ORNL/TM-10965

ornl

OAK RIDGE
NATIONAL
LABORATORY

MARTIN MARIETTA

Site Characterization Report for the Proposed Transuranic Waste Handling and Packaging Plant

Oak Ridge National Laboratory
Oak Ridge, Tennessee

A. W. Campbell
G. F. Cada
R. H. Ketelle
R. L. Kroodsma
R. R. Lee
L. R. Pounds

OAK RIDGE NATIONAL LABORATORY
CENTRAL RESEARCH LIBRARY
CIRCULATION SECTION
4500N ROOM 175
LIBRARY LOAN COPY
DO NOT TRANSFER TO ANOTHER PERSON
If you wish someone else to see this report, send in name with report and the library will arrange a loan.
UCN-7969 (3 9-77)

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy: A07; Microfiche A01

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Energy Division

SITE CHARACTERIZATION REPORT FOR THE PROPOSED TRANSURANIC WASTE HANDLING AND PACKAGING PLANT

OAK RIDGE NATIONAL LABORATORY
OAK RIDGE, TENNESSEE

A. W. Campbell
G. F. Cada*
R. H. Ketelle
R. L. Kroodsma*
R. R. Lee
L. R. Pounds**

*Environmental Sciences Division
**Department of Ecology, The University of Tennessee

Date Published—March 1989

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES

3 4456 0299295 6

CONTENTS

Page

LIST OF FIGURES v

LIST OF TABLES vii

ACRONYMS AND ABBREVIATIONS ix

SUMMARY xi

1. INTRODUCTION 1
   1.1 BACKGROUND OF DOE TRU WASTE MANAGEMENT 1
   1.2 PURPOSE AND SCOPE OF THIS REPORT 2

2. PROJECT DESCRIPTION 3
   2.1 WASTE HANDLING AND PACKAGING PLANT (WHPP) 3
      2.1.1 Work-Off of Stored RH TRU Waste 7
         2.1.1.1 Hot-cell waste 7
         2.1.1.2 RH TRU liquids and sludges 7
      2.1.2 Processing of Newly Generated RH TRU Solid Waste 8
      2.1.3 Schedule for RH TRU Waste Disposal 8
   2.2 WHPP SITE SELECTION PROCESS 8

3. SITE CHARACTERISTICS 15
   3.1 GEOGRAPHY AND DEMOGRAPHY 15
      3.1.1 Site Location 15
      3.1.2 Population 15
      3.1.3 Transportation System 19
      3.1.4 Cultural Resources 19
   3.2 METEOROLOGY AND AIR QUALITY 21
   3.3 GEOLOGY 21
      3.3.1 Topography 21
      3.3.2 Stratigraphy 22
      3.3.3 Structure 22
      3.3.4 White Oak Creek Fault 25
         3.3.4.1 Existing data 25
         3.3.4.2 Investigation approach 26
         3.3.4.3 Data acquisition 26
         3.3.4.4 Data analysis 29
         3.3.4.5 Conclusion 33
      3.3.5 Seismicity 34
      3.3.6 Soils 35

CONTENTS (continued)

3.4 WATER RESOURCES 35
3.4.1 Surface Water 35
3.4.1.1 Hydrology 35
3.4.1.2 Water quality 39
3.4.2 GROUNDWATER 39
3.4.2.1 Groundwater movement 40
3.4.2.2 Groundwater quality 46
3.5 ECOLOGY 46
3.5.1 Terrestrial Biota 46
3.5.1.1 Flora 46
3.5.1.2 Fauna 49
3.5.2 Aquatic Biota 50
3.5.2.1 Benthic invertebrates 51
3.5.2.2 Fish 51
3.5.2.3 Threatened/endangered aquatic species 52
3.6 AMBIENT RADIOLOGICAL CHARACTERISTICS 53
3.6.1 Natural Background 53
3.6.2 Man-Made Radioactive Pollutants 53

4. POTENTIAL ENVIRONMENTAL ISSUES 57
4.1 COMMUNITY RESOURCES 57
4.2 AIR QUALITY 57
4.3 GEOLOGY AND GEOHYDROLOGY 57
4.4 SURFACE WATER QUALITY AND AQUATIC ECOLOGY 58
4.4.1 Construction 58
4.4.2 Operations 58
4.5 TERRESTRIAL ECOLOGY 59
4.6 RADIATION 59

5. REFERENCES 63

Appendix A. ARCHAEOLOGICAL SURVEY OF TWO PARTIALLY STANDING STRUCTURES ON THE OAK RIDGE RESERVATION A-1

LIST OF FIGURES

Figure		Page
1	Projected sources of non-Oak Ridge National Laboratory uncertified remotely handled transuranic wastes for Waste Handling and Packaging Plant processing	4
2	Functional areas of the proposed Waste Handling and Packaging Plant	6
3	Waste Handling and Packaging Plant project schedule	9
4	Sites evaluated for location of the proposed Waste Handling and Packaging Plant at Oak Ridge National Laboratory	12
5	Location of the preferred site for the Waste Handling and Packaging Plant at Oak Ridge National Laboratory on the Oak Ridge Reservation	14
6	The Oak Ridge Reservation is located in East Tennessee between the Cumberland Mountains and the Great Smoky Mountains National Park, about midway between the Kentucky and Georgia borders	16
7	The Oak Ridge Reservation encompasses three major U. S. Department of Energy facilities (Oak Ridge Gaseous Diffusion Plant, Oak Ridge National Laboratory, and the Y-12 Plant)	17
8	Population density within 50-mile radius of the Oak Ridge Reservation	18
9	Primary highways serving the U.S. Department of Energy Oak Ridge Reservation	20
10	Geologic map of the Oak Ridge National Laboratory area	23
11	Borehole geophysical logs and a generalized lithologic log representative of bedrock formations beneath Melton Valley	24
12	White Oak Creek Fault geologic study map for the WHPP	27

LIST OF FIGURES (continued)

Figure		Page
13	Summary WHPP site geologic study stereograms	28
14	Structure contour map of the Rogersville/Maryville contact. (Hachuring - WHPP site)	31
15	Structure contour map of the Maryville/Nolichucky contact. (Hachuring - WHPP site)	32
16	White Oak Creek drainage basin and a portion of the Clinch River	36
17	Mean weekly stream flow in Melton Branch near MEK 1.9 and near MEK 0.16, and mean weekly stream flow in White Oak Creek near WCK 2.65	38
18	White Oak Creek watershed piezometer locations	41
19	White Oak Creek floodplain water table configuration, May 1987	43
20	Hydrograph for piezometer pair 782 and 783	44
21	Hydrograph for piezometer pair 784 and 785	45
22	Topographic map of the proposed Waste Handling and Packaging Plant site	48

LIST OF TABLES

Table		Page
1	Proposed Waste Handling and Packaging Plant remotely handled transuranic waste acceptance criteria	5
2	Site selection criteria for the Waste Handling and Packaging Plant	11
3	Summary of aquifer characteristics at the Engineering Test Facility in Melton Valley	42
4	Groundwater constituent concentrations measured in shallow piezometer #782 on the White Oak Creek floodplain	47
5	Composite radiological impacts on the maximally exposed individual from nuclear facilities on the Oak Ridge Reservation	60
6	Composite radiological impacts on the surrounding population from nuclear facilities on the Oak Ridge Reservation	61

ACRONYMS AND ABBREVIATIONS

BMAP	Biological Monitoring and Abatement Program
CH	contact handled
DOE	U.S. Department of Energy
ETF	Engineering Test Facility
DTWP	Defense Transuranic Waste Program
EM	electromagnetic
GST	Gunite storage tanks
HFIR	High Flux Isotope Reactor
LLW	low-level waste
MMI	Modified Mercalli Intensity
MVST	Melton Valley storage tanks
NEPA	National Environmental Policy Act of 1969
NERP	National Environmental Research Park
NPDES	National Pollutant Discharge Elimination System
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
RH	remotely handled
SC	special case
TRU	transuranic
TVA	Tennessee Valley Authority
WAC	waste acceptance criteria
WHPP	Waste Handling and Packaging Plant
WIPP	Waste Isolation Pilot Plant
WOC	White Oak Creek

SUMMARY

This report is intended to assist the Oak Ridge National Laboratory Transuranic Waste Program in preparing environmental documentation to comply with the National Environmental Policy Act of 1969. The report presents a characterization of the environmental baseline conditions at a proposed site for a transuranic Waste Handling and Packaging Plant (WHPP) on the U.S. Department of Energy's Oak Ridge Reservation. The information contained in this report will be used in the future analysis of environmental impacts associated with the WHPP.

1. INTRODUCTION

1.1 BACKGROUND OF DOE TRU WASTE MANAGEMENT

Transuranic (TRU) radioactive waste contains alpha-emitting radionuclides with atomic numbers > 92 and half-lives > 20 years. The U.S. Department of Energy (DOE) designates radioactive waste from defense-related activities as TRU when the transuranic concentration level of a single waste package is >100 nCi/g (ref. 1). In addition, certain other wastes that do not conform to the general definition of TRU (e.g., ^{233}U) are often designated as TRU by DOE because of their equivalent hazard or other properties. TRU waste is further categorized by DOE as contact-handled (CH), remotely handled (RH), special case (SC), or buried waste.[2]

Before 1970, DOE disposed of TRU waste by on-site shallow land burial at DOE facilities. In 1970, plans for the selection and development of a permanent disposal technology and site(s) were initiated, and all newly generated TRU waste was relegated to retrievable interim storage. A recent inventory (December 31, 1985) of stored TRU waste reported 84,599 m^3 of CH waste and 1,330 m^3 of RH waste in storage at six DOE sites: Aiken, South Carolina; Hanford, Washington; Idaho Falls, Idaho; Las Vegas, Nevada; Los Alamos, New Mexico; and Oak Ridge, Tennessee.[2] RH TRU waste is also generated by Argonne National Laboratory near Chicago, Illinois. Future annual generation rates of CH and RH TRU waste have been estimated at 5800 and 19.7 m^3 respectively.[2]

One of the continuing goals of the DOE Defense Transuranic Waste Program (DTWP) is to end interim storage and to achieve permanent disposal. Because of the inherent toxicity and long half-lives of TRU isotopes, DOE determined that deposition of stored waste in a geologic repository was the preferred method for permanent disposal. A site near Carlsbad, New Mexico, was chosen as the location for the DOE Waste Isolation Pilot Plant (WIPP), which will accept TRU waste from DOE storage or generating sites or both for disposal by emplacement in a salt formation about 2100 ft underground.[3] Individual sites will take actions necessary to certify that newly generated TRU waste and retrieved packages of stored TRU wastes meet the WIPP waste acceptance criteria (WIPP-WAC) and

will ship certified TRU waste packages to WIPP. Noncertifiable wastes will require mechanical or physical processing, or repackaging, or both to render them acceptable at the WIPP. Currently, DOE plans to construct a facility at the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee, to process the ORNL RH TRU inventory and to possibly process RH TRU wastes from other DOE facilities.[4]

1.2 PURPOSE AND SCOPE OF THIS REPORT

This report is intended to serve as the second step in the preparation of environmental documentation required of DOE by the National Environmental Policy Act of 1969 (NEPA) to address proposed RH TRU waste management activities at ORNL. The first step was the preparation of a NEPA strategy document for the RH TRU waste management program.[5]

ORNL currently stores about 90% of the DOE RH TRU inventory [1283 m^3 as of December 31, 1985] (ref. 6). This inventory includes formerly designated SC wastes that are anticipated to be reclassified as RH TRU either by processing or by exception. Before ORNL can ship RH TRU waste to WIPP, the waste must be processed and certified to meet WIPP-WAC.[3] Planned future activities associated with the processing, certification, and transport of RH TRU waste to WIPP include the design, construction, and operation of a processing facility, the Waste Handling and Packaging Plant (WHPP).

This report characterizes the environment at the location proposed for the WHPP. The site characterization will provide a baseline description that will be used in the future analysis of the potential for environmental impacts associated with the WHPP.

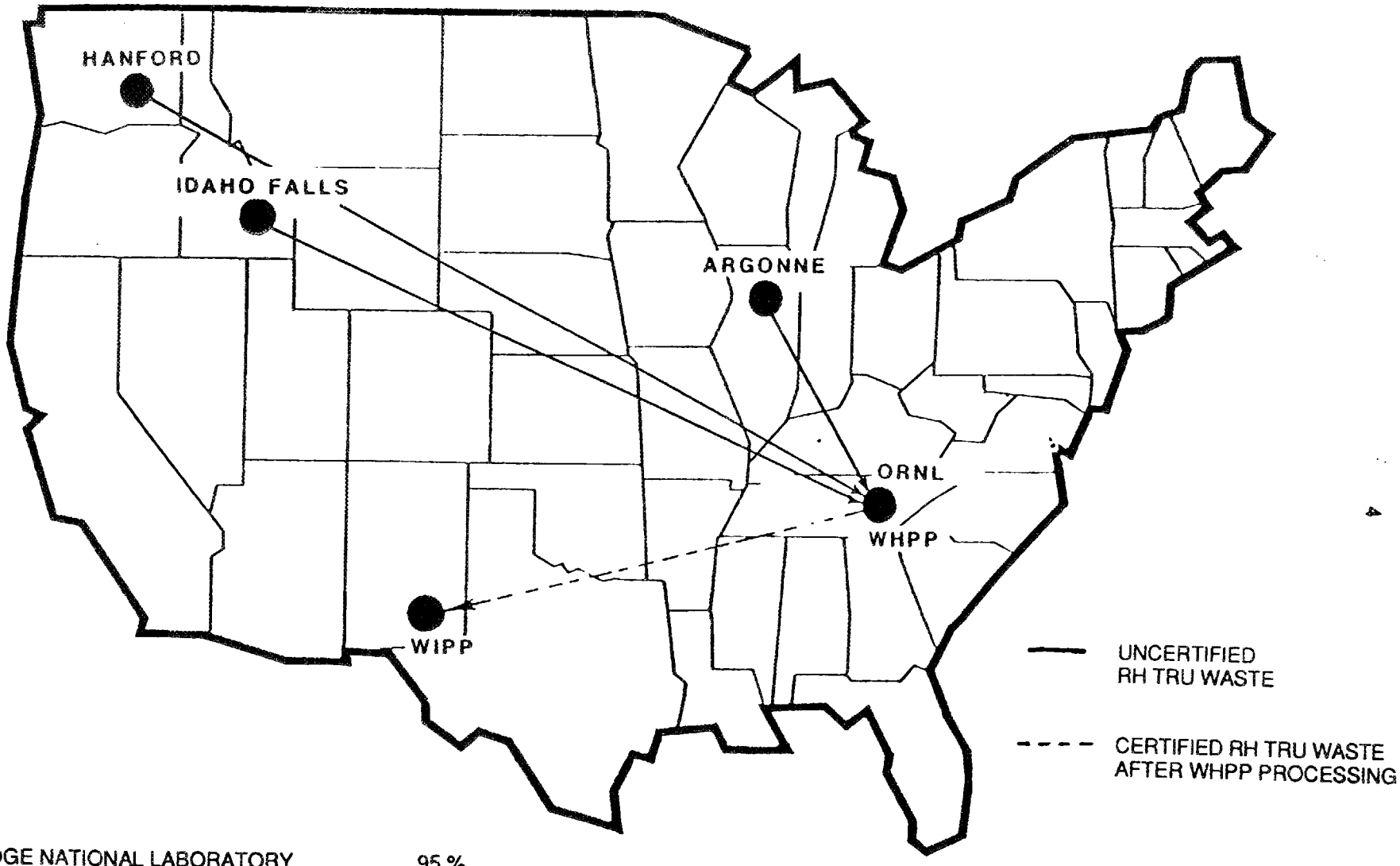
2. PROJECT DESCRIPTION

2.1 WASTE HANDLING AND PACKAGING PLANT (WHPP)

The WIPP is scheduled to begin receiving RH TRU wastes for emplacement and testing in 1989, with actual bulk shipment of waste to begin several years later. The WHPP is planned to retrieve, process, repackage, and certify RH TRU wastes for shipment to the WIPP. The WHPP was recommended for location at ORNL in the TRU Waste Management Program, *Cost/Schedule Optimization Analysis* document prepared by DOE in 1985 (ref. 7). Locating the facility at ORNL was most cost-effective because about 90% of the DOE RH TRU waste inventory is stored at ORNL and all will require repackaging before shipment off-site. Current plans call for the possible receipt of uncertified off-site RH TRU from Idaho, Argonne-East, and Hanford for processing at WHPP (see Fig. 1). Off-site RH TRU waste will be required to meet the WHPP waste acceptance criteria listed in Table 1.

A feasibility study for the WHPP was completed in January 1988 (ref. 8). When the feasibility study originated, plans called for the WHPP to process only solid RH TRU waste. In 1987, a decision was made to add the capability to process RH TRU liquids and sludges which are currently in storage tanks at ORNL. The proposed WHPP will consist of the functional areas depicted in Fig. 2 for solids processing and for solidification of RH TRU liquids and sludges. The total floor space will be about 50,000 ft^2, with about 10,000 ft^2 of concrete-shielded process cells forming the core of the facility.

Wastes entering the WHPP will be processed as required to certify them for emplacement in the WIPP. Because of the variation in characteristics of wastes that will be received, no fixed set of additional processing steps will be followed. Written records of the waste (as supplied by the generator), monitoring equipment available in the WHPP or both will indicate the required processing steps for each waste received. The WHPP will have the capability to:



OAK RIDGE NATIONAL LABORATORY	95 %
HANFORD RESERVATION	2 %
IDAHO NATIONAL ENGINEERING LABORATORY	2 %
ARGONNE NATIONAL LABORATORY	1 %

Fig. 1. Projected sources of uncertified remotely handled transuranic wastes for Waste Handling and Packaging Plant processing.

Table 1. Proposed Waste Handling and Packaging Plant waste acceptance criteria

- Package constraints
  - drums up to 55 gal
  - boxes up to 4 x 4 x 7 ft
  - canisters up to 10 ft by 26 in. diameter
  - weight limited to 13,500 lb
- 1,500 rem/h unshielded dose rate, with neutron contribution limited to 100 rem/h
- Prohibited substances
  - PCBs in quantities regulated by Toxic Substances Control Act
  - elemental mercury
  - explosives
  - pyrophorics
- Other values equivalent to WIPP waste acceptance criteria for
  - surface contamination
  - nuclear criticality
  - ^{239}Pu equivalent activity
  - thermal power
- Each generating site is responsible for meeting U.S. Department of Transportation guidelines

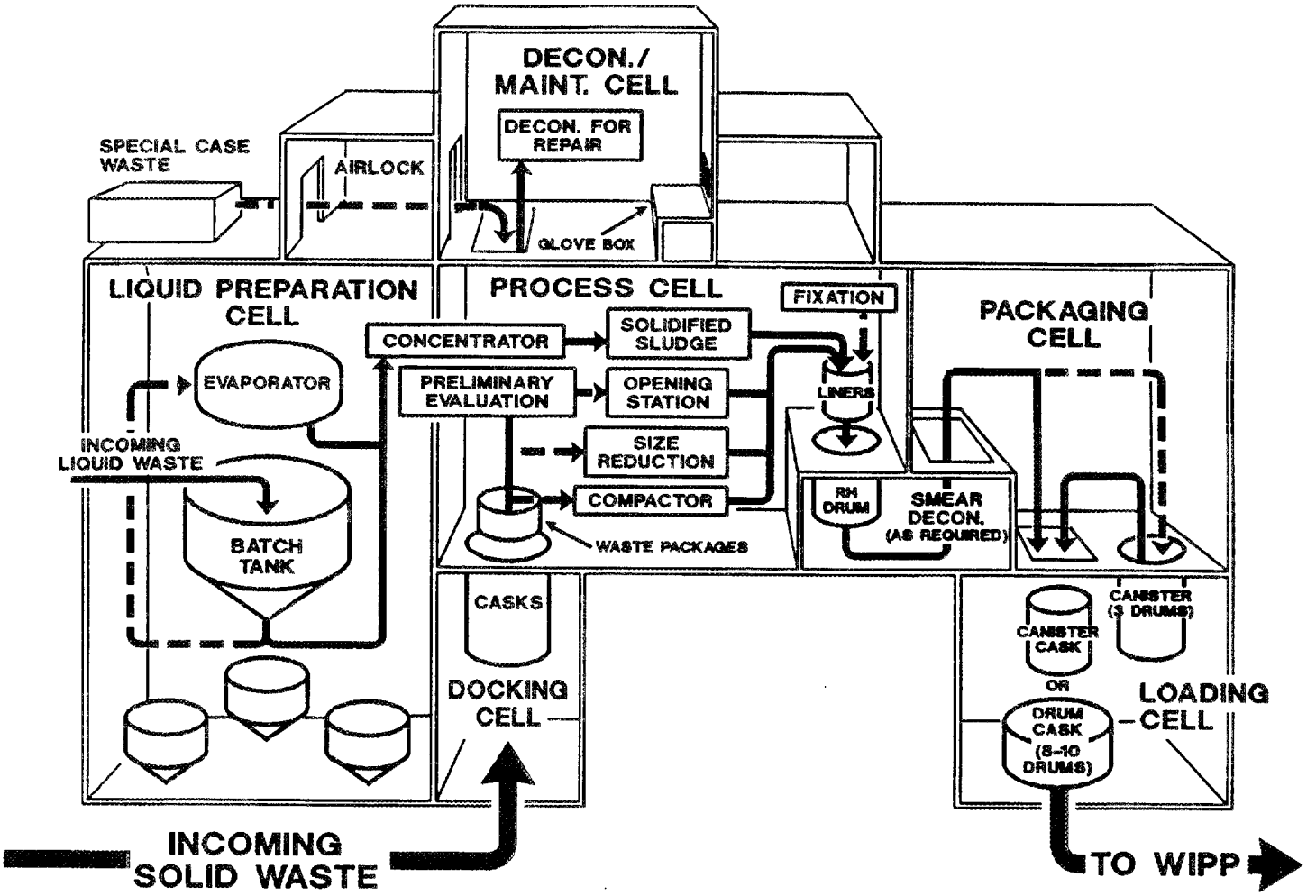


Fig. 2. Functional areas of the proposed Waste Handling and Packaging Plant.

