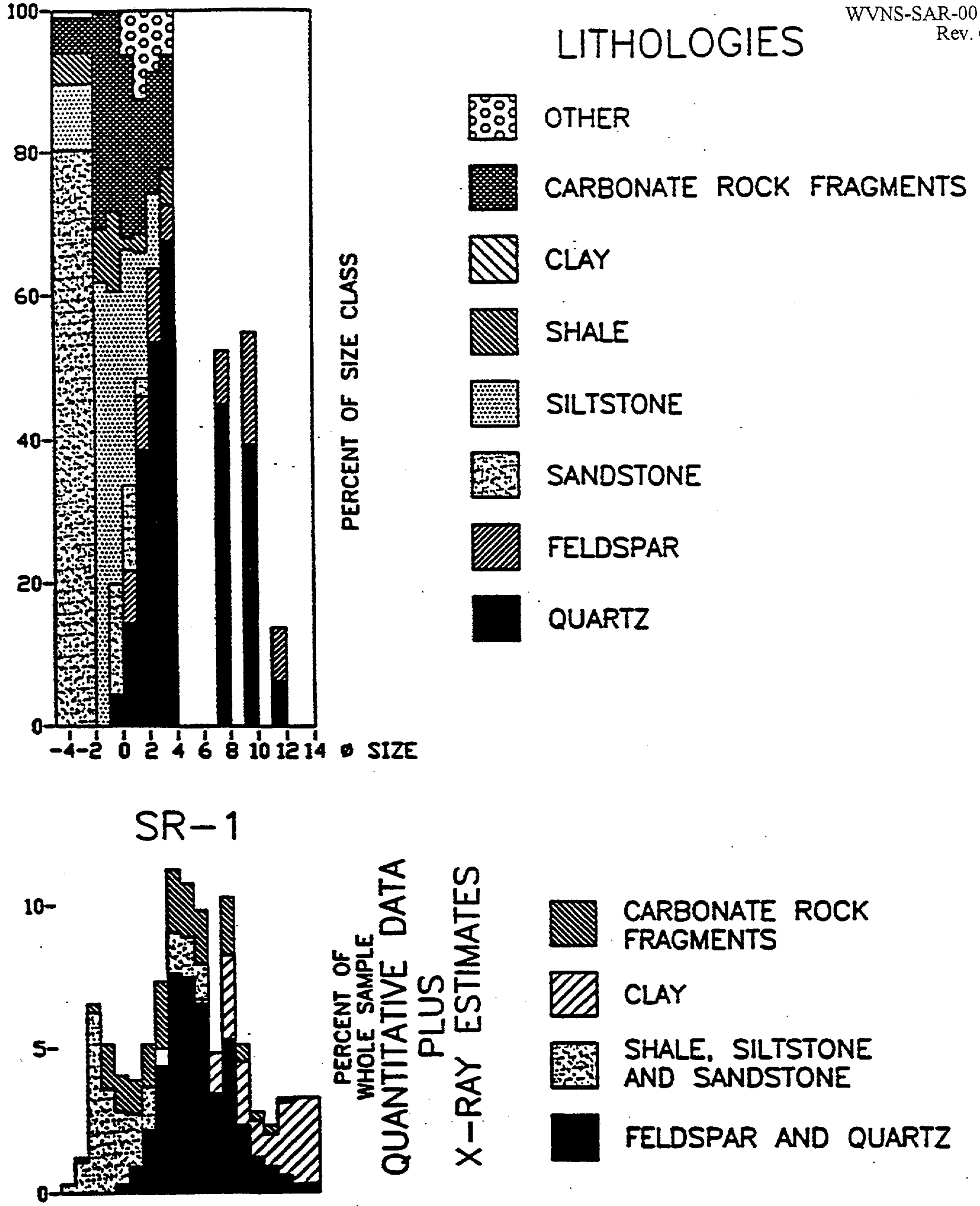


FIGURE A.3.6-30 Sampling Locations Listed in Tables A.3.6-9,-10,-11,-24, and -25



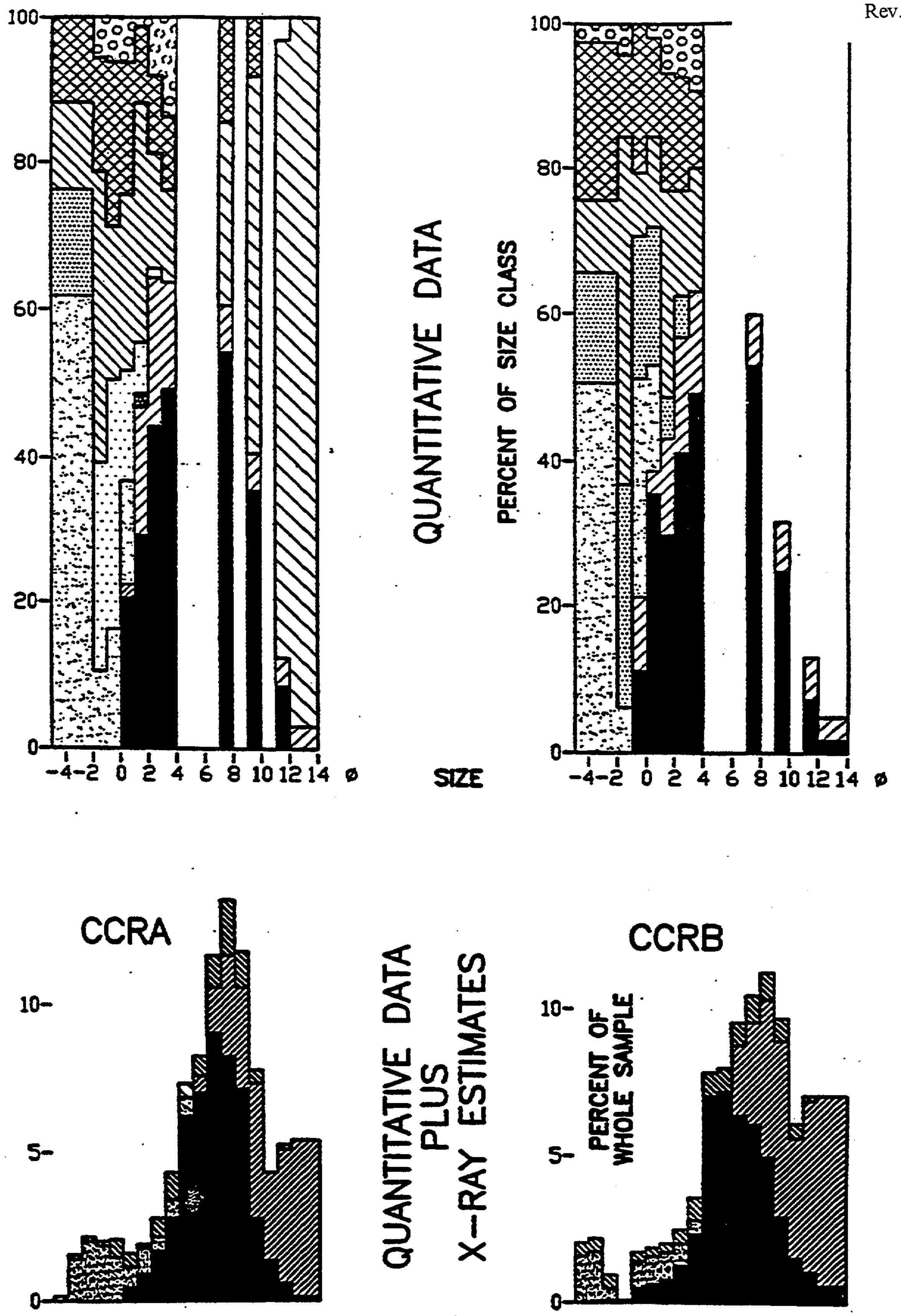
LOCATIONS OF BOREHOLES LISTED IN TABLE A.3.6-15