- solidify RH TRU liquids and sludges,
- immobilize free liquids in solid wastes,
- eliminate loose particulates,
- neutralize corrosives,
- perform size reduction,
- compact hot cell waste, and
- examine wastes in process.

2.1.1 Work-Off of Stored RH TRU Waste

2.1.1.1 Hot-cell waste

Wastes will be retrieved from storage in concrete bunkers and burial sites and transported to WHPP for processing, including monitoring of radiation levels and weighing. The waste will be repackaged in 55-gal drums. If required, the drums will be loaded into RH TRU canisters and remotely welded. Wastes that are determined to be certifiable to WIPP-WAC will be loaded into RH casks and shipped to WIPP. Wastes that do not meet the definition of TRU will be segregated for processing as low-level waste (LLW).

2.1.1.2 RH TRU liquids and sludges

Processing of the radioactive liquid contents of the six ORNL Gunite storage tanks (GST) for disposal by hydrofracture in 1984 left a remainder of about 116,000 gal of sludge that has been designated as RH TRU waste. Approximately 51,000 gal is stored in eight Melton Valley storage tanks (MVST) and 65,000 gal in the Gunite storage tanks. Altogether, after removal and solidification, the TRU-contaminated liquids and sludges in these tanks represent about 1000 m^3 of RH TRU waste that will ultimately be sent to WIPP for disposal.

The RH TRU sludge will be solidified and certified to WIPP-WAC. A technical and economic evaluation of alternative solidification processes conducted by ORNL concluded that the most suitable process was concentration by evaporation and melting.[9]

2.1.2 Processing of Newly Generated RH TRU Solid Waste

About 6 m^3 of RH TRU waste is expected to be generated annually at ORNL over the next 20 years. Wastes generated after 1988 will be certified as to waste form and stored for processing in WHPP.

2.1.3 Schedule for RH TRU Waste Disposal

All ORNL RH TRU waste must be certified to meet WIPP-WAC before shipment for disposal. Currently, certification capability is available for only CH TRU waste at ORNL. Certification of RH TRU waste forms was anticipated to begin in 1988; however, certification of RH TRU waste packages for shipment to WIPP will not be initiated until WHPP is operational (L. D. Bates, ORNL, personal communication with A. W. Campbell, ORNL, May 28, 1987).

The WHPP has been recommended for construction as an FY 1992 line item,[10] and operation is anticipated to begin in April 1996 (ref. 11). Processing will begin in 1996 at an anticipated rate of about 200 shipments/year, with all stored RH TRU "worked off" (sent to WIPP) by the year 2013 (ref. 6). The WHPP project schedule is described in Fig. 3.

2.2 WHPP SITE SELECTION PROCESS

Numerous 5-acre sites at the Oak Ridge Reservation (ORR) could serve as the location of the WHPP. However, an area immediately south of ORNL was chosen to be screened for the best possible site because of its proximity to the RH TRU solid waste storage areas and the Transuranium Processing Plant (TPP), Bldg. 7920, which will generate future RH TRU waste on-site. Some of the stored RH TRU waste to be processed in the WHPP is in containers that have not been approved by the U.S. Department of Transportation and would not be allowed on public roads without repackaging; therefore sites on the ORR outside the perimeter of ORNL were not considered acceptable.

In 1987, a site evaluation study was conducted for the WHPP on the basis that the facility has the capability to process only *solid* RH TRU waste. The weighted site selection

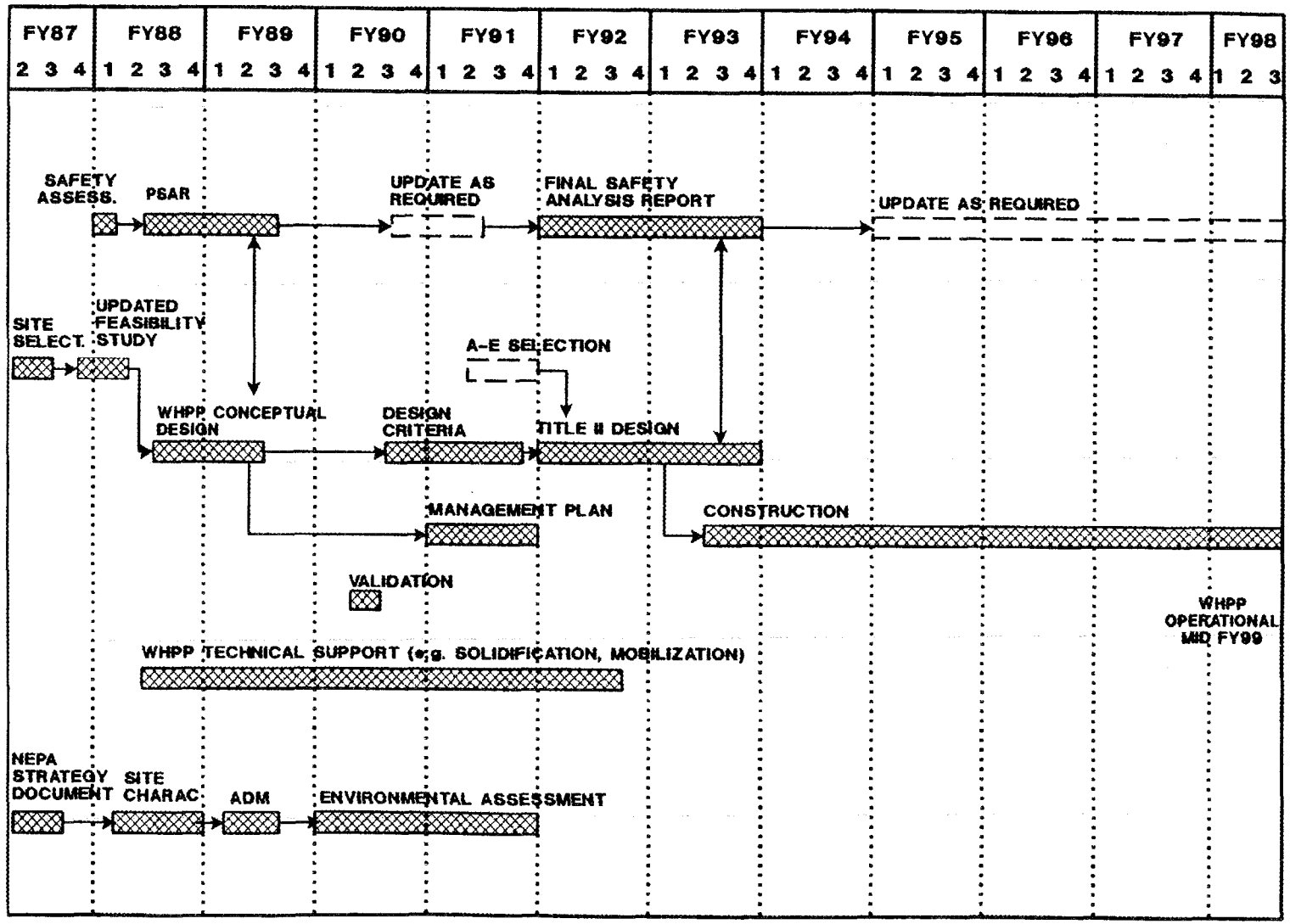


Fig. 3. Waste Handling and Packaging Plant project schedule.

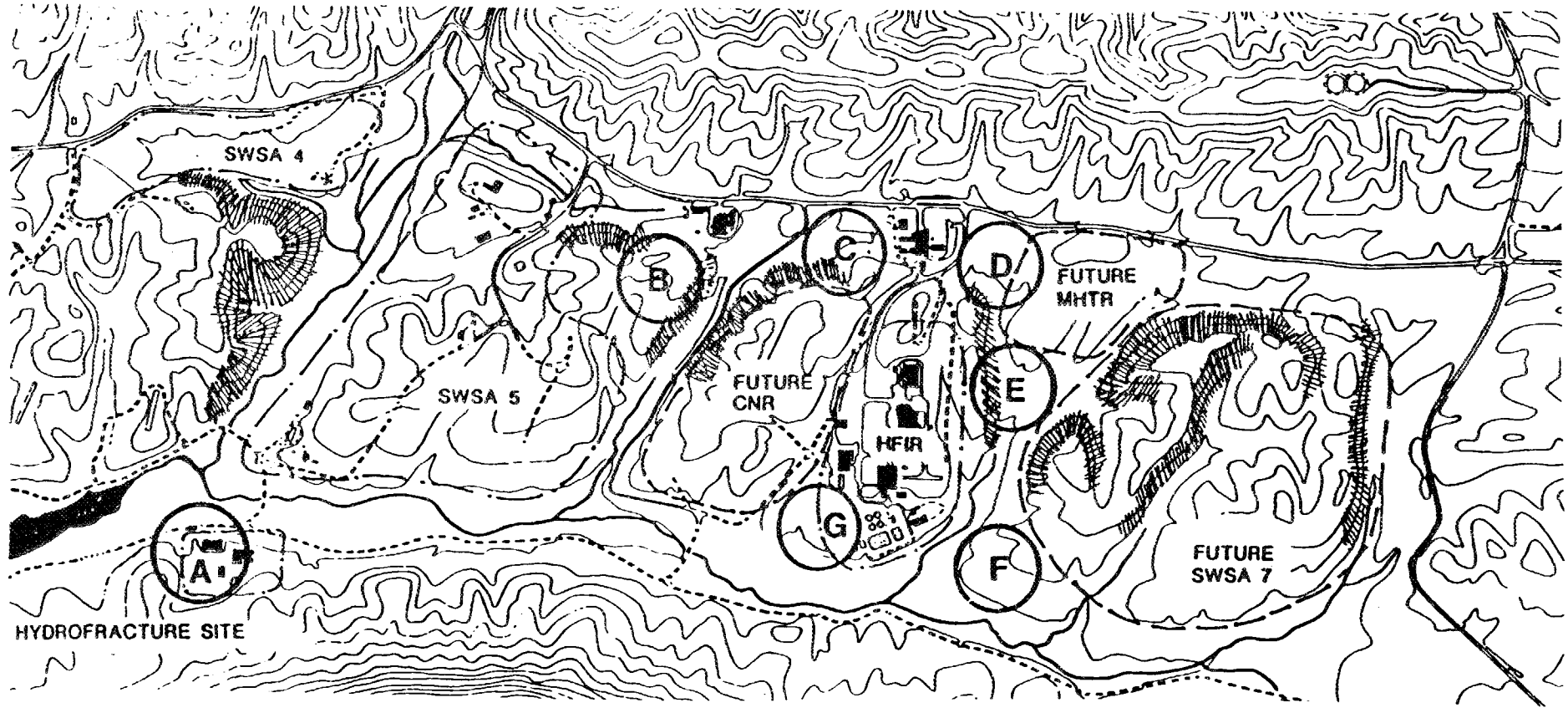
criteria are indicated in Table 2. Seven candidate sites which were considered are shown in Fig. 4. Site "G," which is just west of the High-Flux Isotope Reactor (HFIR) on the figure, was designated as the preferred site; it has the advantages of immediate availability of utilities, proximity to the TPP and HFIR and RH TRU solid waste storage areas, and existing access roads. During site selection, a feasibility study was in progress for the WHPP. At the same time, plans were being developed for a facility to immobilize the RH TRU liquids and sludge contained in the Melton Valley Storage Tanks (MVST), which are located near site "A" on Fig. 4. A decision was made to expand the New Hydrofracture Facility, just southeast of the MVST, to include an RH TRU sludge solidification facility. This would minimize the distance that the RH TRU sludge would have to be transported via underground pipeline for processing but would still require the on-site transport of the solidified sludge from site "A" to site "G" on Fig. 4 for final packaging and shipment to WIPP.

Following the completion of the feasibility study, which called for independent solids and sludge processing facilities, and prior to the initiation of the WHPP Conceptual Design, decisions were reevaluated. It became apparent that significant duplication of capabilities (e.g., alpha-qualified ventilation systems, drum handling facilities, decontamination and health physics areas) would result from the decision to construct and operate independent solids and sludge facilities. By combining the two in a consolidated WHPP, which would have the additional capability to immobilize the sludge, approximately $20 million would be saved.

A decision on the appropriate siting of a consolidated facility was then necessary. Unfortunately, a consolidated WHPP would be too large to locate in the immediate vicinity of the MVST. In addition, the distance for underground transport of the sludge from the MVST to a WHPP, if it were located near the HFIR, would be expensive and less environmentally acceptable than if the solidification facility were located nearer the MVST. For these reasons, other potential sites were investigated. It was concluded that a site not previously considered, located about 400 ft west and south of the MVST (Fig. 5), would have the advantages of proximity to the MVST, availability of utilities for extension, suitable topography, suitable access roads, and essential services. The alternate site considered for the consolidated facility was the original site near HFIR.

Table 2. Site selection criteria for the Waste Handling and Packaging Plant

Mission goals
Available land
Consistent with planning goals
Proximity to waste generators
Primary and secondary access
Cross-traffic on-site
Existing security
Natural factors
Topography
Vegetative cover
Hydrology
Floodplain
Soils characteristics
Utilities
Potable water
Fire lines >8 in.
Sanitary drainfield
Process waste
Low-level waste
Steam
Electricity
Telecommunications
Gas/air



DEDICATED LAND USE
PROPOSED 8 ACRE SITE
SLOPES GREATER THAN 25%
FUTURE PROJECTS

WHPP - WASTE HANDELING PILOT PLANT
CNR - CENTER FOR NEUTRON RESEARCH
HFIR - HIGH FLUX ISOTOPE REACTOR
MHTR - MODULAR HIGH TEMPERTURE REACTOR
SWSA - SOILD WASTE STORAGE AREA

N

Fig. 4. Sites evaluated for location of the proposed Waste Handling Packaging Plant at Oak Ridge National Laboratory.

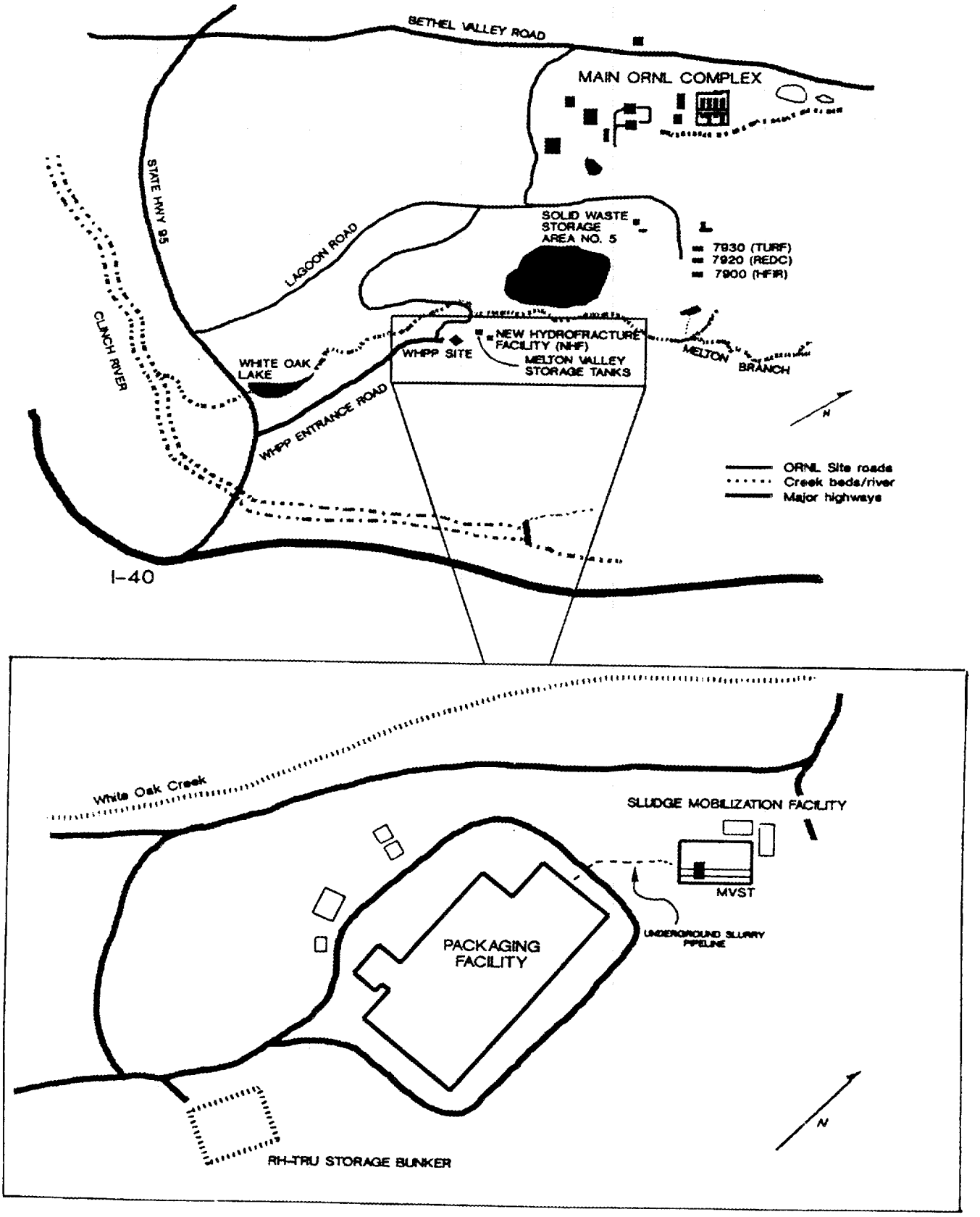


Fig. 5. Location of the preferred site for the Waste Handling and Packaging Plant at Oak Ridge National Laboratory on the Oak Ridge Reservation.

The determining factors in the decision to locate the WHPP at the MVST area (near Site "A") were the cost and the environmental risks of pipeline transport to a WHPP in the HFIR area. An additional disadvantage was that locating the WHPP near HFIR would encroach upon other plans to expand the existing facilities. The pipeline transport of sludge from the MVST to the site near "A" would be one-tenth the distance of transport to the HFIR area (4000 ft vs 400 ft), and the transport route would not likely be within previously contaminated areas, as it would en route to the HFIR area.

3. SITE CHARACTERISTICS

3.1 GEOGRAPHY AND DEMOGRAPHY

3.1.1 Site Location

The proposed site for the WHPP (see Fig. 5) is located on the ORR, which is within the corporate limits of the city of Oak Ridge in eastern Tennessee. Oak Ridge lies in a valley between the Cumberland and Southern Appalachian mountain ranges and is bordered on one side by the Clinch River (Fig. 6). The ORR is predominantly to the west and south of the population center of the city (Fig. 7). The Cumberlands are about 16 km (10 miles) northwest; 113 km (70 miles) to the southeast are the Great Smoky Mountains.

Oak Ridge and the ORR are within the region known as the Great Valley of the Tennessee River. The ORR consists of approximately 15,000 ha (37,000 acres) of federally owned lands in this valley. The three primary plant complexes on the site [Oak Ridge Gaseous Diffusion Plant (ORGDP), Oak Ridge National Laboratory (ORNL), and Oak Ridge Y-12 Plant (Y-12)] have a combined fenced area of 810 ha (2,000 acres) designated as a buffer for health and safety reasons. Another large part of the Reservation [5,500 ha (13,590 acres)] is designated as a National Environmental Research Park (NERP).