FIGURE A.3.6-31



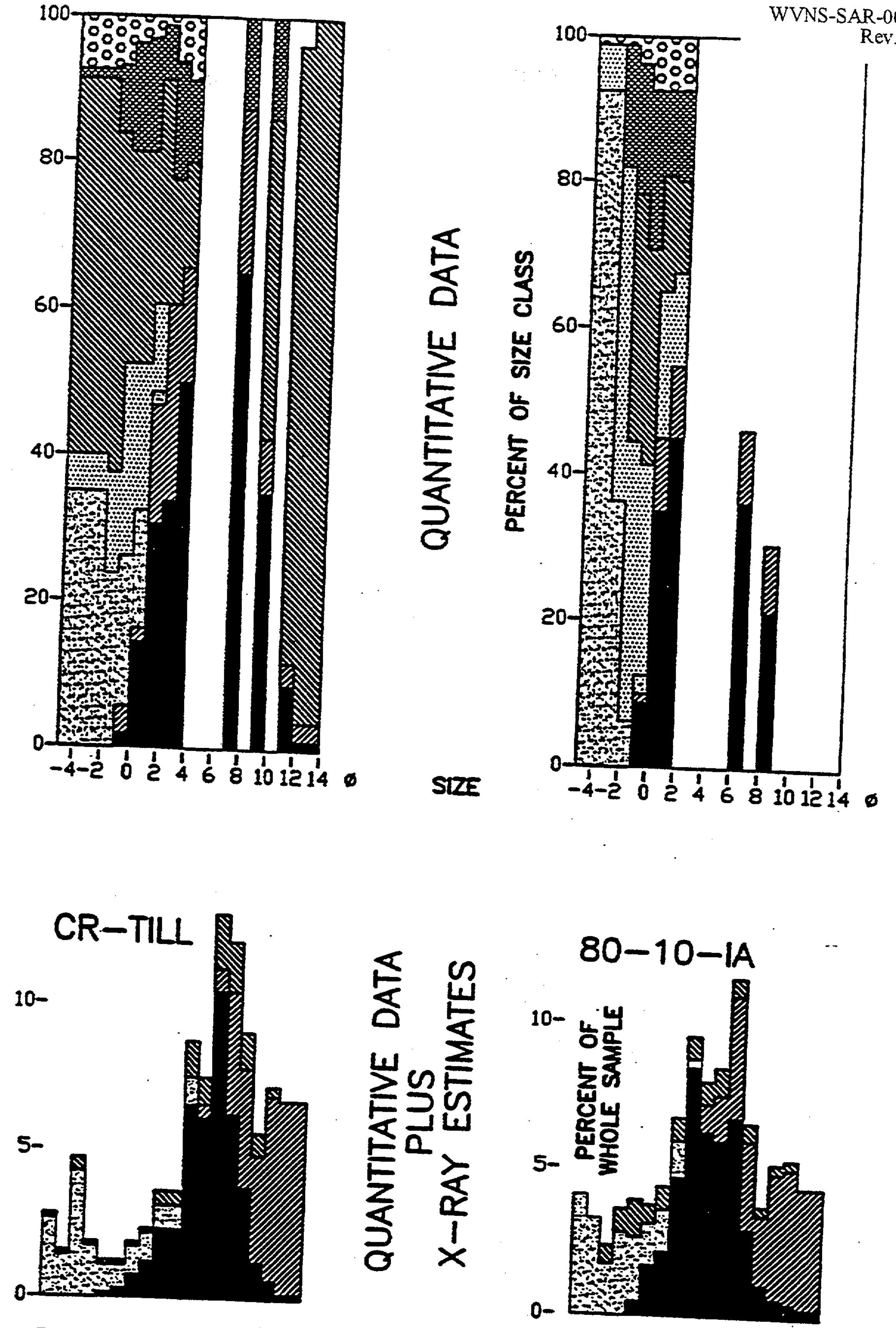
BAR GRAPHS SHOWING COMPONENTS AS A PERCENT OF EACH GRAIN SIZE CLASS (ABOVE) AND AS A PERCENT OF THE WHOLE SAMPLE (BELOW). SR-1 IS A SAMPLE OF KENT TILL, CCRA, CCRB, CR-TILL, AND 80-10-IA ARE ALL SAMPLES OF LAVERY TILL.