3.1.2 Population

The city of Oak Ridge, which has a population of about 28,000, was built within the original Reservation to house the builders and operators of the K-25 (ORGDP), X-10 (ORNL), and Y-12 facilities for the Manhattan Project. Knoxville (population 185,000) is located approximately 48 km (30 miles) southeast of Oak Ridge. The population density within a 50-mile radius of the ORR is depicted in Fig. 8. The population density is <50 per sq. mile within a 5-mile radius of the proposed WHPP site. The population characteristics of the four-county region surrounding ORNL represent a typical distribution of societal categories as measured by age, employment, occupations, and income. The area ranges from rural to urban, trending increasingly to urban with the

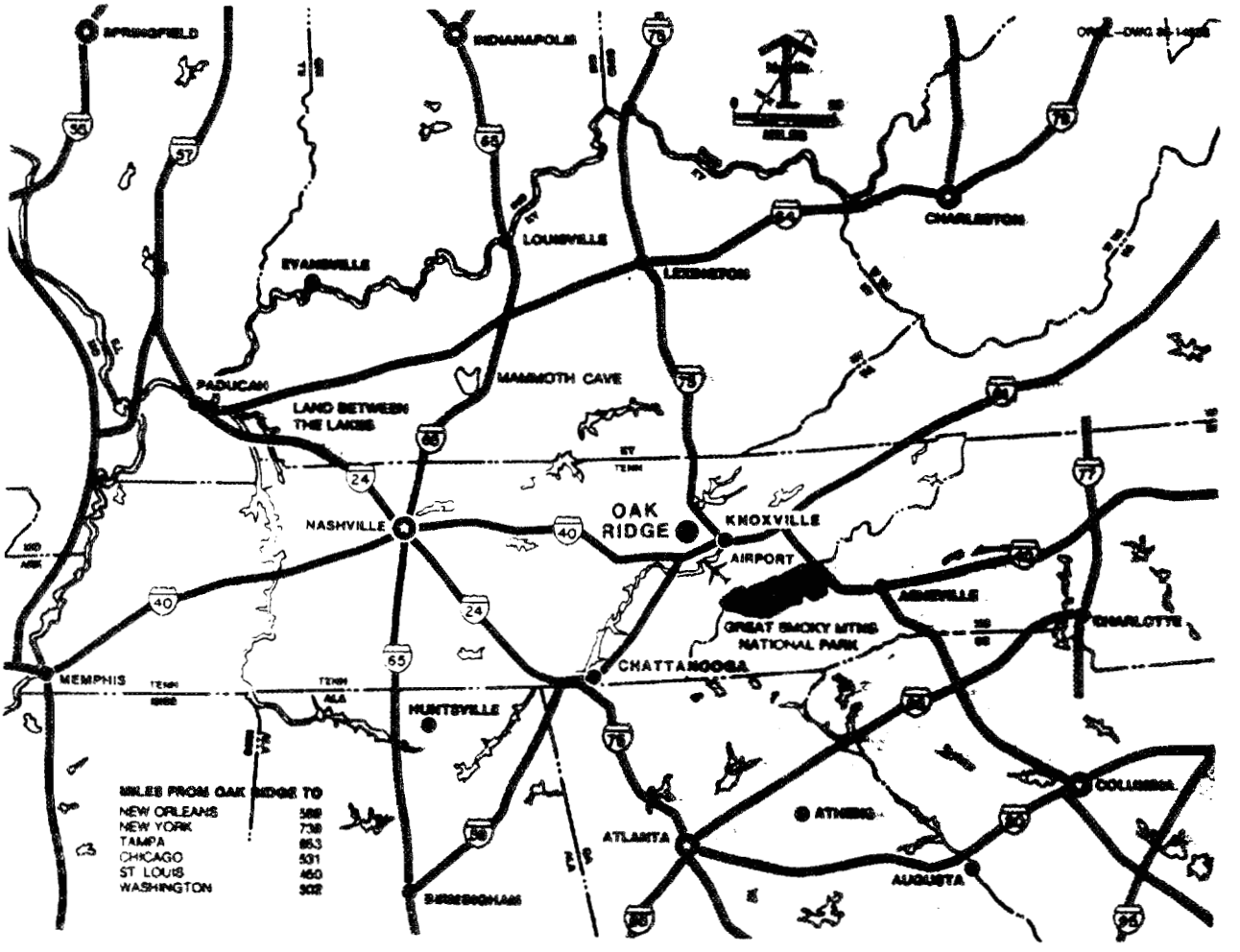


Fig. 6. The Oak Ridge Reservation is located in East Tennessee between the Cumberland Mountains and the Great Smoky Mountains National Park, about midway between the Kentucky and Georgia borders.

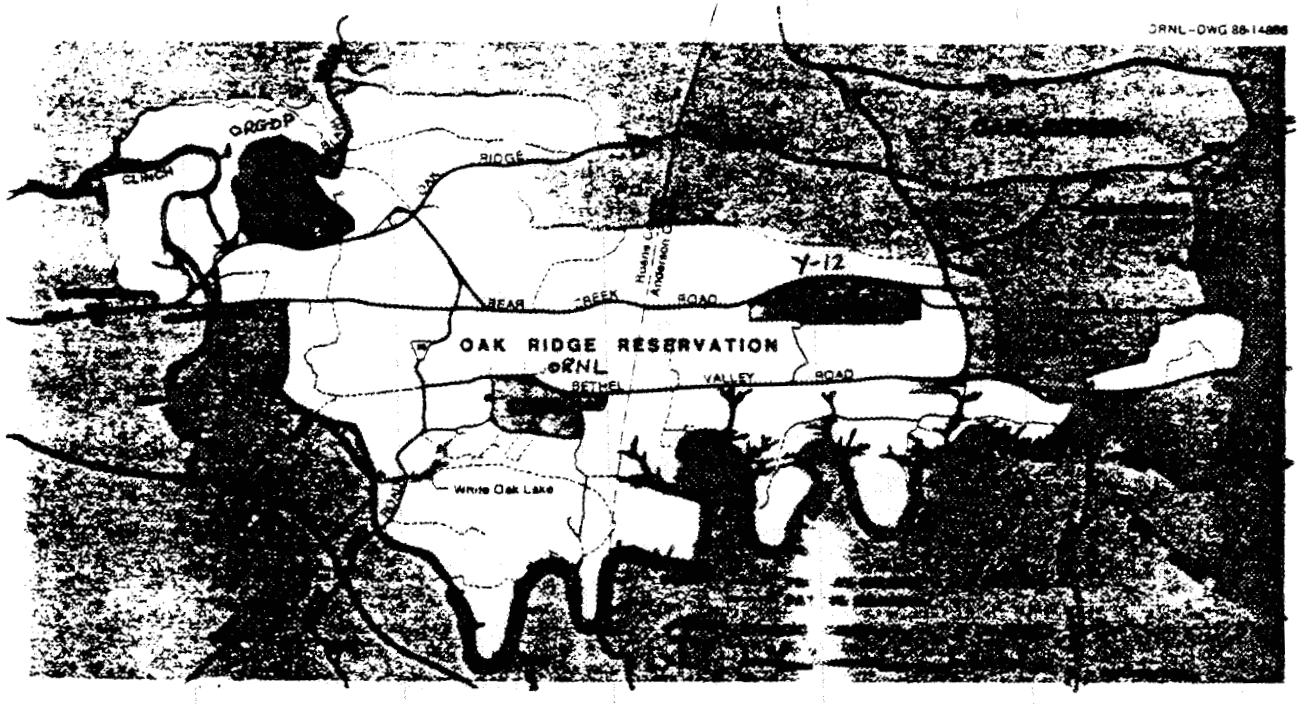


Fig. 7. The Oak Ridge Reservation encompasses three major U.S. Department of Energy facilities (Oak Ridge Gaseous Diffusion Plant, Oak Ridge National Laboratory, and the Y-12 Plant).

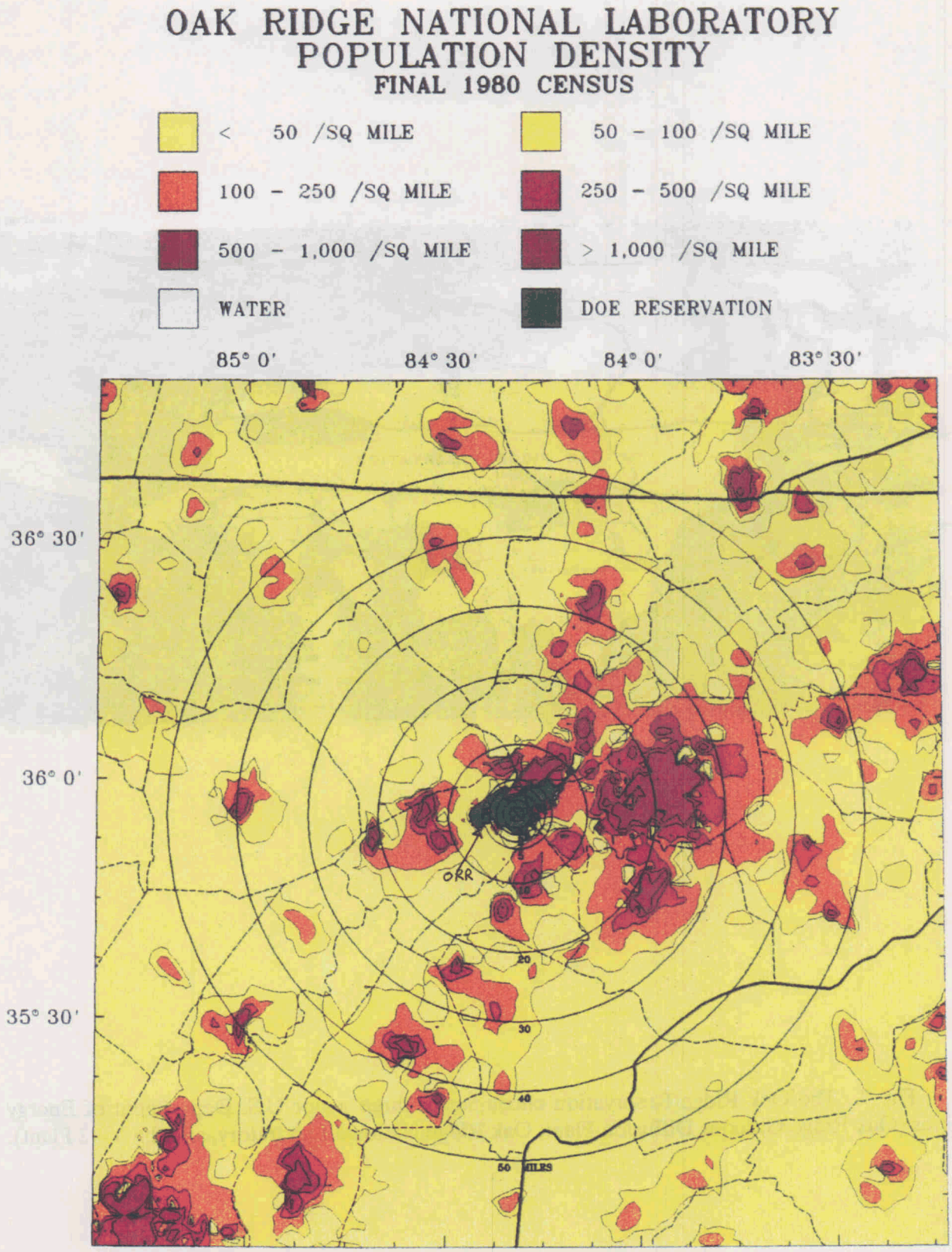


Fig. 8. Population density within a 50-mile radius of the Oak Ridge Reservation.

expansion of Knoxville as a major urban center and with the development of other smaller urban centers. The city of Oak Ridge has a cosmopolitan character, due principally to the above-average educational background of its residents. More than 25% of the population 25 years of age or older has completed 4 years of college. The median number of years of education completed by Oak Ridge inhabitants falls between 12 and 13, about 2 years more than the state average.

3.1.3 Transportation System

The Knoxville-Oak Ridge area is served by three interstate highways: I-40 (east-west), I-75 (north-south), and I-81 (northeast-southwest). A bypass (I-640) around downtown Knoxville was completed in 1982 and has improved traffic flow through the area. The ORR is within a few miles of I-40 and I-75. The Pellissippi Parkway (State Highway 162) connects the ORR to these same highways to the east and serves as the major link between West Knoxville and Oak Ridge. The rural highway system around the ORR is considered adequate to handle the average number of commuter trips by the work force. Some congestion, however, does occur on and near the ORR from 7 to 8 a.m. and from 4 to 5 p.m. The major highway arteries serving the ORR are shown in Fig. 9.

3.1.4 Cultural Resources

The ORR area is rich in archaeological resources, both prehistoric and historic. Preservation of these resources is mandated by Sect. 106 of the Historic Preservation Act of 1966 [16 U.S.C. 470(f)] and by the Tennessee Natural Areas Preservation Act of 1971. In deciding the future use of reservation lands, planners must consider the effects of expansion or new construction on the archaeological resources of the area. Just west of the proposed WHPP site are the remains of a pre-1942 homestead—a partially standing cabin and a barn or crib. In June 1988, the ORR Resource Management Committee contracted with The University of Tennessee, Department of Anthropology, for a survey of the structures to determine their historical significance. The survey concluded that the site has been irreversibly and adversely affected by modern activity and that it is not deemed

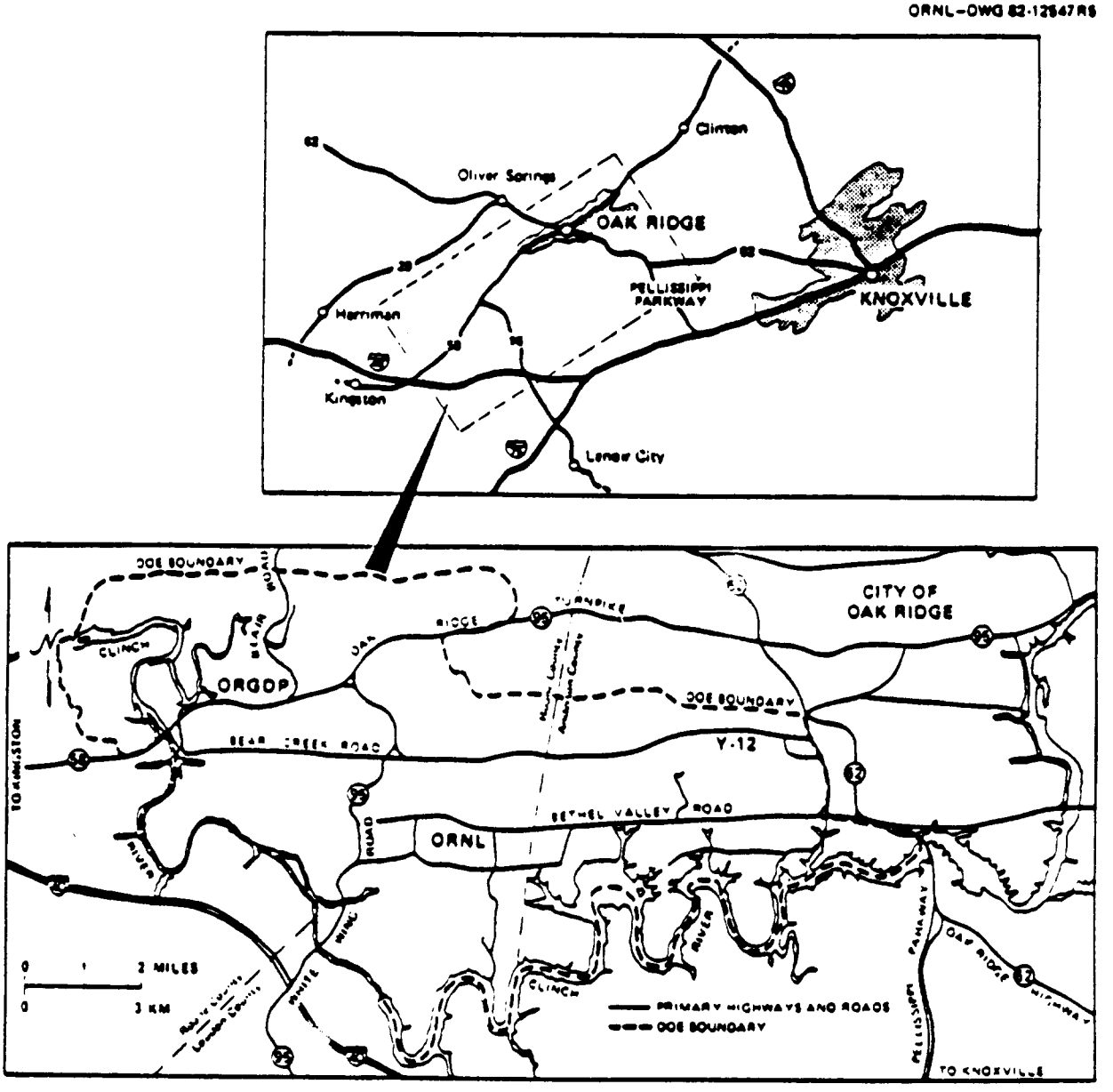


Fig. 9. Primary highways serving the U.S. Department of Energy Oak Ridge Reservation.

significant enough to warrant its inclusion on the *National Register of Historic Places*. The archaeological survey report is presented in Appendix A.

3.2 METEOROLOGY AND AIR QUALITY

Oak Ridge enjoys a mild climate with warm, humid summers and cool winters. It is very infrequent for extreme conditions to prevail in temperature, precipitation, or winds. Spring and fall are usually long; the weather is normally pleasing—dry and sunny with mild temperatures. Severe storms such as tornadoes or high-velocity windstorms are rare. The mountains frequently block hot, muggy, southeasterly winds that develop along the south Atlantic Coast.

Oak Ridge has an annual mean air temperature of 14.4°C (58°F). Total annual precipitation (water equivalent) is 1.36 m (53.5 in.), including approximately 0.25 m (10 in.) of snowfall. Total precipitation peaks in January and February. Prevailing winds are northeasterly and southwesterly. ORNL is located in Air Quality Control Region 207, which includes east Tennessee and southeast Virginia. Air quality in the vicinity of the ORR is generally within National Ambient Air Quality Standards, except for occasional violations of ozone standards.

The ORR air monitoring system consists of 10 stations that are, with one exception, outside the ORNL, Y-12, and ORGDP plant boundaries but inside the ORR boundary. These provide data for evaluating releases from Oak Ridge facilities to the immediate environment. The remote air monitoring system consists of seven stations that are outside the ORR at distances of 19 to 121 km (12 to 75 miles). This system provides background data to aid in evaluating local conditions and fallout data.

3.3 GEOLOGY

3.3.1 Topography

The WHPP site is located on the ORR in southwestern Melton Valley, which is one of several elongated alternating valleys and ridges that comprise the Valley and Ridge Physiographic Province of the Appalachian Highlands. Melton Valley is bounded on the

southeast by Copper Ridge and on the northwest by Haw Ridge (Fig. 10). These topographic features are each underlain by different rock units, the weathering and erosion of which resulted in the present terrain. The altitude on the ORR ranges from 720 to 1335 ft.

The WHPP site area (elevation 830 to 880 ft) is located at the northwestern base of Melton Hill where the terrain flattens to nominally 1.5%. Several moderately to poorly incised ephemeral and perennial drainages, oriented normal to the long valley axis, cross the site at regular intervals providing surface drainage for adjacent Melton Hill.

3.3.2 Stratigraphy

Melton Valley is underlain by the shale, limestone, and siltstone lithologies of the Cambrian Conasauga Group. Figure 11 illustrates borehole geophysical logs and a generalized lithologic log representative of the bedrock formations beneath Melton Valley. Previous geologic investigations elsewhere in Melton Valley document the detailed stratigraphic characteristics of the Conasauga Group rock units.[12] Thin residual, alluvial, and colluvial soils form upon the Conasauga Bedrock. The soils are underlain by a thick zone of saprolite. Saprolite is weathered bedrock which has lost its cement but retains the bedding characteristics of the parent bedrock material.

The WHPP site area is underlain by the Nolichucky Shale which is comprised of shale, limestone, and calcareous siltstone in alternating thick to thin beds. Reconnaissance field study has determined that the WHPP site is underlain by the middle and upper Nolichucky. No apparent variations from previous reports of middle and upper Nolichucky lithologies are identified at the site.

3.3.3 Structure

Structural deformation during the Appalachian Orogeny resulted in the present bedrock orientation. Regional strike is N 55 to 60 E degrees, and dip is typically 20 to more than 45 SE degrees locally. Geologic strike in Melton Valley is typically about N 58 E degrees, and dip varies from about 10 SE degrees in the southern portion of the valley to about 30 or 40 SE degrees in the northern portion of the valley.

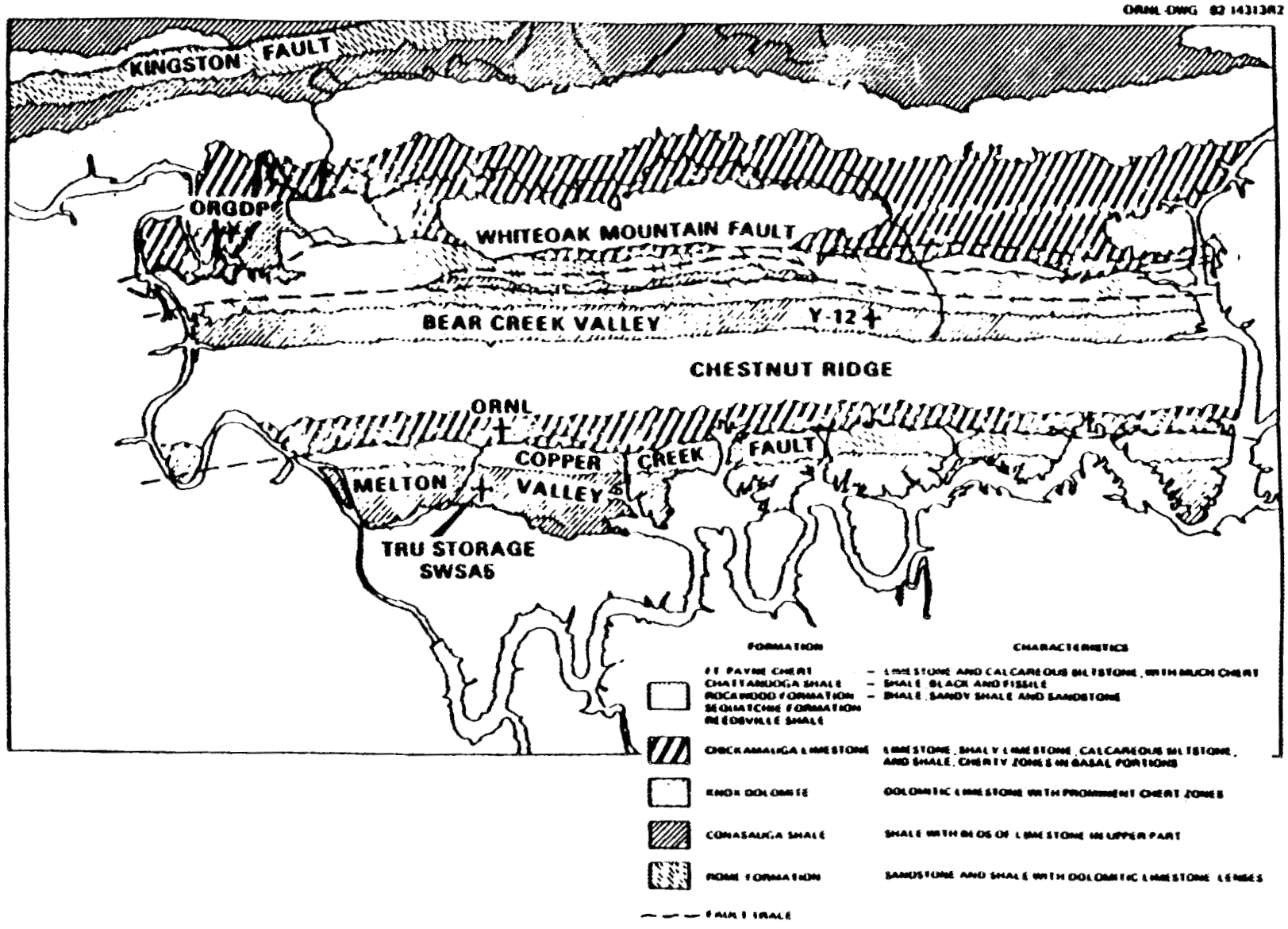


Fig. 10. Geologic map of the ORNL area.