Figure A.3.6-32



BAR GRAPHS SHOWING COMPONENTS AS A PERCENT OF EACH GRAIN SIZE CLASS (ABOVE), AND AS A PERCENT OF THE WHOLE SAMPLE (BELOW).

Figure A.3.6-33



BAR GRAPHS SHOWING COMPONENTS AS A PERCENT OF EACH GRAIN SIZE CLASS (ABOVE) AND AS A PERCENT OF THE WHOLE SAMPLE (BELOW).

Figure A.3.6-34

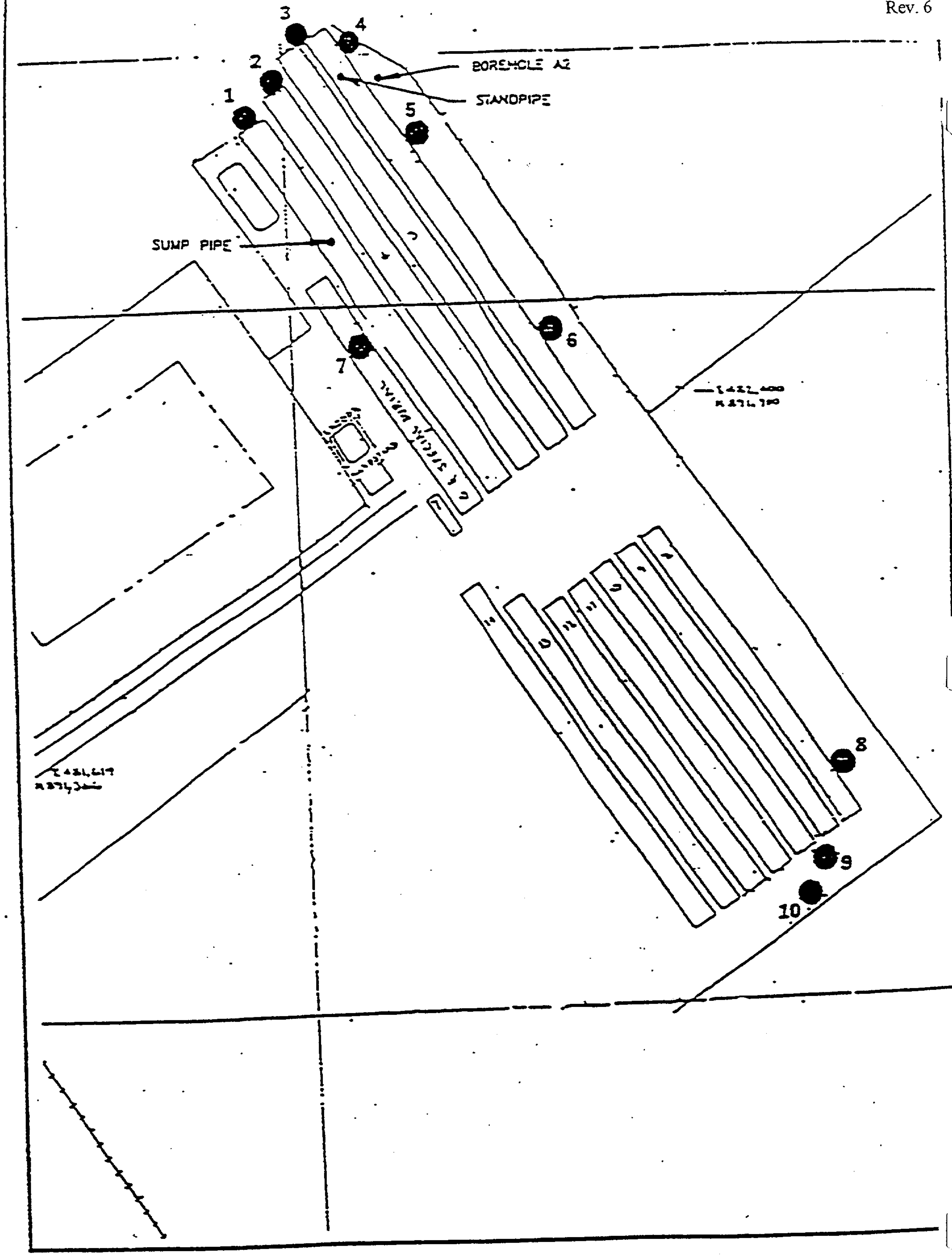
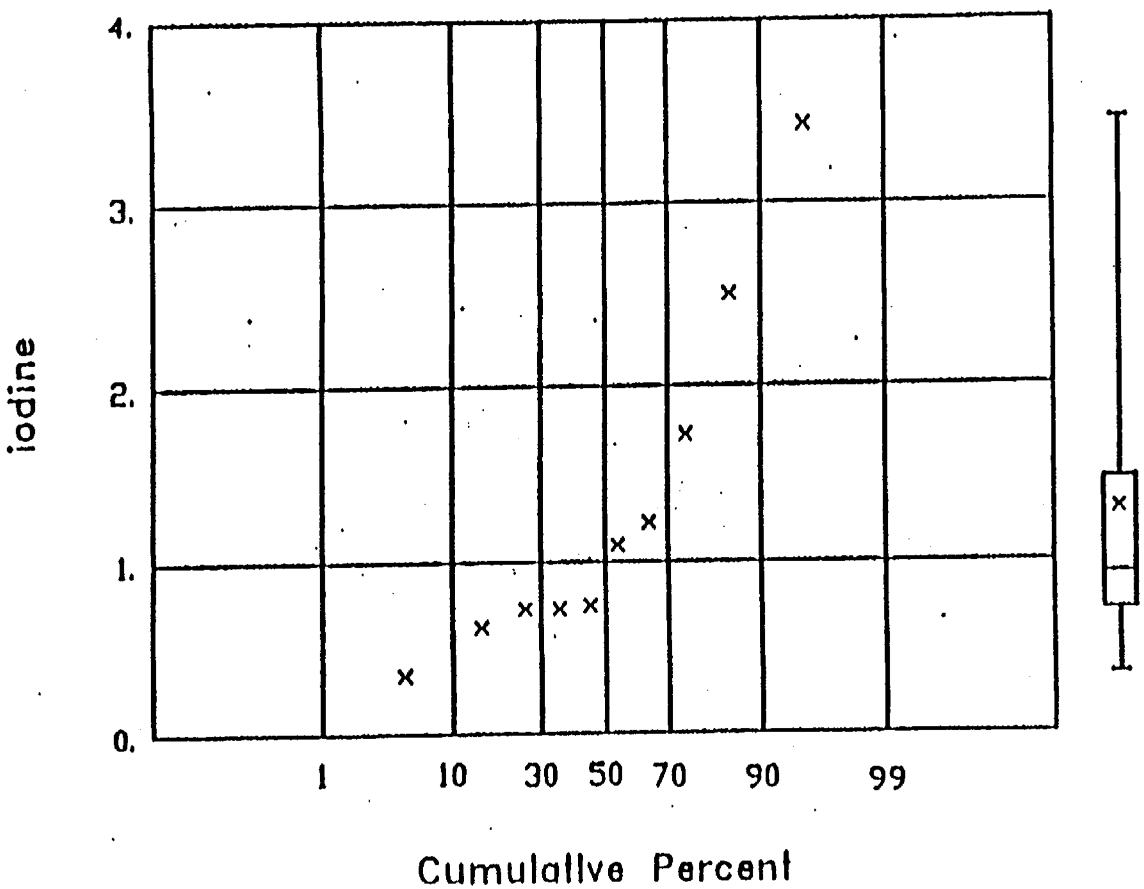


FIGURE A.3.6-35 Locations of Boreholes 1 Through 10 at the SDA

Normal Probability Plot for Iodine
Data file: kd_iodin.dat



Statistics

N Total	:	10
N Miss	:	0
N Used	:	10
Mean	:	1.313
Variance	:	.938
Std. Dev.	:	.968
% C.V.	:	73.736
Skewness	:	1.182
Kurtosis	:	3.189
Minimum	:	.355
25th %	:	.681
Median	:	.921
75th %	:	1.472
Maximum	:	3.409