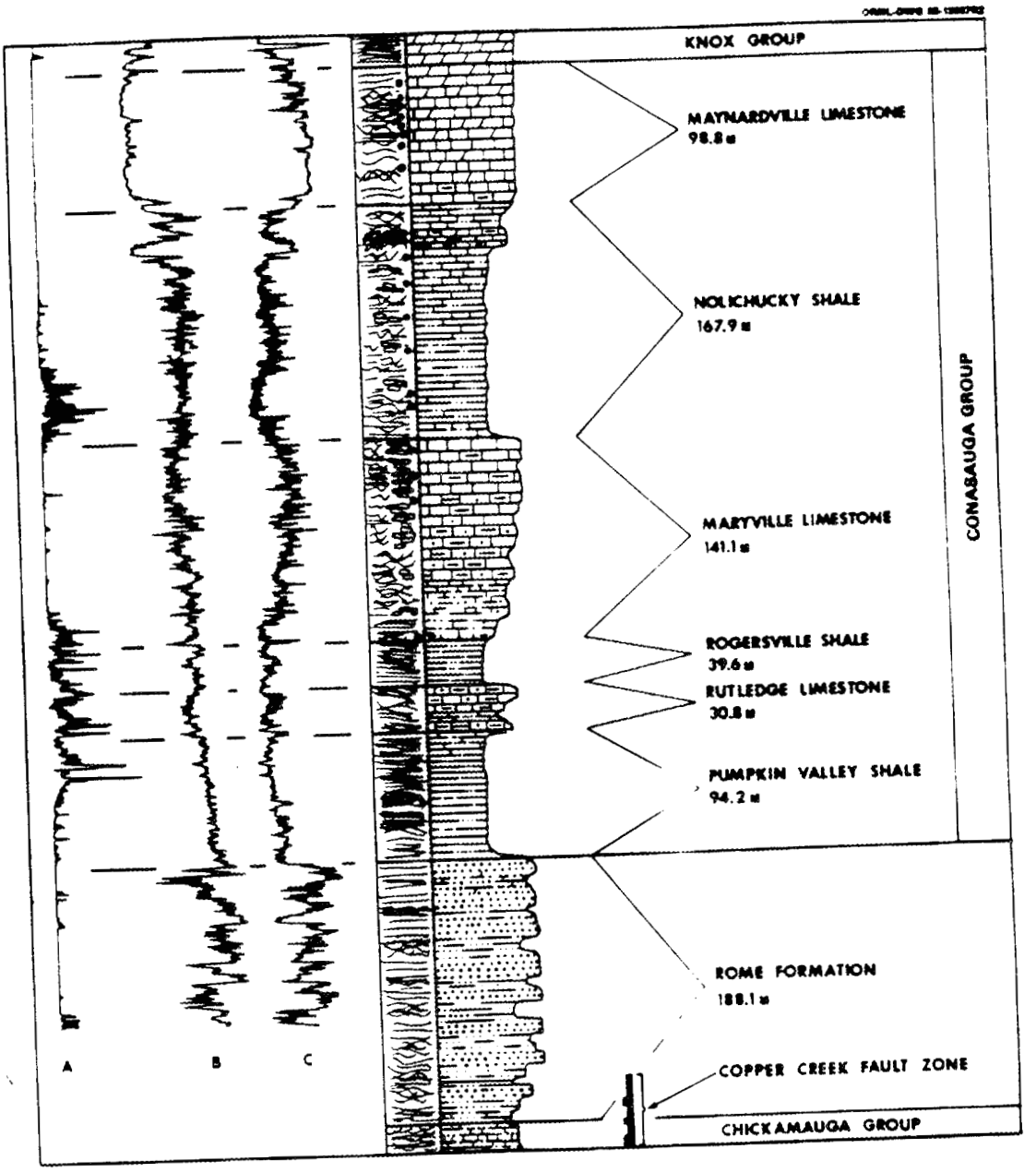


Fig. 11. Borehole geophysical logs and a generalized lithologic log representative of bedrock formations beneath Melton Valley.

Small- and intermediate-scale geologic structural deformation in the form of drag folding, minor shear faulting, and fracturing is prevalent throughout Melton Valley.[13] Characteristics of these features have been related to the deformation history of the Copper Creek Fault beneath the valley.[14] The presence of small and intermediate-scale structural deformational features complicates structural geologic studies on the ORR. Detailed data describing such deformation has been reported by Dreier and Beaudoin (ref. 15).

3.3.4 White Oak Creek Fault

Mapping of the White Oak Creek (WOC) Fault in Melton Valley[16] has raised concern regarding its presence on the proposed WHPP site. The proposed site for the WHPP is located south of the New Hydrofracture Facility near the southern terminus of the mapped WOC Fault. Investigations to determine the presence of the WOC Fault at the WHPP site were a major component of the geologic site characterization.

3.3.4.1 Existing data

The WOC Fault is a postulated tear fault exhibiting as much as 350 ft of surface displacement in the central portion of Melton Valley, with displacement reduced to about 40 ft in the northern and southern portions of the valley. Evidence supporting the presence of the WOC Fault includes topography in the White Oak Creek area and interpretation of subsurface stratigraphic and structural data. Topographic data supporting the presence of the fault include apparent offsets in Haw Ridge north of the valley and the minor ridge in the center of the valley. Subsurface stratigraphic data which have been interpreted to support the presence of the WOC Fault include Conasauga Group formational contacts determined from geophysical logs of deep wells in Melton Valley. The geophysical stratigraphic picks are correlated to core hole data for control. Geologic structural data which support the presence of the WOC Fault are dominated by near-surface fracture and fold orientations. Field data from limited man-made and natural surficial bedrock exposures indicate a rotation of bedding to an orientation nearly normal to the fault[16] and a possible higher incidence of medium-scale folding in the vicinity of the fault which may extend at least 100 m on either side of the fault trace.[17] Rotation of fracture orientation has also been

associated with the WOC Fault and other small-scale structural deformation in Melton Valley.[14]

3.3.4.2 Investigation approach

The initial approach to fault investigation at the WHPP site was to use surface geophysical methods (EM) to look for geophysical anomalies suggestive of faulting and then excavate at the anomalies to determine their cause. Additional excavations at and near the projected fault trace to obtain bedrock and fracture orientation data were compared with similar data from elsewhere in Melton Valley supportive of the fault interpretation. These initial investigation methods were supplemented by rock coring near and on opposing sides of the projected fault trace.

3.3.4.3 Data acquisition

Fig. 12 shows the locations of the EM survey lines, the excavated trenches, and the core holes. Excavation into eight apparent EM anomalies determined that with the exception of anthropogenic features (i.e., metal stakes) the anomalies measured soil moisture content and perhaps moisture chemical properties. Following the trenching operations in EM line 1, discussions with the geophysicist supervising the survey corroborated the interpretation, and further excavations were not conducted on EM survey line 2.

Stereo plots of bedrock and fracture orientation data from all excavated site trenches and from several natural outcrops are shown in Fig 13. Orientations of small-scale fold axes identified in several excavated trenches are included in Fig. 13. In trench 16 two very low-angle faults, trending roughly E-W and with little to no displacement, were identified in the western portion of the trench. In the eastern portion of the trench, a thin zone of brecciation was identified, but intersection of the water table near the breccia prohibited determining the spatial orientation of the zone.

In all three site core holes, small- to intermediate-scale structural deformation in the form of faulting and folded bedding was identified. The style and vertical extent of this deformation is not considered anomalous with respect to similar deformation identified in other Melton Valley core holes.[13]

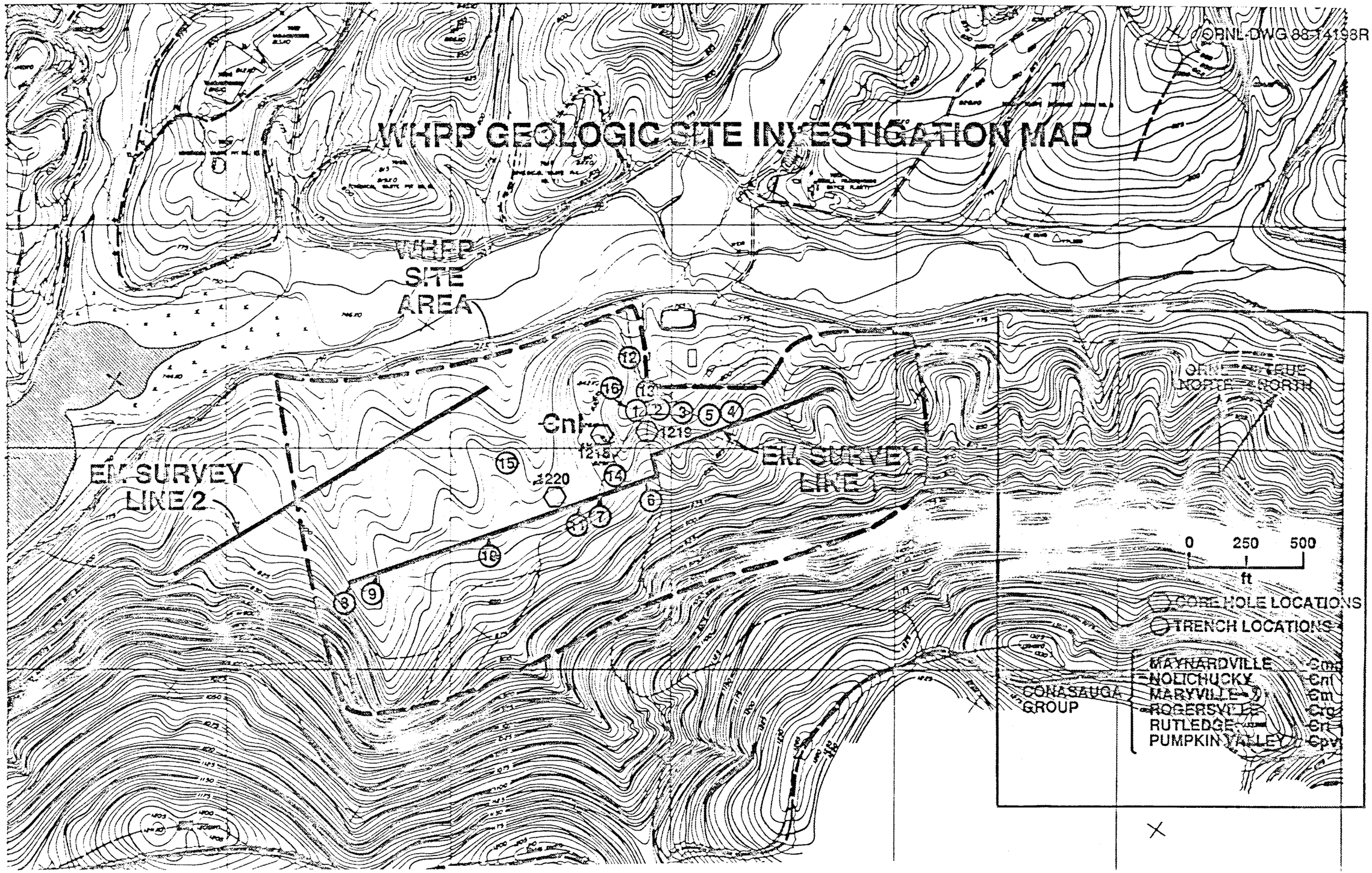
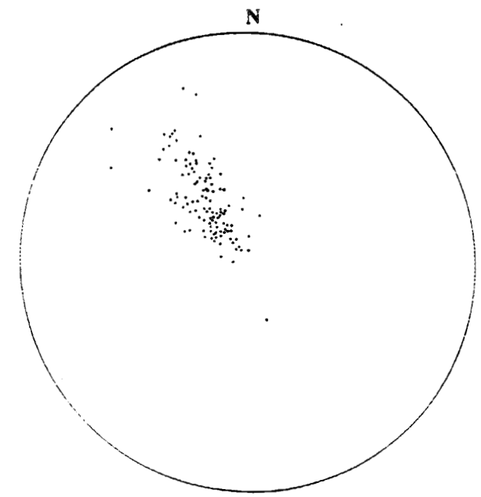
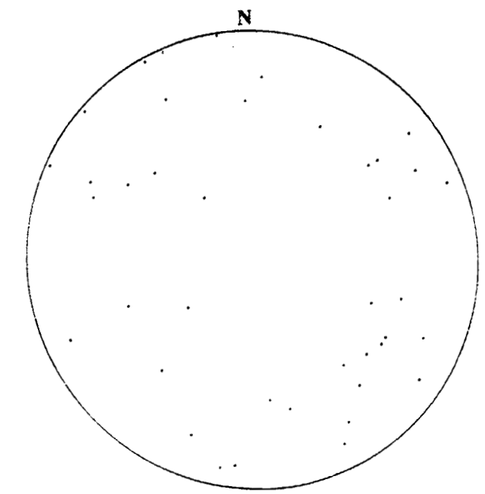


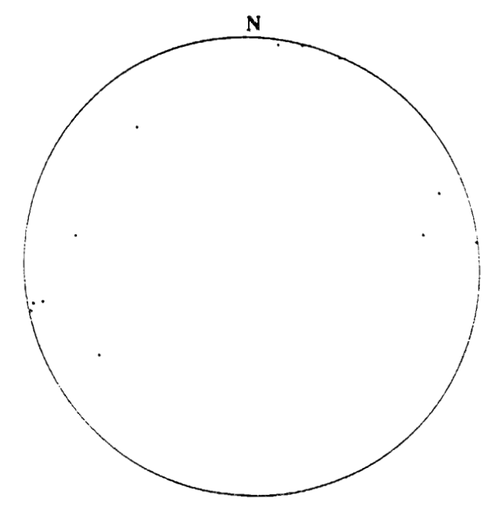
Fig. 12. White Oak Creek Fault geologic study map for WHPP site.



Poles to bedding.



Poles to fractures.



Fold axes nonstereographic projection.
(Points on perimeter represent absence of fold axis plunge datum)

Fig. 13. Summary WHPP site geologic study stereograms.

Core holes 1218, 1219, and 1220 were drilled to 281, 201, and 175 ft respectively. Core holes 1218 and 1219 were drilled near and on opposing sides of the projected fault trace. These two holes were drilled to achieve stratigraphic control with other bore holes near the WHPP site. The Maryville-Nolichucky formational contact was intersected in 1218 and 1219 at 255 and 172 ft respectively. Core hole 1220 was drilled to determine bedrock conditions beneath one area proposed for construction of the WHPP facility and lies on the projected fault trace in the southern portion of the site. Zones of small- and intermediate-scale structural deformation were encountered in all core holes, similar to deformation identified in other Melton Valley core holes.[13] Deformation in 1218 and 1220 was particularly noteworthy, extending for 47 and 75 ft respectively, and heavily fractured rock in the upper roughly 62 ft of 1219 resulted in unstable bore wall conditions and poor core recovery.

3.3.4.4 Data analysis

Comparison of WHPP site geologic structural data with similar data obtained elsewhere in Melton Valley supportive of the WOC Fault interpretation is presented below. This data comparison is followed by an analysis of several hypotheses that could reasonably relate the small- and intermediate-scale structural features identified at the WHPP site to a larger-scale structural feature such as the WOC Fault.

Analysis and comparison of geologic structural data with similar data from elsewhere in Melton Valley do not support the presence of the fault at the WHPP site. A weak roughly E-W structural orientation trend may be seen in the fold axis data and in the low-angle faults seen in trench 16 which could be related to faulting. This orientation, however, is similar to the orientation of similar structural features in locations elsewhere in Melton Valley unrelated to the WOC Fault and is likely to be attributed to regional, not local, effects (R. B. Dreier, personal communication). The increased incidence of deformation adjacent to the projected fault trace, reported elsewhere in Melton Valley,[17] was not identified at the WHPP site. Minor folding, with wavelengths on the order of 1 m and less, was observed in 9 of the 16 excavated trenches and at several other man-made bedrock exposures in the WHPP site area. Rotation of bedding and/or fracture orientation, associated with faulting elsewhere in Melton Valley,[14,16] is not apparent at the WHPP site.

Fractures tend to fan about minor folds and return to a regional norm orientation with bedding.

For comparison with interpretations of existing subsurface data supportive of the WOC Fault, subsurface borehole formational contact data from both the WHPP site and elsewhere in Melton Valley were used as input to the contouring computer program PLOT3D (ref. 18) to construct structure contour maps of selected formational contacts. The purpose of the exercise was to provide a purely quantitative data analysis. The Rogersville-Maryville and Maryville-Nolichucky contacts were selected as being most relevant to the WHPP site. Computer data input included published depths to the formational contacts and engineering survey data for each well. Two locations where the Rogersville-Maryville contact was identified in saprolite were included in the data set. The computer-generated formational contact structure contour maps are shown on Figs. 14 and 15. In Fig. 14 a roughly N 20 W oriented structural anomaly is apparent which is in close agreement with the published location and geometry of the WOC Fault. The deformation occurs between the 600 ft and 350 ft contours, and its southernmost expression terminates roughly 500 ft north of the WHPP site. In Fig. 15 a subtle anomaly exhibiting no apparent displacement is oriented in a roughly N 45 E azimuth north of the WHPP site.

Analysis of the computer-generated structure contour maps suggests that in the middle portion of the Conasauga Group stratigraphic section, at the Rogersville-Maryville contact northwest of the WHPP site, roughly 50 to 100 ft of stratigraphic displacement may be associated with the WOC Fault. Higher in the stratigraphic section, at the Maryville-Nolichucky contact near the WHPP site, this displacement is not observed.

The hypothesis that a geometric relationship existed between the structural deformation in core holes 1218 and 1220 was considered. The deformation in those two core holes occurs in the lower Nolichucky and upper Maryville Formations, at depths of 100 ft and greater beneath the WHPP site. Scaled projection of the deformed intervals to the ground surface indicates the deformation in both core holes subcrops beneath White Oak Creek, however, relating the deformation between holes produces the unrealistic geometry of northerly dipping deformation. Comparing the location of the deformed intervals in the two cores indicates that the deformation is not stratabound.

The hypothesis that the brecciation identified in the eastern portion of trench 16 may indicate the presence of the WOC was evaluated. This hypothesis is significant because

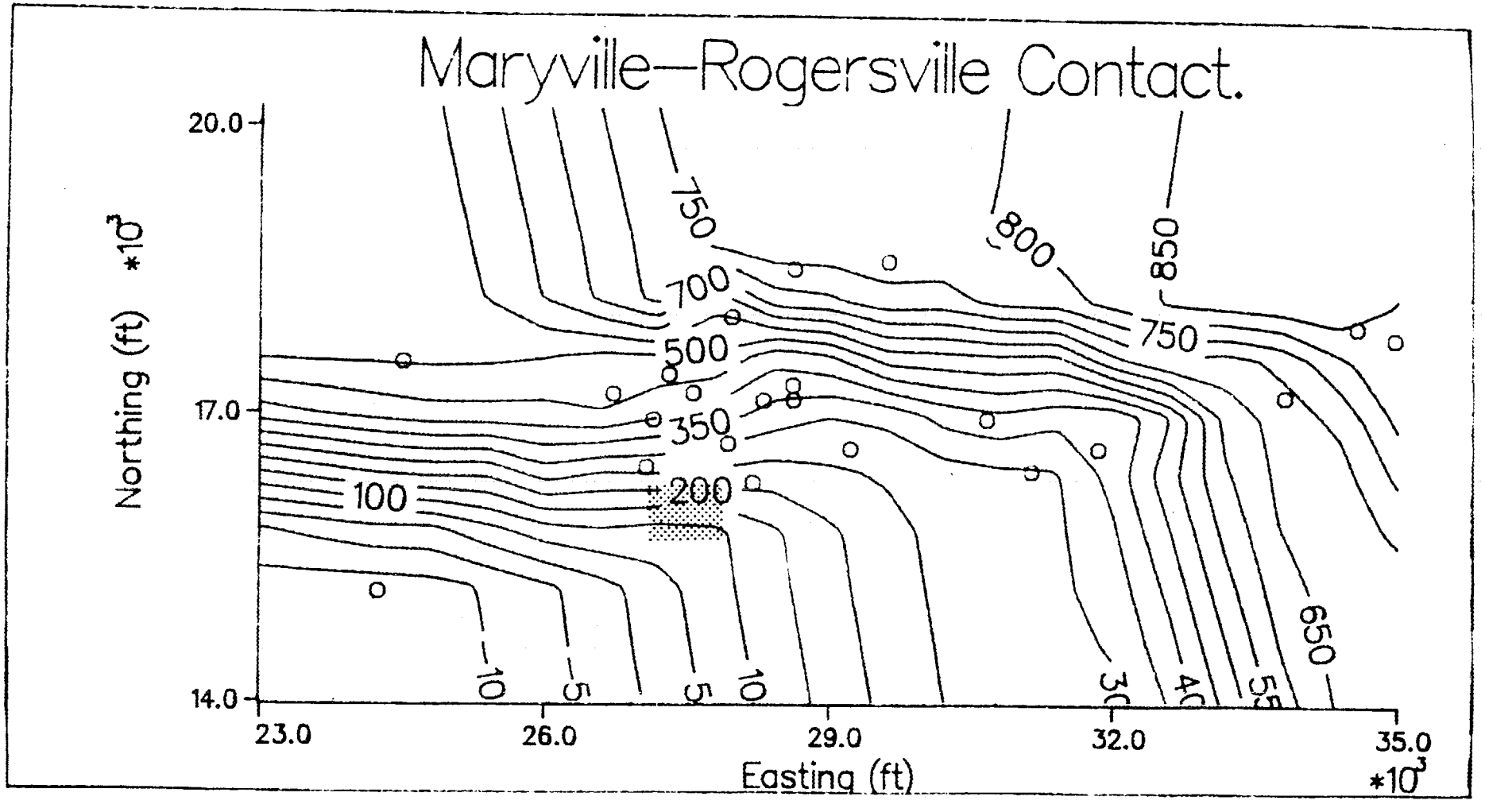


Fig. 14. Structure contour map of the Rogersville/Maryville contact. (Hachuring - WHPP site).

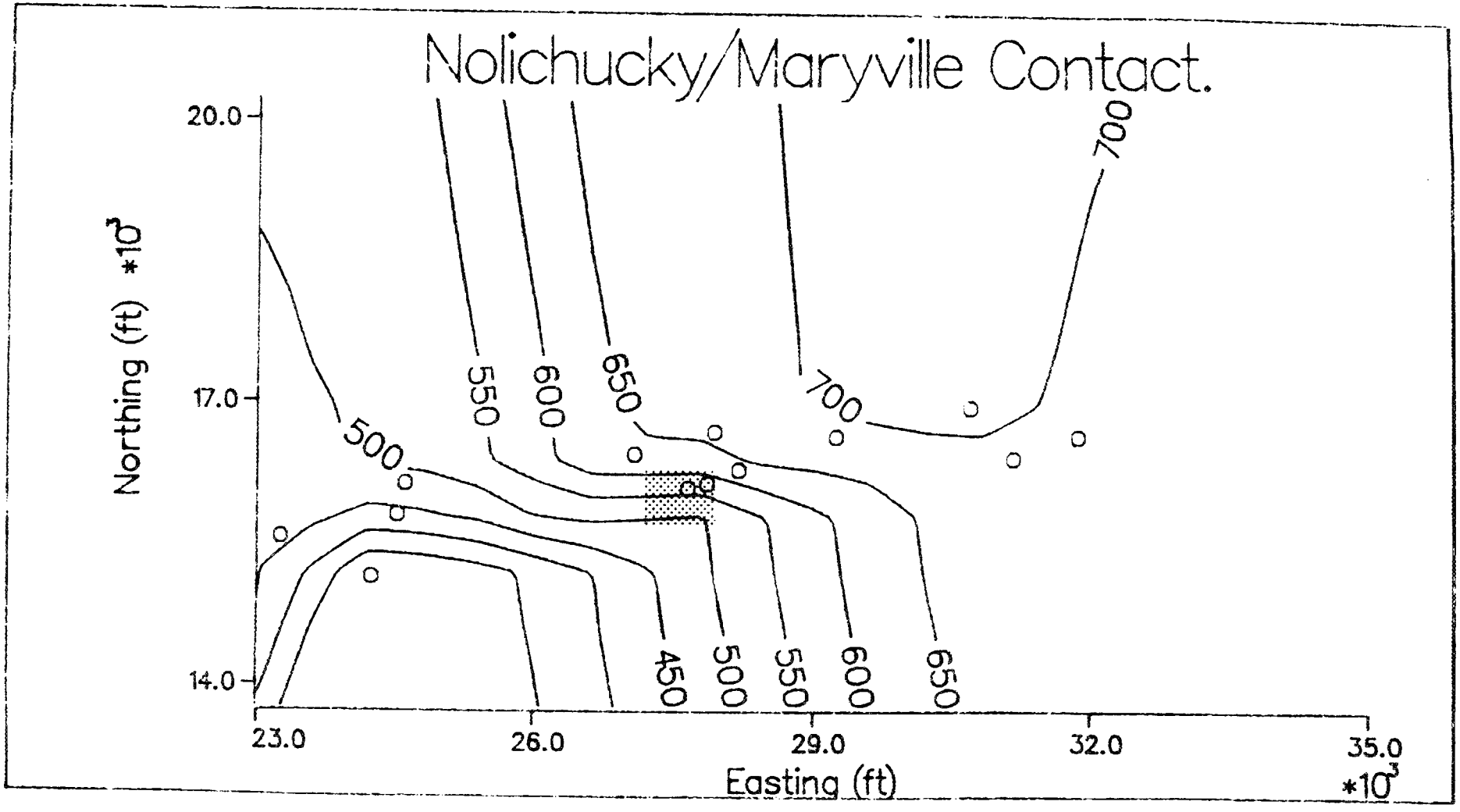


Fig. 15. Structure contour map of the Maryville/Nolichucky contact. (Hachuring - WHPP site).

the breccia is located in an area coincident with the projected location of the WOC terminus. This area also lies between core holes 1218 and 1219, enabling testing of the hypothesis. Observations which make this hypothesis appealing include the location of the breccia, the presence of deformed intervals in the lower Nolichucky and upper Maryville formations in both core holes, and the apparent roughly 40 ft offset of the Maryville-Nolichucky formational contact between the two core holes.

Conditions strongly supporting the hypothesis that the breccia is related to a deeply penetrating structural feature would include the observation of similar structural features in core and saprolite and the presence of similar amount and sense of offset in strata through a range of depths. Data obtained from core holes 1218 and 1219 and trench 16 fail to fulfill these conditions. The deformation observed in core was dominated by folded and contorted beds with small-scale fault offsets oriented parallel to slightly oblique to strike. The breccia was atypical of the type of deformation observed in core. Strata from the two core holes were correlated at depth as well as near the ground surface. At the Maryville-Nolichucky formational contact, roughly 40 ft of offset was observed. Correlation of beds between these two holes near the land surface showed no significant bedding offset. The displacement at depth appears to be associated with the 47 ft of deformation identified in core hole 1218 which dissipates above that depth. Based on these arguments, the breccia does not represent a zone of surface stratigraphic displacement associated with significant faulting.

The data suggest that the bulk of fault deformation near the center of Melton Valley dissipates in the upper Maryville and lower Nolichucky Formations and does not reach the ground surface at the WHPP site. However, intermediate-scale structural deformation identified in rock core at depth and in surface excavations may be considered to be related to the WOC Fault. If this is the case, it suggests that structural deformation near the fault terminus may be areally distributed into numerous splays, each possessing minor deformation.

3.3.4.5 Conclusion

Results of the WHPP site structural geology investigation indicate that small- and intermediate-scale structural deformation similar to that reported elsewhere in Melton

Valley is pervasive and complex. No structural deformation was found at the WHPP site that could be confidently related to a large-scale structural feature such as the WOC Fault. The hypothesis developed from the site investigation is that apparent stratigraphic displacement near the middle of Melton Valley dissipates into minor structural features, changes orientation, or terminates north of the WHPP site. Near the fault terminus, the increased shale content of the Nolichucky Shale may accomodate and dampen the fault motion by folding and minor faulting. This deformation may be areally distributed into numerous splays, each possessing structural deformation indistinguishable from the ubiquitous small- and intermediate-scale deformation seen elsewhere in Melton Valley.

3.3.5 Seismicity

Several recent seismic hazard studies have been conducted for the ORR.[19-23] Additional studies have been conducted by the Tennessee Valley Authority (TVA) and the Clinch River Breeder Reactor Plant project management office. Based on the results and recommendations of those studies, among others, a seismic hazard curve for the ORR was recommended by Beavers et al. (1982).[24] The following summarizes that study.

Three historical earthquakes have had a significant impact on the ORR. The Charleston, South Carolina, earthquake of 1886 had an estimated Modified Mercalli Intensity (MMI) of VI at the ORR. The Giles County, Virginia, earthquake occurred in 1897 with an estimated effect at the ORR of between MMI V and VII. The third earthquake occurred northwest of Knoxville in 1913. It had an estimated MMI of V to VI at the ORR.

Another seismic event of significance to the ORR is the New Madrid, Missouri, earthquakes which occurred in 1811 and 1812. The effect at the ORR has been estimated at an MMI of between V and VI. Ground shaking at the ORR may have lasted from 2 to 3 minutes.

The major potential for earthquake damage to the ORR is the seismic source zone of the Valley and Ridge Physiographic province. While considerable microseismic activity occurs in the area, none can be attributed to known faulting.

Based on the above historical seismic activity in the southeastern United States, the effective peak ground acceleration for a 100-, 500-, and 1000-year seismic return period at

the ORR is estimated at approximately 0.06 gravity (g), 0.12 g, and 0.15 g respectively. For a facility with an expected 50-year life, the 100-year return period (0.06 g) is generally known as the design earthquake or operating earthquake. The estimated maximum effective peak ground acceleration for that facility is 0.12 g.

3.3.6 Soils

Middle and upper Nolichucky soils have not been studied in detail in Melton Valley, because of their location away from previous or proposed waste disposal facilities. These soils have been studied elsewhere on the ORR, and the results provide a general indication of soil characteristics at the WHPP site.

Nolichucky residual soils are Dystrochrepts, which are generally clayey, loamy skeletal, mixed, and thermic. Soil colors range from dark yellowish brown to brown and yellowish red. The pH is generally 4.7 or 4.8. Nolichucky soils generally have poor to fair water infiltration characteristics. Detailed analysis of Nolichucky soils from Bear Creek Valley on the ORR, which is considered representative of such soils in Melton Valley, is available in Lee et al.[25]

3.4 WATER RESOURCES

3.4.1 Surface Water

3.4.1.1 Hydrology

The proposed site for the WHPP is located within the White Oak Creek watershed (Fig. 16). Surface water draining the WHPP site would flow into either White Oak Creek or the lower portions of the Melton Branch tributary to White Oak Creek, and from thereto White Oak Lake and the Clinch River. White Oak Creek, Melton Branch, and White Oak Lake receive treated and untreated process wastewater, treated sanitary sewage effluent, and reactor cooling water from ORNL facilities. The hydrology of White Oak Creek watershed is described in Loar (1988).[26]

Base-flow discharge in Melton Branch is typically low, and owing to below normal precipitation extended periods of zero discharge occurred in the upper reaches in 1986 and

ORNL-DWG 80-15923R4

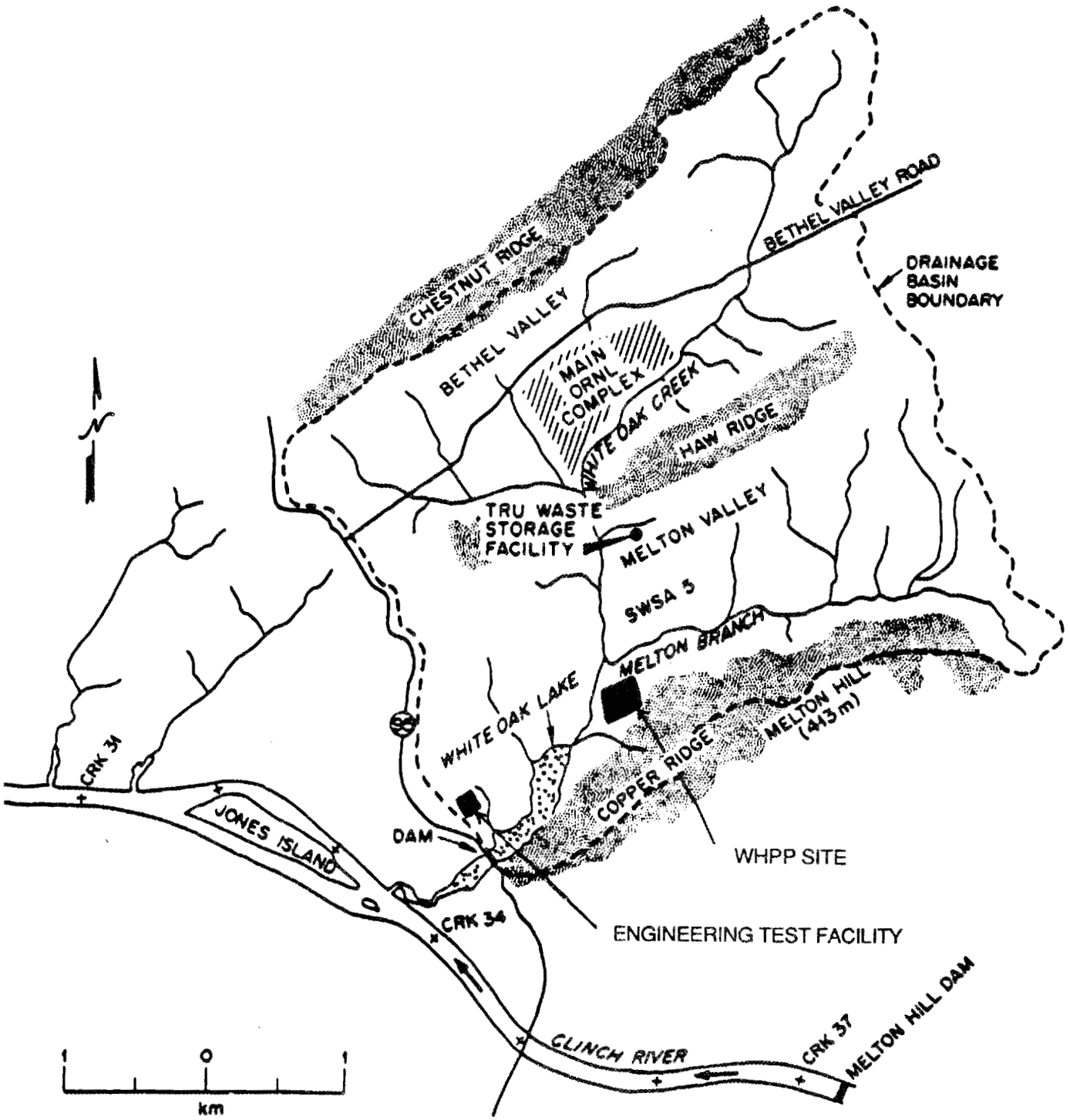


Fig. 16. White Oak Creek drainage basin and a portion of the Clinch River.

1987 (Fig. 17). Stream flow in lower Melton Branch, within the influence of the WHPP site, has been augmented by discharges from the High Flux Isotopes Reactor (HFIR).[26] HFIR discharges entered Melton Branch about 1.4 km above the confluence of Melton Branch with White Oak Creek. Although the HFIR discharges were a source of heat and chemical contamination to lower Melton Branch, they ensured stream flow at times when the upper reaches were reduced to a series of isolated pools. Stream flow in Melton Branch between 1955 and 1963 averaged 0.07 m^3/s; maximum flow during that period was 6.85 m^3/s, although this may underestimate actual flood flows.[27]

Stream flow in White Oak Creek in the vicinity of the WHPP site is also augmented by discharges from various facilities at ORNL and by the Melton Branch tributary.[26] Although there were no periods of zero discharge in lower White Oak Creek (that portion of the stream between ORNL and White Oak Lake) during 1985-87 (Fig. 17), high flows have also been rare in recent years owing to the absence of major rainstorms. Average stream flow in lower White Oak Creek was 0.27 m^3/s between 1950 and 1963; maximum flow was 18.2 m^3/s (ref. 27).

A small unnamed tributary drains into the headwaters of White Oak Lake near the WHPP site on the north slope of Copper Ridge (Fig. 16). This stream consists of a series of pools and small waterfalls over much of its length. The tributary is believed to be an intermittent stream (D. K. Cox, Environmental Sciences Division, ORNL, personal communication to G. F. Cada), although it is not gauged and there are no known hydrological or water quality data available for it.

White Oak Lake is a shallow impoundment that was created in 1941 by construction of a dam approximately 1 km above the confluence of White Oak Creek with the Clinch River (Fig. 16). The lake functions as a final settling basin for waste effluents discharged to White Oak Creek, Melton Branch, and other, smaller streams in the White Oak Creek watershed. It extends 0.7 km upstream from the dam and has a surface area of about 8 ha (ref. 26). Descriptions of White Oak Lake and the Clinch River in the vicinity of the White Oak Creek embayment are provided in Loar (1988),[26] Boyle et al. (1982),[27] Loar et al. (1981),[28] Oakes et al. (1982),[29] and Sherwood and Loar (1987).[30]

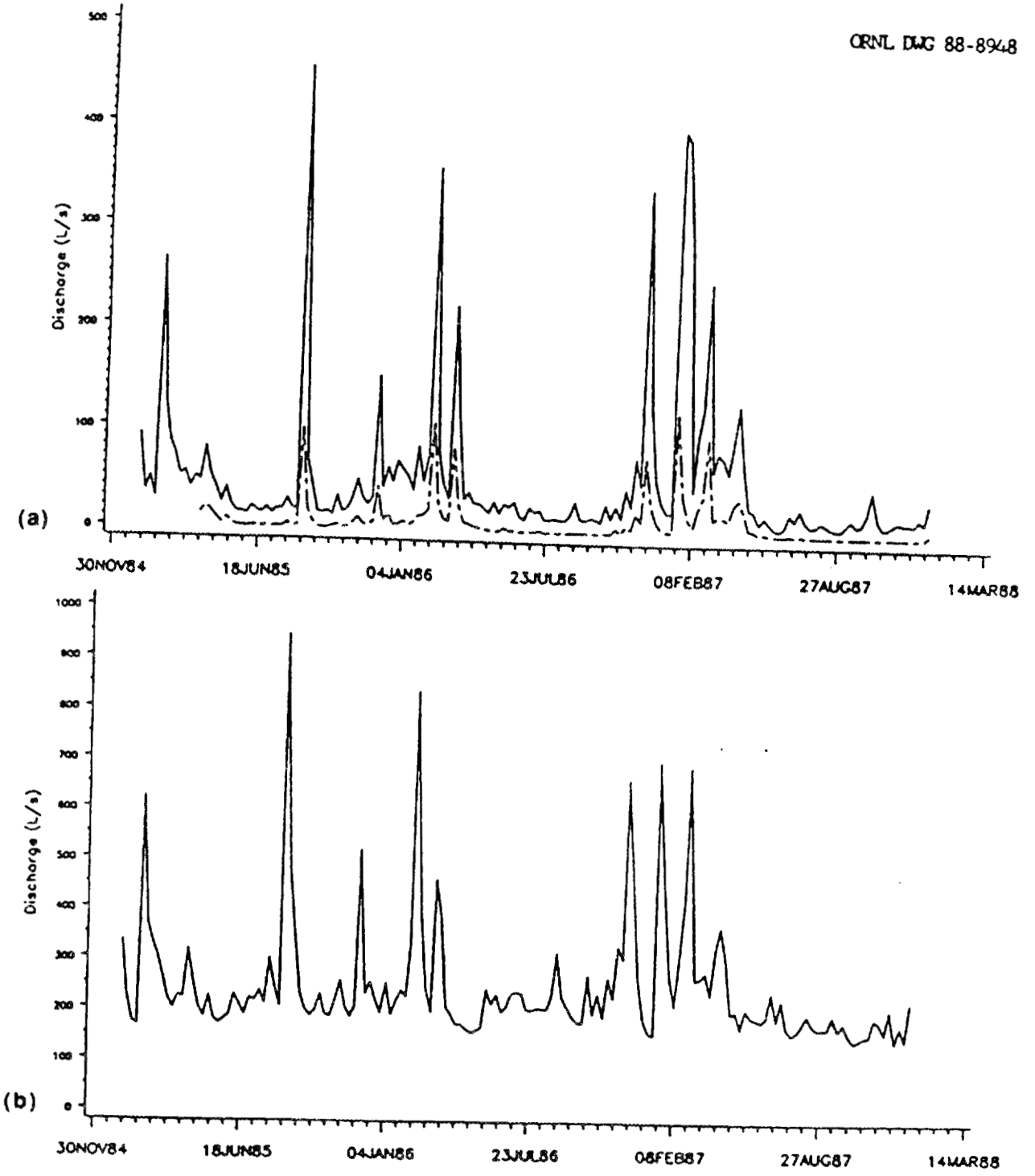


Fig. 17. (a) Mean weekly stream flow in Melton Branch near MEK 1.9 (dashed line) and near MEK 0.16, (b) mean weekly stream flow in White Oak Creek near WCK 2.65.

3.4.1.2 Water quality

The water quality of Melton Branch and White Oak Creek is monitored as part of both the National Pollutant Discharge Elimination System (NPDES) permit and the Biological Monitoring and Abatement Program (BMAP). Sampling locations, parameters, protocols, and the results of recent monitoring are all reported in Loar (1988).[26] In particular, Table 2-5 in Loar (1988)[26] presents median concentrations and ranges of thirty-four NPDES water quality parameters that are routinely monitored in lower Melton Branch and lower White Oak Creek. The waters of lower White Oak Creek were characterized by moderate levels of dissolved solids, occasional high turbidity, elevated concentrations of most metals, low concentrations of organic compounds, moderate phosphorus enrichment, periods of low dissolved oxygen concentrations, and relatively high temperatures. The water quality of lower Melton Branch improved considerably between 1986 and 1987, owing to the shutdown of the HFIR and consequent reduction in cooling tower blowdown and HFIR process ponds discharge.