NORMAL PROBABILITY PLOT FOR I-129 DATA
CONTAINED IN TABLE A.3.6-20 AND -22

FIGURE A.3.6-30

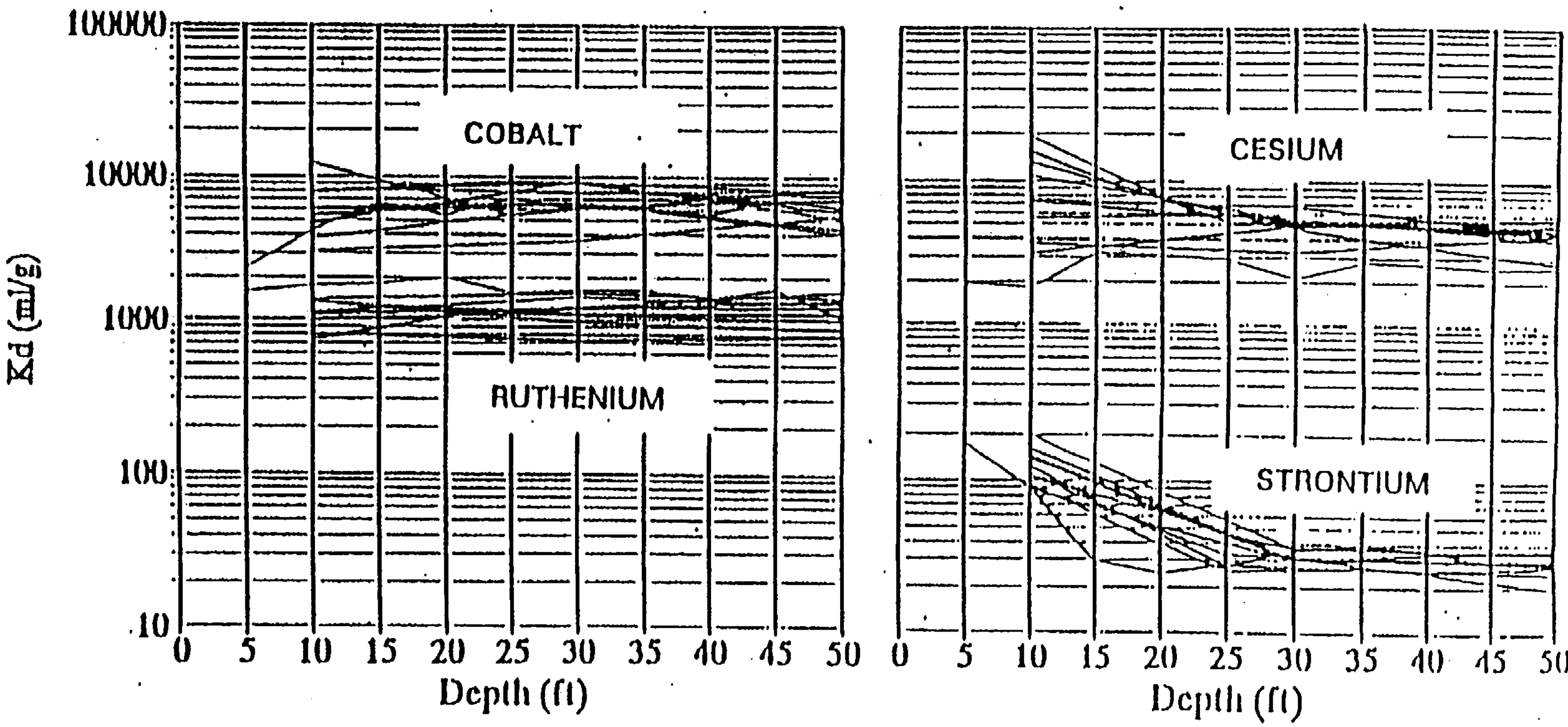
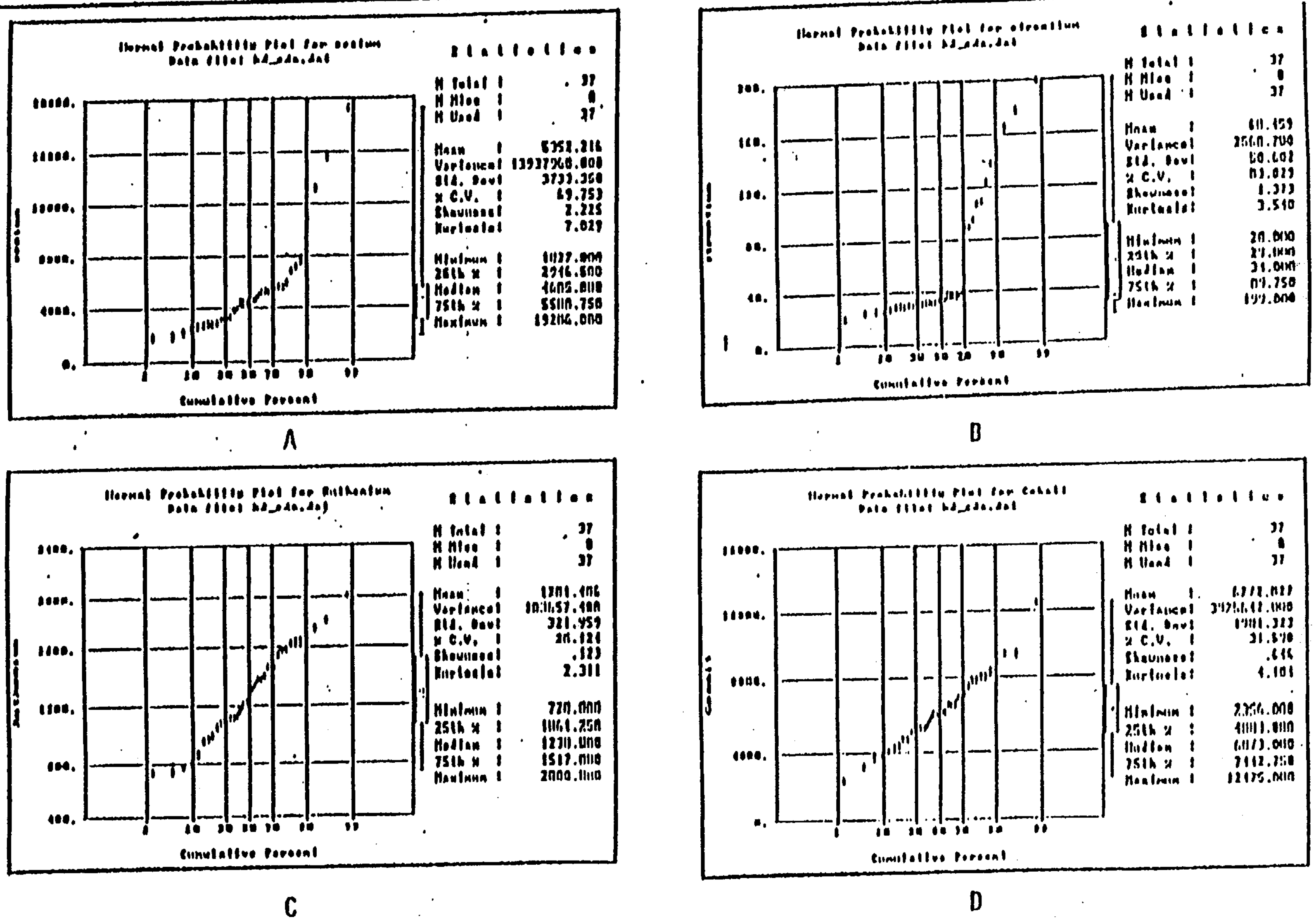


Figure A.3.6-37 VARIATION WITH DEPTH IN DISTRIBUTION COEFFICIENTS OF Cs-137, Sr-85, Ru-106, AND Co-60



NORMAL PROBABILITY PLOTS OF THE DATA
CONTAINED IN TABLE A.3.8-20

FIGURE A.3.8-38