Considerable information about both radiological and nonradiological contaminants in White Oak Lake has been developed in recent years [Loar (refs. 26 and 31)]. More than 99 percent of the radioactivity in White Oak Lake is found in the sediments, and most is the result of three radionuclides, ^{137}Cs, ^{60}Co, and ^{90}Sr. Preliminary screening of nonradiological contaminants in the lake indicated that As, Cr, Mn, Ag, Ni, Cd, and Pb were present in high enough concentrations in the water to warrant further investigations.

3.4.2 GROUNDWATER

The proposed WHPP site lies within the White Oak Creek drainage basin in Melton Valley (see Fig. 16). Melton Valley is bordered on the southeast by Melton Hill and on the northwest by Haw Ridge. As part of a data collection program associated with ongoing ORNL remedial investigations in nearby lower White Oak Creek, groundwater monitoring in several piezometers provides the most reliable groundwater data for the WHPP site. Groundwater studies rely on the piezometers to provide areal monitoring for suspected

groundwater contamination from past and present waste disposal operations. Piezometers typically monitor water level and water quality in the upper portion of the saturated zone.

The conceptual model for groundwater flow on the ORR envisions aquifer recharge on topographic highs and discharge to surface drainages in valleys for eventual surface discharge to the Clinch River. Groundwater gradients generally mimic topography, and flow is roughly normal to groundwater gradient. Piezometer locations near the WHPP site are shown on Fig. 18.

Hydraulic properties of the groundwater system must be known to describe flow. Data from the Engineering Test Facility (ETF)[32] nearby in Melton Valley (Table 3) may be reasonably extrapolated to provide general indications of aquifer properties at the WHPP site. The approximate location of the ETF is shown on Fig. 16.

3.4.2.1 Groundwater movement

Groundwater flow in an unconfined aquifer generally moves in a direction normal to the groundwater gradient. These conditions are most closely met in the near-surface weathered bedrock. Below this material in unweathered bedrock, flow is influenced by complex interactions of local bedding, solution channels, and fracture systems. Thus, localized groundwater movement in the deeper portions of the groundwater system may have little relationship to the direction of movement indicated by the groundwater gradient.

Water level data from WHPP site area piezometers adjacent to lower White Oak Creek indicate flow in the shallow groundwater system is generally toward White Oak Creek (Fig. 19). Flow in the deeper bedrock system may vary somewhat from the flow direction in the shallow system. Recent hydrographs for piezometer pairs 782/783 and 784/785 are shown in Figs. 20 and 21 respectively.

Slug testing was performed on 38 piezometers in lower White Oak Creek floodplain to obtain estimates of hydraulic conductivity and transmissivity. The geometric mean of the values is 0.056 m/day for hydraulic conductivity and 0.180 m^2/day for transmissivity.

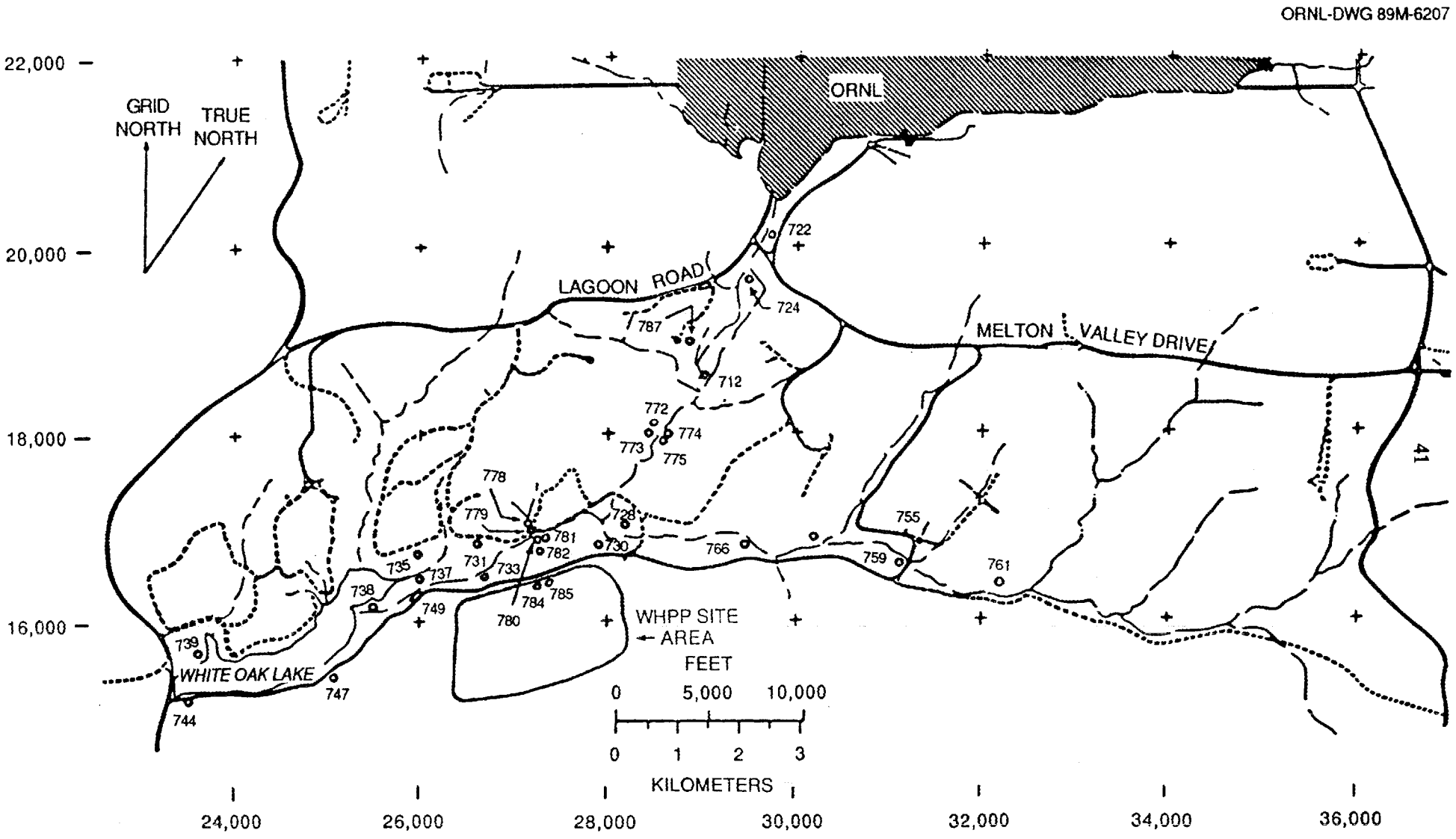


Fig. 18. White Oak Creek watershed piezometer locations.

Table 3. Summary of aquifer characteristics at the Engineering Test Facility in Melton Valley

Tracer test	Average linear velocity	0.17 m/d
Pump test	Transmissivity (T)	1.25×10^{-3} to 4.36×10^{-3} m^2/min
	Storage coefficiency (S)	5×10^{-4} to 0.01
Well slug test	Hydraulic conductivity (K)	6.31×10^{-5} cm/s
Darcy equation	Effective porosity (O)	0.03
	Effective aquifer thickness	67 m

Source: Davis et al. 1984.[32]

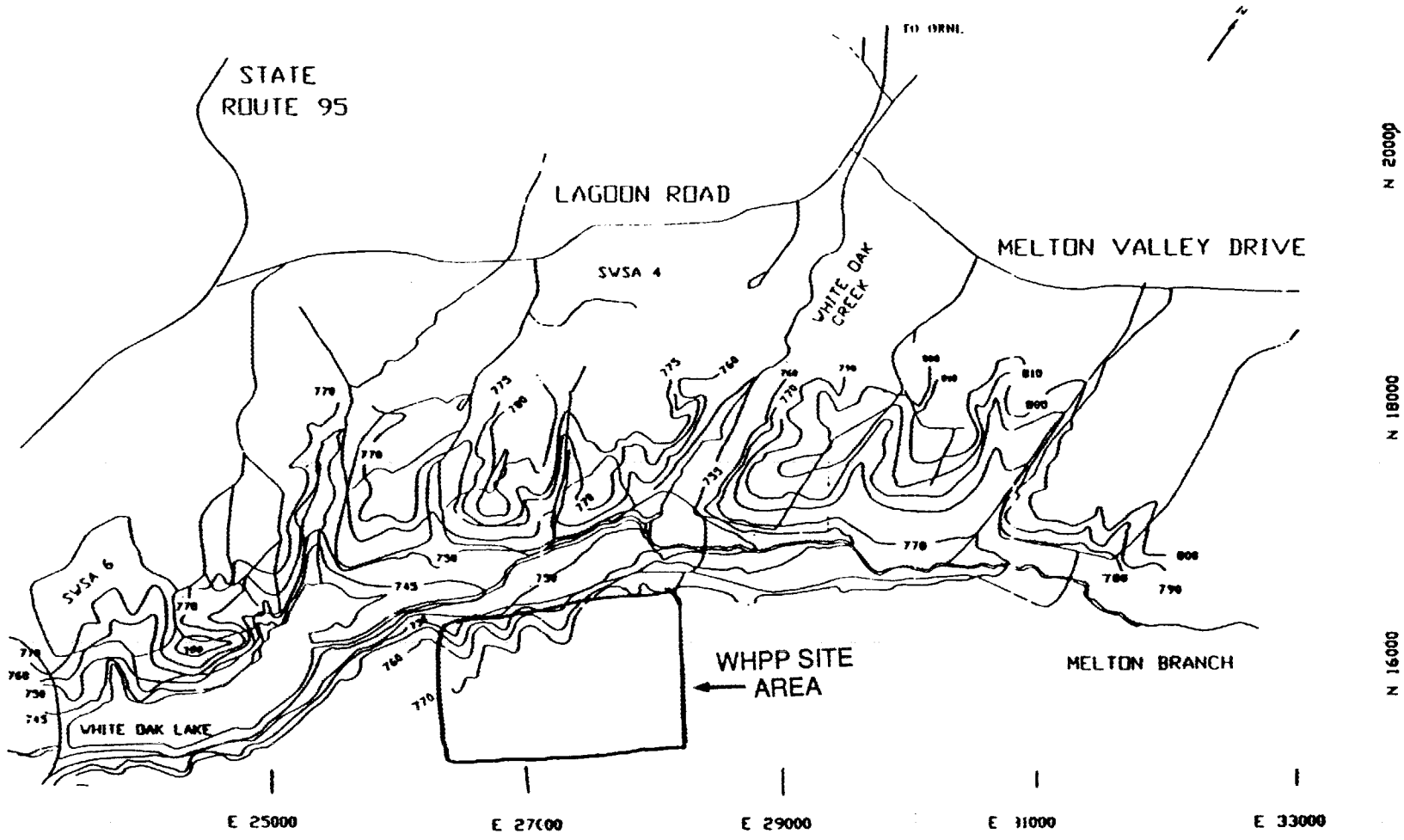


Fig. 19. White Oak Creek floodplain water table configuration, May 1987.

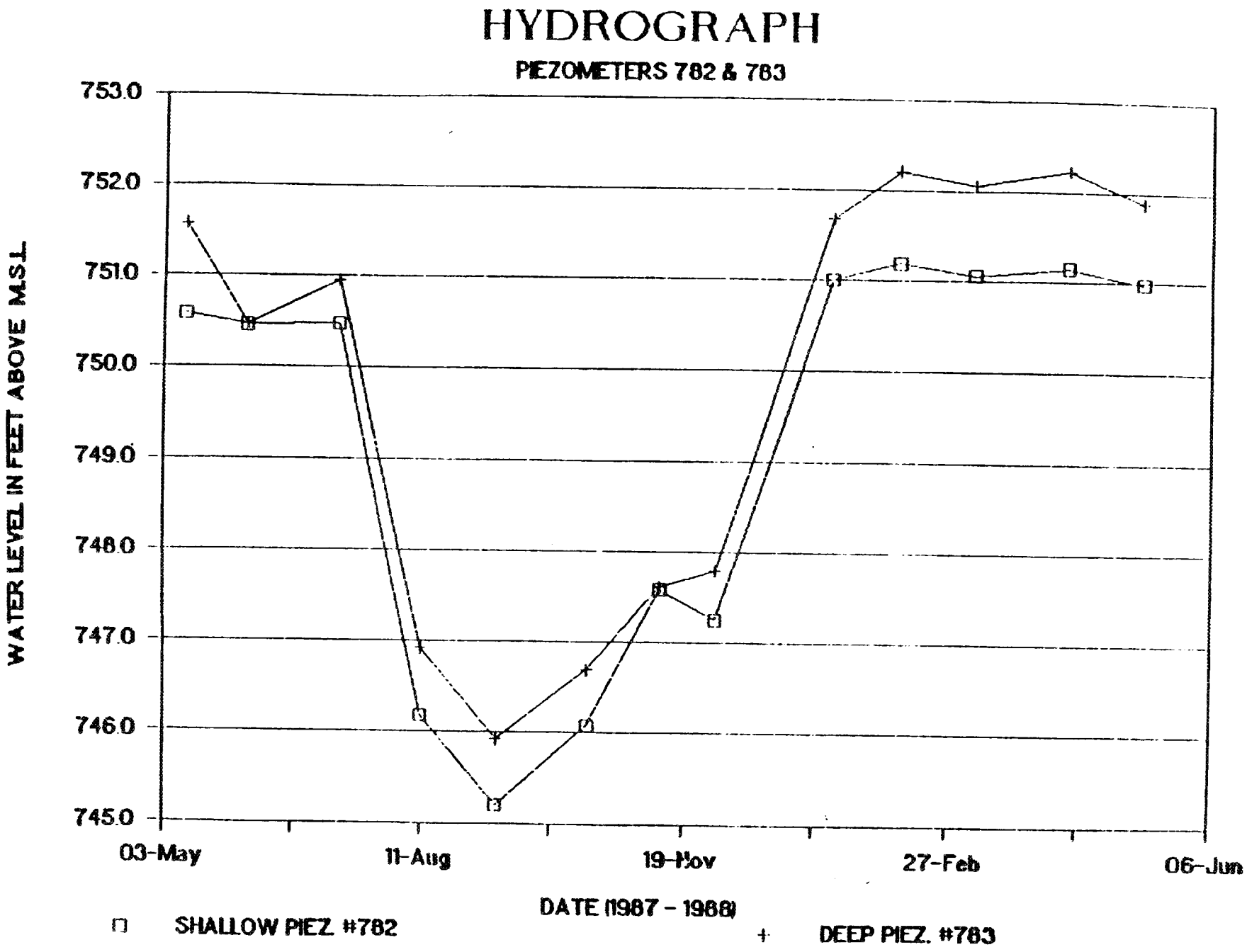


Fig. 20. Hydrograph for piezometer pair 782 and 783.

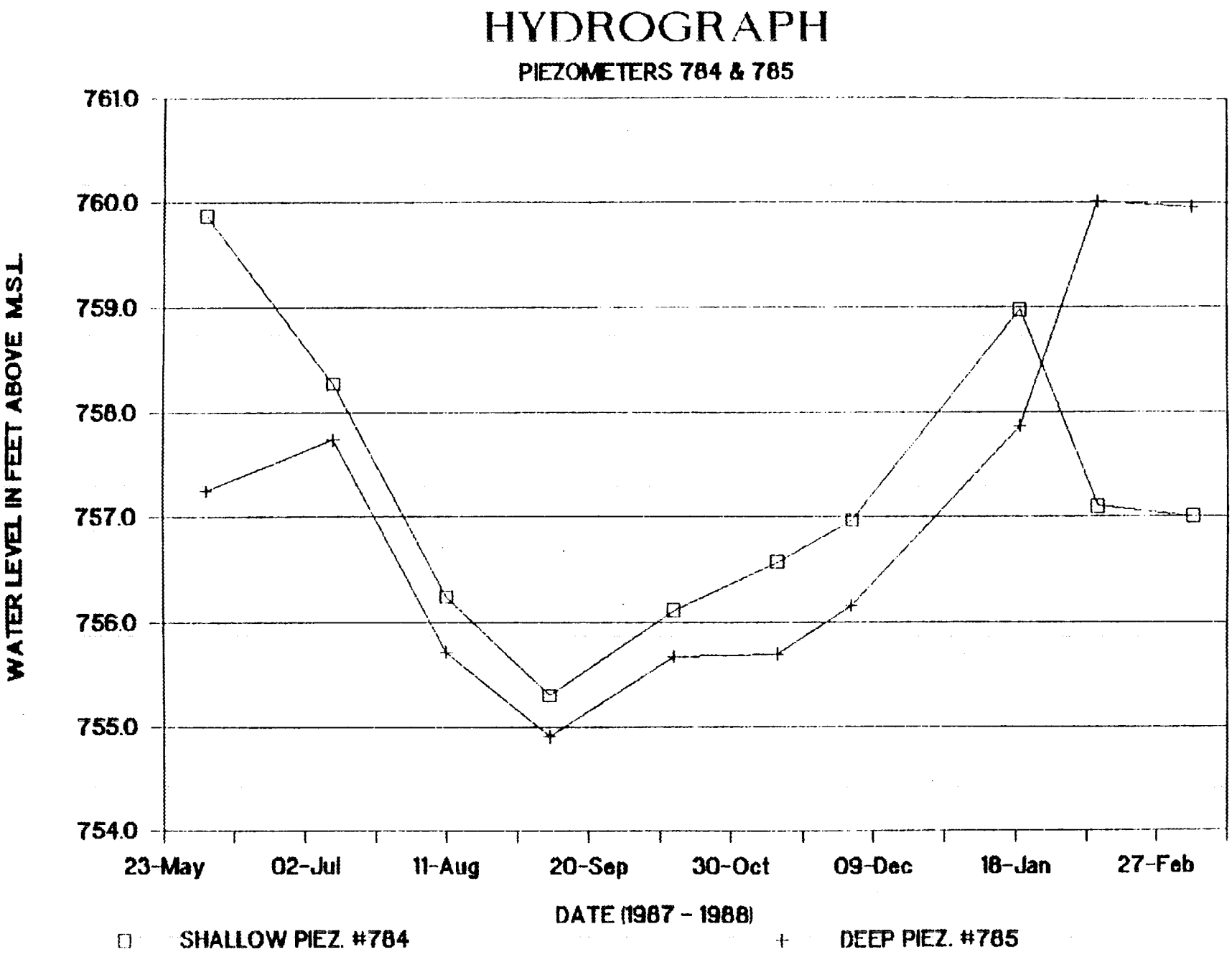


Fig. 21. Hydrograph for piezometer pair 784 and 785.

3.4.2.2 Groundwater quality

Water quality samples were collected from 27 shallow piezometers during the period March through July 1987. Analytical results are shown in Table 4 for piezometer #782, which is the sampling well nearest the proposed WHPP site and which is probably most representative of groundwater at the WHPP site. Instances of chemical and radiological contamination of the shallow groundwater are attributed to upstream facilities on Melton Branch. Those wells south of the White Oak Creek floodplain and near the WHPP site area, such as #782, show considerably less contamination than those located in the floodplain, such as #733. A groundwater characterization and monitoring program is planned at the WHPP site in 1989 to define the water table configuration groundwater quality.

3.5 ECOLOGY

This section describes the terrestrial and aquatic ecosystems, including threatened or endangered species, at the proposed site for the WHPP on the ORR. Field surveys were conducted during June and July 1988.

3.5.1 Terrestrial Biota

Field surveys for terrestrial biota were conducted within the area shown on Fig. 22.

3.5.1.1 Flora

The general vegetative cover of the ORR is about 80% forest. Plant communities on and near Reservation lands are characteristic of those found in the inter-mountain regions of central and southern Appalachia. The dominant deciduous forest is an oak/hickory association. Extensive stands of shortleaf pine and mixed hardwoods (maple, hickory, sourwood, dogwood, redbud, hackberry, elder, sycamore, oak, elm, sweet gum, and yellow poplar) typify the area. Yellow poplars often form nearly pure stands on well-

Table 4. Groundwater constituent concentrations measured in shallow piezometer #782 on the White Oak Creek floodplain
(Units are in mg/L except radiological concentrations, which are in Bq/L.)

Parameter	Concentration
Cl	44
F	<1
NO_3	<1
PO_4	<1
SO_4	17
Ag	<0.05
Al	<0.2
As	<0.1
B	0.17
Ba	0.21
Be	<0.002
Ca	64
Cd	<0.005
Co	<0.01
Cr	<0.04
Cu	<0.02
Fe	0.094
Ga	<0.3
Li	<0.2
Mg	11
Mn	0.053
Mo	<0.04
Na	16
Ni	<0.06
P	<0.3
Pb	<0.2
Sb	<0.2
Se	<0.2
Si	8.3
Sn	<0.05
Sr	1.1
Ti	<0.02
V	<0.01
Zn	<0.02
Zr	<0.02
^{60}Co	<0.2
^{137}Cs	<0.2
G-alpha	<1
G-beta	1.6
^{3}H	<30
^{90}Sr	0.1

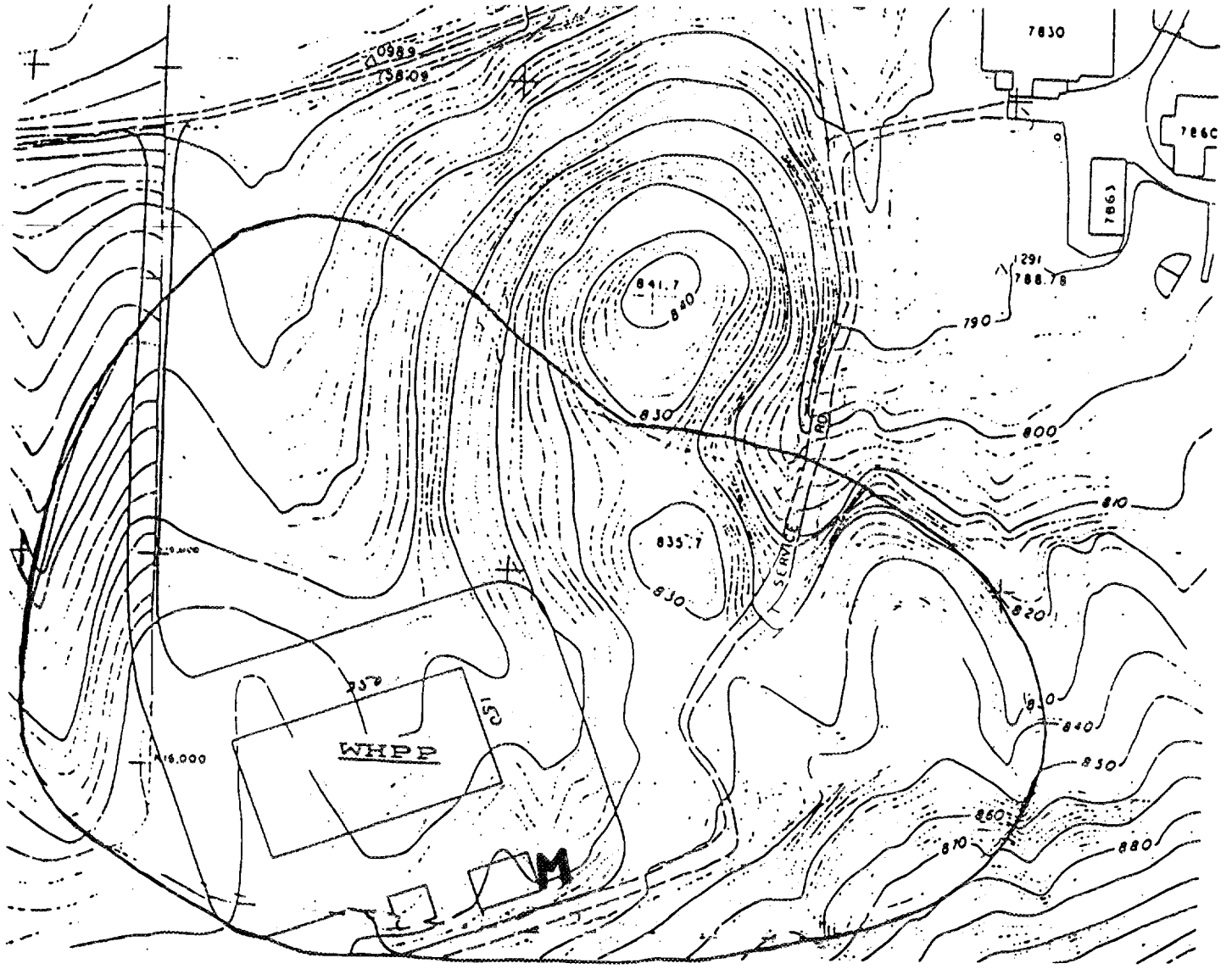


Fig. 22. Topographic map of the proposed Waste Handling and Packaging Plant site with the ecological survey area circled and the wet meadow indicated by the letter "M".

drained bottomlands, sinkholes, and lower slopes. Willow, sycamore,and box elder are found along stream banks and are dominant on poorly drained floodplains. Coniferous forests are largely cedar, hemlock, white pine, and shortleaf pine. The ORR forest is managed and maintained as a multiuse area. The forested land provides health and safety buffers, research areas, wildlife habitats, habitats for endangered plants, and occasional revenue from timber harvests. Environmentally, the forest provides the needed ecological balance for evapotranspiration of water, erosion control, and purification of the air. Aesthetically, the forest provides natural serenity and beauty in contrast to the industrial facilities on ORR.

A survey of vegetation was conducted at the proposed WHPP site in June and July 1988. The survey area was highly disturbed from homesteading prior to 1942. Succession on the fields of the former homestead has produced a relatively open forest of pines and cedars with some hardwood species (e.g., yellow poplar). On the ORR, this type of vegetation is typical of shallow soils over limestone (or dolomite). The dominant species is eastern red cedar, associated shortleaf and Virginia pine, yellow poplar, oaks, hickories, redbud, sassafras, and other hardwoods. The WHPP site lies at the base of Melton Hill. The forest on the steep slopes of Melton Hill above the WHPP site is unusually undisturbed.

No plant species on state or federal lists (or proposed for federal listing) were found to occur in the survey area for the proposed WHPP site.[33] Within the surveyed site is a small area, about a tenth of an acre, of wet meadow (an uncommon habitat on the ORR) which is produced by seepage (indicated by "M" on Fig. 22). Two uncommon species, Acorus calmus (sweetflag) and Selaginella apoda (a species of spikemoss, which is a fern ally), were noted in the wet meadow.

3.5.1.2 Fauna

Because of its small size, the WHPP site possesses relatively few habitat types and supports only a fraction of the number of faunal species found on ORR. The site's vertebrate fauna consists of species relatively common to the ORR's second-growth, mixed hardwood-pine forest. A few of these are the rat snake, black racer, red-eyed vireo, scarlet

tanager, red-tailed hawk, yellow-billed cuckoo, deer mouse, gray squirrel, flying squirrel, and white-tailed deer. No field or wetland habitats for wildlife are present on the site.

No animal species listed by the U.S. Fish and Wildlife Service as threatened or endangered is known to be present on the ORR.[34] Of the species listed as threatened or endangered by the Tennessee Wildlife Resources Commission, the only one known to occur on the ORR is the threatened Cooper's hawk, a woodland hawk that is secretive and difficult to find during the breeding season. Although it was not found during a brief survey of the WHPP site, it has been observed during the nesting season in several areas on the ORR and probably has a low-density population (e.g., 1 pair per 6 to 8 square miles) throughout the Reservation's forested areas. Conversion of forest to industrial areas would reduce the habitat available to the Cooper's hawk and would be expected to adversely affect this hawk's actual or potential population size on the ORR. However, any effect of the WHPP on the Cooper's hawk would be very small because of the project's small size.

The state of Tennessee also lists about 80 vertebrate species as "in need of management" (ref. 34). Such species that may occur on and in the vicinity of the WHPP site are the black vulture and red-shouldered hawk. Neither one is known to nest on the site.

3.5.2 Aquatic Biota

Early reports on the aquatic biota of lower Melton Branch and White Oak Creek have been summarized in Loar et al.[28] Most recently, extensive studies of these streams have been carried out which include not only instream ecological monitoring, but also toxicity monitoring, radioecological studies, and bioaccumulation of nonradiological contaminants. Results of the studies from 1986 and 1987 have been reported.[26,31] Monitoring of these areas is continuing and will be reported annually by Loar. No biological surveys have been conducted on the small, unnamed tributary which drains the north slope of Copper Ridge and runs through the WHPP site.

3.5.2.1 Benthic invertebrates

Annual density of benthic invertebrates in lower Melton Branch averaged 115 organisms/0.1 m^2, and biomass averaged 225 mg/0.1 m^2 (ref. 26). These values were lower than most of those for 15 other sites sampled in the White Oak Creek watershed. Over 80 benthic invertebrate taxa were collected at the lower Melton Branch site, but the taxonomic list was dominated by chironomidae (midge) larvae and contained relatively few examples of "clean water" insects (e.g., mayflies and stoneflies).

Lower White Oak Creek had a mean benthic invertebrate density of 169 organisms/0.1 m^2 and a mean biomass of 494 mg/0.1 m^2 (ref. 26). These values were near the middle of the range for the 16 sites sampled in White Oak Creek watershed. Like Melton Branch, numerous taxa were collected, but the site was numerically dominated by midge larvae and had relatively few mayflies and stoneflies. The benthic invertebrate communities in both Melton Branch and White Oak Creek near the WHPP site are moderately impacted, probably by a variety of stresses including chemical discharges, nutrient enrichment, elevated temperatures, altered flow regimes, and siltation.[26]

Bimonthly sampling of White Oak Lake collected a total of 23 benthic invertebrate taxa, of which 14 were Diptera (true flies).[26] Diptera dominated the benthic invertebrate community of the lake, totaling 93 percent by number and 79 percent by weight of the quantitative samples. The benthic fauna of White Oak Lake is neither very rich nor very diverse, but it is typical of the communities found in small, silt-bottomed pond habitats.

3.5.2.2 Fish

Surveys of the fish communities of Melton Branch have revealed few species. For example, Cada (1986)[35] collected only two species, creek chub (Semotilus atromaculatus) and blacknose dace (Rhinichthys atratulus), at three sites in Melton Branch. More recently, samples in lower Melton Branch (0.6 km above its confluence with White Oak Creek) found creek chub, blacknose dace, and red-breast sunfish (Lepomis auritus).[26] Densities and biomasses in lower Melton Branch varied considerably among dates, but were frequently lower than values from 15 other sites sampled in the White Oak Creek watershed.[26] The

relatively depauperate fish fauna in this stream is probably the result of its small size, intermittent nature over much of its length, and past thermal and chemical discharges from the HFIR. Some recovery of lower Melton Branch has occurred since the HFIR was shut down.

Recent quantitative surveys of lower White Oak Creek collected 12 species of fish, of which five were sunfishes and four were minnows.[26] During 1987, total densities ranged from 0.31 to 0.79 fish/m^2, and total biomass ranged from 5.0 to 21.4 g/m^2, values which were near the middle of the ranges for 15 other sites in the White Oak Creek watershed.

A recent survey of fishes in White Oak Lake collected 18 species, of which the most abundant were bluegill sunfish (Lepomis macrochirus), gizzard shad (Dorosoma cepedianum), largemouth bass (Micropterus salmoides), red-ear sunfish (L. microlophus), carp (Cyprinus carpio), red-breast sunfish, and golden shiner (Notemigonus crysoleucas). Numbers and biomass of each species are given in Appendix F of Loar.[26] The total biomass of fish in the lake (198 kg/ha) was similar to a 1953 estimate and to that of comparable, fertilized ponds in Alabama.[26] In addition to stress from radionuclides and other contaminants, fish in White Oak Lake will continue to be affected by loss of habitat resulting from eutrophication and siltation.

3.5.2.3 Threatened/endangered aquatic species

There are no known threatened or endangered aquatic species on the Oak Ridge Reservation. The mountain redbelly dace (Phoxinus oreas) is listed by the state of Tennessee as in need of management, which requires protection of its habitat. Although the mountain redbelly dace has been found in some Reservation streams, it has not been collected in the extensive surveys of the White Oak Creek watershed.[26]

3.6 AMBIENT RADIOLOGICAL CHARACTERISTICS

3.6.1 Natural Background

The natural background radiation dose to man is received from cosmic rays (primarily galactic and solar cosmic rays) and from external and internal exposure to terrestrial sources. Terrestrial sources include both cosmogenic radionucles (^{3}H, ^{7}Be, ^{14}C, ^{22}Na, and ^{24}Na) and primordial radionuclides (mainly ^{238}U, ^{235}U, ^{232}Th, and daughters, and ^{40}K and ^{87}Rb). The cosmogenic radionuclides are produced through the interaction of cosmic rays with target atoms in the atmosphere and in the earth; the primordial radionuclides are those that have always existed in the earth's crust. The estimated average annual genetically significant dose to individuals in the Oak Ridge area population from natural radiation is about 1.29 mSv (129 mrem/year) (ref. 27). Of this total, external exposure from cosmic and terrestrial radiation accounts for 0.44 mSv (44 mrem) and 0.60 mSv (60 mrem) respectively. Internal exposure via inhalation and ingestion of naturally occurring radioactivity yields about 0.25 mSv (25 mrem).

3.6.2 Man-Made Radioactive Pollutants

Man-made radiation sources include residual fallout from nuclear weapons testing, routine nuclear power plant operation, medical uses of radiation, air transportation, technologically enhanced radiation, and consumer products containing and/or emitting radiation. Annual doses to a typical U.S. resident from these sources are estimated to be 40 μSv (4 mrem) from fallout, 3 μSv (0.3 mrem) from nuclear power, 0.92 mSv (92 mrem) from medical uses (diagnostic and radiopharmaceutical), 40 μSv (4 mrem) from technologically enhanced radiation, 5 μSv (0.5 mrem) from air travel, and about 50 μSv (5 mrem) from consumer products.[27]

In the Oak Ridge area, in addition to the above sources are routine releases from the Oak Ridge nuclear facilities. External gamma radiation measurements are made routinely at the perimeter and remote air monitoring stations, at ORNL's local air monitoring stations, along the Clinch River near ORGDP, and at known contaminated

areas at ORNL. Groundwater from solid waste disposal areas is analyzed routinely from about 150 wells on the ORR for radionuclides. Liquid wastes in the major discharge streams for all plants, the Clinch River, and the Kingston Water Plant are monitored for radioactive and nonradioactive materials.

One of the most important pathways of radioactivity to humans is from atmospheric deposition and uptake in vegetation and animals. Monitoring of this pathway consists of measuring uptake by soil and grass and in deer muscle and cow's milk. Radionuclides are analyzed in deer killed on the ORR and in milk samples from surrounding dairies. Aquatic pathways have also been monitored on the ORR through analysis of fish tissue and stream sediments at various locations in the Clinch River.

The following description of existing radiological conditions on the ORR is based on monitoring data from 1981.[36,37]

Combined stack releases from ORNL indicate that annual discharges of ^{131}Iodine to the atmosphere were less than or equal to 17.6 gigabecquerels (GBq) [0.48 curies (Ci)]. The average annual concentration of ^{131}I at the perimeter stations was more than 2.5 times greater than the concentration at the background stations. However, this concentration was < 0.01% of the inhalation concentration guide for individuals in uncontrolled areas.

Analysis of radioactivity at local and perimeter air monitoring sites indicates that the average annual concentrations are well below DOE criteria (DOE Order 5480.1, Chap. XI). However, it appears that the average annual concentration of alpha activity at the ORNL local air monitoring stations is about twice (0.75E-4 Bq/m^3) that of the average background concentration (0.39E-4 Bq/m^3) measured at the remote stations. Average annual concentrations were not different at the perimeter (0.33E-4 Bq/m^3) and the background stations.[37]

There appear to be no differences in the average annual concentrations of beta activity at the local, perimeter, or remote (background) sites based on the analysis of filter paper, gummed paper, and rainwater.[37]

The average annual concentrations of several specific radionuclides were higher at the local and perimeter stations than at the remote stations:[37] The thorium species was 2 to 3 times higher; the uranium species was 5 to 6 times higher; and plutonium-238 was 5

times higher. All specific radionuclides were at least 1000 times less than the applicable DOE concentration guides for the radionuclides detected.[37]

4. POTENTIAL ENVIRONMENTAL ISSUES

4.1 COMMUNITY RESOURCES

Construction and operation of the WHPP would not be expected to adversely impact local communities. Construction labor will be derived from an available local pool; plant operators will likely be DOE contractor employees.

A decision as to the fate of the potentially historic structure near the WHPP site will be made after consideration of the conclusions from The University of Tennessee survey. The Jenkins House site is not deemed significant enough to warrant its inclusion on the National Register of Historic Places. However, the best management policy for any cultural property is avoidance.

4.2 AIR QUALITY

Construction of the WHPP and the development of utilities and access roads will likely cause short-term degradation of air quality in the immediate vicinity. Vehicle exhaust will increase levels of carbon monoxide and hydrocarbons; excavation and construction traffic will increase fugitive dust. None of these impacts would affect sensitive receptors.

Operation of the WHPP will result in routine atmospheric releases from process areas. Stack gas pollution control equipment, including HEPA filters, will be installed and an isokinetic sampling system is planned to monitor exhaust gases.

4.3 GEOLOGY AND GEOHYDROLOGY

Investigations to date have identified no geologic or geohydrologic site characteristics of environmental concern. While preliminary data analysis does not support an interpretation for the presence of the WOC Fault in the WHPP site area, ongoing investigations may determine that modification of this conclusion is warranted. If this

occurs, the potential for the WOC Fault to provide a preferred pathway for contaminant migration to groundwater must be addressed quantitatively.

Structures will be designed for the seismic zone of ORNL (Zone 2) in accordance with the Uniform Building Code. Reinforced concrete will be used in cell areas. In addition, the overhead cranes, off-gas exhaust stacks, and process equipment will be designed appropriately for the seismic loads. The ability of the WHPP to withstand hazardous seismic events will be further addressed in the safety analysis for the plant.

4.4 SURFACE WATER QUALITY AND AQUATIC ECOLOGY

4.4.1 Construction

Site clearing and construction of access roads, buildings, fences, etc., would result in soil erosion and subsequent sedimentation in nearby water bodies (White Oak Creek, White Oak Lake, perhaps Melton Branch, and any other streams that might be affected by road building). Because the WHPP site is on a fairly steep slope, the potential for erosion is high. Spills of chemicals, oils, etc., used in construction could also migrate to these water bodies if not properly contained. Proper construction practices (e.g., Best Management Practices, berms, filter strips, settling basins) should prevent significant impacts to aquatic systems from construction.

4.4.2 Operations

The WHPP will be designed as a "zero-discharge" facility, therefore, routine operation would not affect aquatic systems. Thus, concerns about aquatic ecosystems would be related to only impacts of accidental releases of contaminants both at the WHPP site and from transportation accidents.

4.5 TERRESTRIAL ECOLOGY

Construction of the WHPP will result in the loss of terrestrial flora and fauna relatively common to the ORR. No known federally listed or state-listed threatened and endangered species will be affected.

Routine operation of the WHPP will result in "zero discharge" of effluents to the ecosystem and controlled releases of atmospheric pollutants; therefore, adverse impacts are unlikely.

4.6 RADIATION

Tables 5 and 6 summarize the radiological impacts calculated as doses to the maximally exposed individual and the population from data for ORR releases in 1981 and 1982. For ORNL, the dose to the individual was two orders of magnitude less than background. For the general population, the gaseous exposure dose was equal to background and the liquid dose an order of magnitude greater than background. The WHPP will be designed to release no radioactive atmospheric pollutants under normal operating conditions; therefore, radiological doses to the individual and the public near the ORR would not be expected to change significantly as a result of WHPP operation.

Table 5. Composite radiological impacts on the maximally exposed individual[a] from nuclear facilities on the ORR[b]

Exposure pathway	Dose (person-Sv[c]) ORNL	ORGDP	Y-12
Gaseous	3.8E-6	3.7E-8	6.1E-6
Liquid	6.0E-5[d]	3.2E-10	e
Total	6.4E-5	3.8E-8	6.1E-6
Composite[f]	7.0E-5		
Natural background	1.29E-3	1.29E-3	1.29E-3

[a]Maximum individual dose to the total body from each facility. Radiation doses are not to the same individual.

[b]Source: Daniels, K. L., *Resource Management Plan for the U.S. Department of Energy Oak Ridge Reservation,* Volume 5, Appendix E: Environmental Monitoring.

[c]To convert Sieverts to rem, multiply by 100.

[d]Doses from liquid effluents from ORNL include a shoreline dose.

[e]Liquid effluents from Y-12 into East Fork Poplar Creek not considered an exposure threat.

[f]Composite = ORNL + ORGDP + Y-12.

Table 6. Composite radiological impacts on the surrounding population[a] from nuclear facilities on the ORR[b]

Exposure pathway	Dose (person-Sv[c]) ORNL	ORGDP	Y-12
Gaseous	1.1E-3	4.4E-4	4.5E-2
Liquid	3.8E-2	1.5E-5	d
Total	3.9E-2	4.6E-4	4.5E-2
Composite[e]	8.4E-2		
Natural background[f]	1.1E3	8.7E2	9.5E2

[a]For gaseous releases, population used for ORNL was 841,211 persons; for ORGDP, population was 678,053 persons; and Y-12 population was 734,387 persons.

[b]Source: Daniels, K. L., *Resource Management Plan for the U.S. Department of Energy Oak Ridge Reservation*, Volume 5, Appendix E: Environmental Monitoring.

[c]To convert person-Sv to person-rem, multiply by 100.

[d]Only includes drinking water from Clinch and Tennessee rivers (downstream from ORNL and ORGDP). Liquid effluents from Y-12 into East Fork Poplar Creek not considered as exposure threat.

[e]Composite = ORNL + ORGDP + Y-12.

[f]Using 1.29 mSv as background dose to individual multiplied by each population group.

5. REFERENCES

1. U.S. Department of Energy Order 5820.2, Radioactive Waste Management, Feb. 6, 1984.

2. U.S. Department of Energy, Joint Integration Office, Draft Long-Range Master Plan for Defense Transuranic Waste Management, March 1987.

3. U.S. Department of Energy, Assistant Secretary for Defense Programs, Final Environmental Impact Statement: Waste Isolation Pilot Plant, DOE/EIS-0026, October 1980.

4. Oak Ridge National Laboratory TRU Waste Program, Current Year Work Plan (FY 1987), RH Strategy Implementation, FTP/A No. ONLWT73, Oak Ridge National Laboratory, Oak Ridge, Tenn.

5. Campbell, A. W., Disposal of Remotely Handled Transuranic Waste from Oak Ridge National Laboratory: A Strategy for NEPA Compliance, ORNL/TM-10802, Oak Ridge National Laboratory, Oak Ridge, Tenn., June 1988.

6. Oak Ridge National Laboratory TRU Waste Program, Revised Draft, Inventory Work-off Plan for Transuranic Waste at the Oak Ridge National Laboratory, Oak Ridge, Tenn., June 1987.

7. U.S. Department of Energy, Joint Integration Office, TRU Waste Management Program, Cost/Schedule Optimization Analysis, DOE-JIO-004, October 1985.

8. Martin Marietta Energy Systems, Inc., Engineering, Feasibility Study for RH TRU Waste Handling Facility, X-OE-254, Sept. 28, 1984.

9. NUS Corp., Technical and Economic Evaluation of Alternation Solidification Technologies Applicable to Melton Valley Wastes, August 1986.

10. L. J. Mezga, Martin Marietta Central Waste Management Office, Strategic Solid Radioactive Waste Management Plan for the Department of Energy Installations Operated by Martin Marietta Energy Systems, Inc., March 1987.

11. U.S. Department of Energy, Joint Integration Office, Defense Remote-Handled Transuranic Waste Implementation Plan, DOE-JIO-026, October 1987.

12. Haase, C. S., E. C. Walls, and C. D. Farmer, Stratigraphic and Structural Data for the Conasauga Group and the Rome Formation on the Copper Creek Fault Block near Oak Ridge, Tennessee: Preliminary Results from Test Borehole ORNL-JOY No. 2, ORNL/TM-9159, Oak Ridge National Laboratory, Oak Ridge, Tenn., June 1985.

13. Haase, C. S., E. C. Walls, and C. D. Farmer, Stratigraphic and Structural Data for the Conasauga Group and the Rome Formation on the Copper Creek Fault Block near Oak Ridge, Tennessee: Preliminary Results from Test Borehole ORNL-JOY No. 2, ORNL/TM-9159, June 1985.

14. Lutz, C. T. and R. B. Dreier, Differences in Local Deformation History as Indicated by Fracture Orientations in Two Foreland Thrust Sheets, Geol. Soc. Am. Abstracts with Programs, 1988, p. A182.

15. Dreier, R. B. and C. M. Beaudoin, Shallow Trench Characterization Study, Preliminary Report, ORNL/RAP86-86, September 1986.

16. Dreier, R. B., C. S. Haase, C. M. Beaudoin, H. L. King, and J. Switek, Summary of Geological Data in the Vicinity of the Hydrofracture Facilities, ORNL/RAP/LTR-87/26, June 1987.

17. Dreier, R. B., R. J. Selfridge, and V. M. Mares, Status Report on Hydrofracture Structural and Geophysical Investigations, ORNL/RAP/LTR-87/72, September 1987.

18. Nestor, C. W. and J. M. Bownds, PLOT3D: Computer Software for Fitting a C1 Surface and Contours to Irregularly Spaced Data, unpublished.

19. Seismic Investigations for the AEC Gaseous Diffusion Plants, John A. Blume & Associated Engineers, San Francisco, Report No. JABE-UCC-01, prepared for the Union Carbide Corp., Nuclear Div., Oak Ridge, Tenn., May 1973.

20. Seismic Design Criteria, Gaseous Diffusion Plants, Oak Ridge, Tennessee, Paducah, Kentucky, and Portsmouth, Ohio, Dames & Moore, San Francisco, prepared for the Union Carbide Corp., Nuclear Div., Oak Ridge, Tenn., April 1973.

21. Hasselman, T. K., Seismic Criteria for Design, Analysis and Test of the Gas Centrifuge, J. H. Wiggins Company, Tech. Report 77-1315-1, prepared for the AiResearch Manufacturing Company of California (AiR), Torrance, Calif., April 1978.

22. McClain, W. C., and O. H. Meyers, Seismic History and Seismicity of the Southeastern Region of the United States, U.S. Atomic Energy Commission Report ORNL-4582, Oak Ridge National Laboratory, Oak Ridge, Tenn., June 1970.

23. Seismic Hazard Analysis for Oak Ridge National Laboratory and the Paducah, Portsmouth and FMPC Sites, TERA Corp., submitted to Lawrence Livermore National Laboratory, February 1981.

24. Beavers, J. E., W. E. Manrod, and W. C. Stoddart, Recommended Seismic Hazard Levels for the Oak Ridge, Tennessee; Paducah, Kentucky; Fernald, Ohio; Portsmouth, Ohio, Department of Energy Reservations, K/BD-1025/R1, December 1982.

25. Lee, S. Y., et al., Soil and Surficial Geology Guidebook to the Oak Ridge Reservation, ORNL-10803, Oak Ridge National Laboratory, Oak Ridge, Tenn., June 1988.

26. Loar, J. M., ed., Second Annual Report on the ORNL Biological Monitoring and Abatement Program, Draft ORNL/TM, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1988, 475 pp.

27. Boyle, J. W., et al., Environmental Analysis of the Operation of the Oak Ridge National Laboratory (X-10 Site), ORNL-5870, Oak Ridge National Laboratory, Oak Ridge, Tenn.

28. Loar, J. M., J. A. Solomon, and G. F. Cada, Technical Background Information for the ORNL Environmental and Safety Report, Vol. 2: A Description of the Aquatic Ecology of White Oak Creek Watershed and the Clinch River Below Melton Hill Dam, ORNL/TM-7509/V2, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1981, 198 pp.

29. Oakes, T. W., et al., Technical Background Information for the ORNL Environmental and Safety Report, Vol. 4: White Oak Lake and Dam, ORNL-5681, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1982, 233 pp.

30. Sherwood, C. B., and J. M. Loar, Environmental Data for the White Oak Creek/White Oak Lake Watershed, ORNL/TM-10062, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1987, 178 pp.

31. Loar, J. M., et al., First Annual Report on the ORNL Biological Monitoring and Abatement Program, Draft Report, ORNL/TM-10399, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1987, 354 pp.

32. Davis et al., Site Characterization Techniques Used at a Low-Level Waste Shallow Land Burial Field Demonstration Facility, ORNL/TM-9146, Oak Ridge National Laboratory, Oak Ridge, Tenn., July 1984.

33. Parr, P. D., "Endangered and Threatened Plant Species on the Department of Energy Oak Ridge Reservation: An Update," J. Tenn. Acad. Sci. 59(4), 65-68 (1984).

34. Kroodsma, R. L., Resource Management Plan for the Oak Ridge Reservation, Vol. 24: Threatened and Endangered Animal Species, ORNL/ESH-1/V24, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1987, 24 pp.

35. Cada, G. F., Characterization of Fish and Benthic Invertebrates of Melton Branch, Oak Ridge Reservation, unpublished report, 1986, 15 pp.

36. Industrial Safety and Applied Health Physics Division Annual Report for 1981, Oak Ridge National Laboratory, Oak Ridge, Tenn.

37. Environmental Monitoring Report, U.S. Department of Energy Oak Ridge Facilities, Y/UB-16, Oak Ridge, Tenn.

Appendix A

ARCHAELOGICAL SURVEY OF TWO PARTIALLY STANDING STRUCTURES ON THE OAK RIDGE RESERVATION

ARCHAEOLOGICAL INVESTIGATIONS OF THE JENKINS HOUSE SITE (40Re188) AND THE JONES HOUSE SITE (40Re189), COPPER RIDGE, OAK RIDGE RESERVATION, ROANE COUNTY, TENNESSEE

Written by

James E. Myster

for

Environmental Resources Department
Martin Marietta
Oak Ridge, Tennessee

Submitted by

Charles H. Faulkner, Principal Investigator
Midsouth Anthropological Research Center
Department of Anthropology
University of Tennessee
Knoxville, TN 37996-0720
(615) 974-4408

September 1988

Management Summary

On June 21, 1988 the Environmental Resources Department of Martin Marietta contracted with the Midsouth Anthropological Research Center to conduct a Phase II survey of two historic house sites within the Oak Ridge Reservation on the north side of Copper Ridge approximately one mile south of Oak Ridge National Laboratories. Architectural and archaeological field research was conducted on July 25th and 26th and again on August 17th and 19th. This research was conducted in an effort to comply with Section 106 of the National Historic Preservation Act of 1966, the National Environmental Policy Act of 1969, and the Archaeological and Historic Preservation Act of 1974.

In doing the survey, it was decided that each structure would be inventoried and architecturally documented. Subsurface probing, in the form of shovel tests, would be conducted to sample the extent and nature of any archaeological deposits. If any extensive or unusual artifact concentrations were discovered during the shovel tests, 1 X 1 meter units could be excavated. The overall purpose of these investigations was to document all extant remains for posterity before destruction or further deterioration, and to judge the significance of these sites for possible inclusion on the National Register of Historic Places. To achieve these ends, certain goals were specified: to establish a date range for construction and occupation of the structures, to identify the people who owned and possibly lived in these dwellings, and to assess the integrity, density, and depth of any architectural and archaeological remains.

The Jenkins House site (40Re188) has been irreversibly and adversely affected by modern activity. In addition, the site's natural surroundings have been compromised. While both the log house and the log smokehouse are very well made, they are only partially standing today. The archaeology performed at this site failed to locate any concentrations of artifacts that would indicate special activity areas or locations of household dumping.

The Jenkins House site (40Re188) is not deemed significant enough to warrant its inclusion on the National Register of Historic Places. However, the best management policy for any cultural property is avoidance. Preservation in place for the future enjoyment and research by professionals and the general public is strongly encouraged. If it is at all possible to shift any proposed disturbance away from this site, then, it should be done. On the other hand, if disturbance or wholesale destruction is unavoidable, no further architectural or archaeological work can be justified at this time. It is hoped, however, that as the time nears for the actual destruction of these buildings and their associated archaeological site, the developers of this

piece of land will voluntarily seek the advise of professional archaeologists as to the final disposition of these remains.

The Jones House site (40Re189) is remarkably undisturbed and its natural surroundings are virtually intact. Although the log house is completely collapsed, the odd mixtures of early to late construction styles and artifacts associated with all the structures suggest this site was possibly occupied from the 1820s, or even earlier, into the 1920s. Architectural and archaeological work carried out for this project only began to document the possible research value of this property. While this site represents a typical sourthern Appalachian farmstead, the possibility of a structure being constructed in the early days of Roane county and occupied for at least one hundred years warrants further research.

Therefore, we recommend that the Jones House site (40Re189) be considered for inclusion on the National Register of Historic Places. Again, avoidance of any disturbance to the structures or the land immediately surrounding them is strongly recommended. If disturbance is unavoidable and inevitable than these further recommendations for research should be considered: (1) More detailed documentation and investigation into the construction dates and relationships between the pens of the house and among all the structures; (2) The placement of shovel tests and/or excavation units within the log house and the log barn; (3) The further investigation of that cultural or natural deposit to the southwest of the log smokehouse; and (4) The tracing of the ownership of the property before 1919. There was not enough time to follow up on all the possible leads or to effectively sort out all the similarly described properties.

Acknowledgments

Many people have added so much to this project. The field work was conducted by Jody Carter, Michael Green, Harley Lanham, Hank McKelway, Rick Richardson, Carole Tucker and Lee Ann Wilson. My thanks to Lee Ann for guiding me through the maze of county deed books. Evelyn Badgett, Dave Marsh and Hank McKelway worked on washing, sorting, cataloging and analyzing the artifacts in the laboratory. Terry Faulkner drafted the site map figures. My wife, Sue, helped with the final editing and preparation.

Many thanks go to Dr. Charles Faulkner for helping me take on this project at such short notice. His advise and experience has been invaluable.

At Oak Ridge, thanks also goes out to Merwin Sanders for his patience. Finally, this project would have been far more difficult if it wasn't for Leonard "Red" Williams. His ability to search for documents at a moment's notice and to wield a mean axe when a stubborn tree was in the way was more than appreciated. To Red, here's to historic sites archaeology!

Introduction

On June 21, 1988 the Environmental Resources Department of Martin Marietta contracted with the Midsouth Anthropological Research Center to conduct a Phase II survey of two historic house sites within the Oak Ridge Reservation on the north side of Copper Ridge approximately one mile south of Oak Ridge National Laboratories. Architectural and archaeological field research was conducted on July 25th and 26th and again on August 17th and 19th. This research was conducted in an effort to comply with Section 106 of the National Historic Preservation Act of 1966, the National Environmental Policy Act of 1969, and the Archaeological and Historic Preservation Act of 1974.

In doing the survey, it was decided that each structure would be inventoried and architecturally documented. Subsurface probing, in the form of shovel tests, would be conducted to sample the extent and nature of any archaeological deposits. If any extensive or unusual artifact concentrations were discovered during the shovel tests, 1 X 1 meter units could be excavated. The overall purpose of these investigations was to document all extant remains for posterity before destruction or further deterioration and to judge the significance of these sites for possible inclusion on the National Register of Historic Places. To achieve these ends certain goals were specified: to establish a date range for construction and occupation of the structures, to identify the people who owned and possibly lived in these dwellings, and to assess the integrity, density, and depth of any architectural and archaeological remains.

Field, Archival and Laboratory Methods

Since these two sites had not been previously documented, the field portion of this project was divided into two sections roughly corresponding to a Phase I and a Phase II archaeological survey. After location of the two sites on a topographic map and access was granted within a restricted portion of the reservation, field reconnaissance was conducted. Both sites represented an intact domestic situation consisting of a log house with an associated smokehouse. One site also had an associated barn nearby. All structures were verbally described, photographed in black and white prints and color slides, and accurately mapped with an optical transit and tape. The log houses were additionally documented on a Canadian Inventory of Historic Buildings Survey Form.

A surface collection of artifacts around the structures was done. A metric grid, orientated with the house but tied into magnetic North, was laid out over each site. Subsurface shovel tests , some 30 cm in diameter and excavated in 10 cm arbitrary levels to sterile soil was encountered, were placed in 2 or 4 meter intervals around the house and between the house and the

smokehouse. No shovel tests were placed around the barn. If interesting or unusual concentrations of artifacts were located by the shovel tests, 1 X 1 meter units were excavated. This situation only occurred at one of the sites. All soil excavated was dry-screened through 1/4" mesh. All artifacts were bagged and returned to the laboratory for analysis.

Archival research focused on two aspects: (1) the settlement history of Roane County and the area now occupied by the Oak Ridge Reservation, and (2) the tracing of the ownership through time of the two sites under study. These sites were located on land acquisition maps produced by the federal government in 1942. From these maps it could be determined who owned the tracts of land under study before selling them to the federal government. With these names in hand, and a description of the properties gleaned from associated documents, deed and will records were consulted at the Roane County Courthouse in Kingston. The ownership of each property was traced as far back as possible. Investigations at the Roane County Public Library, the East Tennessee Historical Society's McClung Collection, and University of Tennessee's Hodges Library revealed information about the general and specific histories of both Roane County and the Oak Ridge Reservation area.

In the laboratory and during report preparation, all pertinent documents obtained during field and archival research were summarized and incorporated into this report. All artifacts recovered during the surface collections, shovel tests, and excavation units were washed, sorted, inventoried, cataloged and analyzed. Counts and ratios of certain artifact classes were done as they pertained to the stated goals of the project. Description of all artifacts were entered on a 5 1/4" computer floppy disk (Microsoft Word 3.0). A printout of these descriptions are in this report. All documents and artifacts recovered during this project are curated at the Department of Anthropology, University of Tennessee, Knoxville, Tennessee.

Environmental Setting

The two sites are located on the north side of Copper Ridge in a small valley drained by White Oak Creek and Melton Branch (Figure 1). These waters drain into White Oak Lake which in turn empties into the Clinch River. The Oak Ridge Reservation lies within the Ridge and Valley Physiographic Province as defined by Fenneman (1938). Set between the Blue Ridge Mountains to the East and the Appalachian Plateau to the West, this province consists of a series of NE-SW trending parallel ridges between rounded shallow valleys. It extends some 1200 miles from Pennsylvania to Alabama. In Tennessee, specifically, the Ridge and Valley province is composed of steeply-folded resistant sandstone, cherty limestone, and siltstone ridges underlain by softer clayey limestone and shale exposed in the valleys (Miller

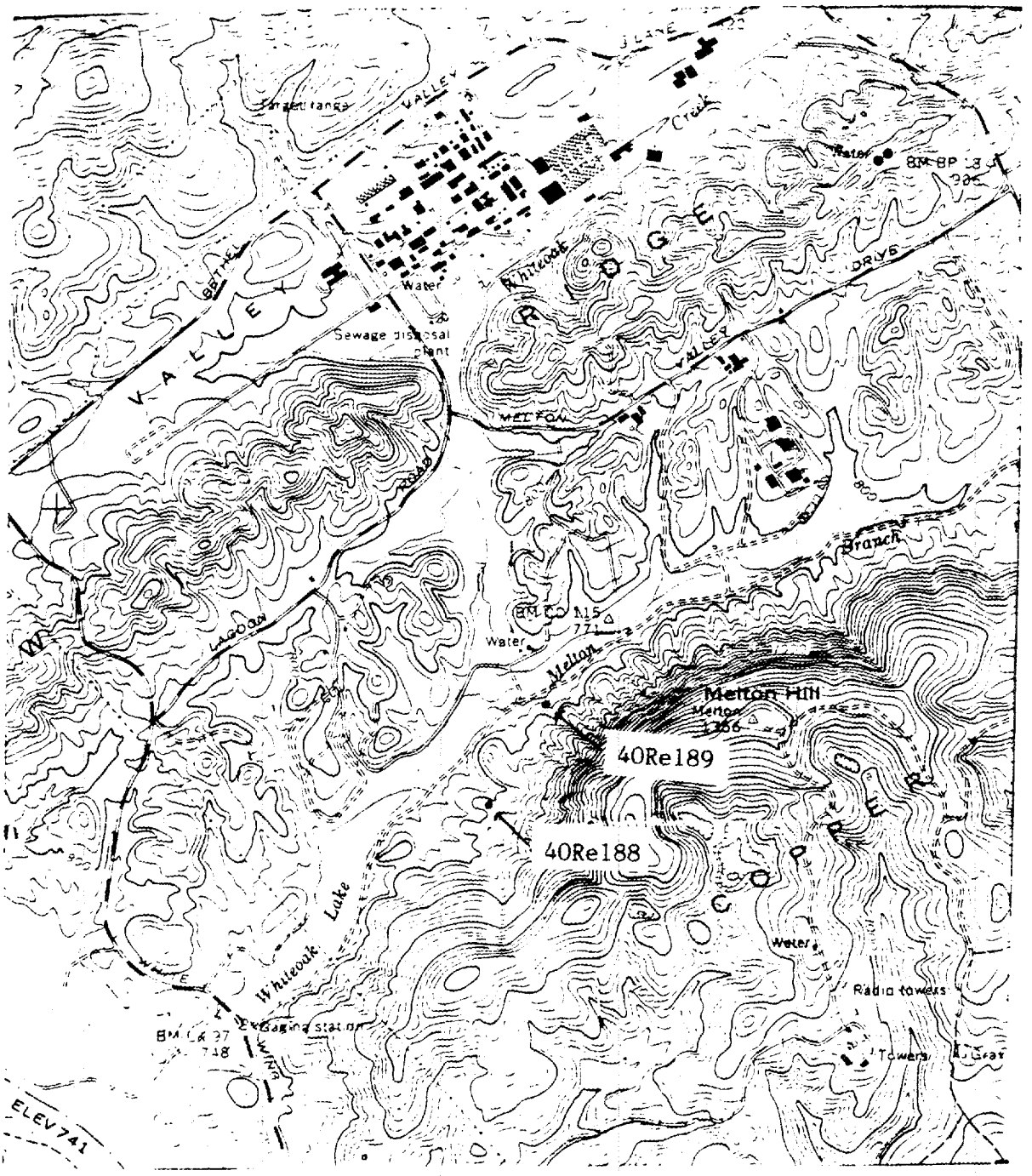


Figure 1. Map of Jenkins House Site (40Re188) and Jones House Site (40Re189) USGS 7.5 Minute Bethel Valley, Tennessee Quad, 1 cm = 240 m, north is toward the top.

1974). Soils in the valley range from highly to poorly productive.

These sites are also within the Carolinian Biotic Province (Dice 1943). The Oak Ridge Reservation is characterized by a thermic temperature regime, udic moisture regime, and a temperate deciduous Oak-Hickory Forest. Animal and plant resources abound. In addition, these resources seem to have remained relatively stable for some time (Delcourt and Delcourt 1981, 1983). The Tennessee Valley has a climate consisting of hot, moist summers with mild, wet winters. Springs and autumns are usually much drier in comparison (Dickson 1978).

Previous Investigations

The majority of early archaeological investigations within and around the Oak Ridge Reservation has focused on prehistoric aboriginal remains. Early surveys by Cyrus Thomas (1894) focused upon significant American Indian sites along the lower Clinch River Valley. In 1933 the Norris Basin survey was conducted under the direction of William Webb (1938). Charles Nash (1941) surveyed sites along the eventual Watts Bar reservoir. In 1960 the area along the Clinch River behind the proposed Melton Hill Dam was surveyed by Charles McNutt (McNutt and Fischer 1960; McNutt and Graham 1961).

By the 1970s, smaller archaeological projects, many mandated by federal cultural protection legislation, became more numerous. From 1972 to 1981, survey and testing was conducted within the area affected by the Clinch River Breeder Reactor site (Schroedl 1972, 1973, 1974a, 1974b, 1988; Jolley 1982). In 1975, George Fielder conducted a survey of both the Exxon Nuclear Company Proposed Bear Creek Plant site (1975a) and the possible expansion area of the Oak Ridge Gaseous Diffusion Plant (1975b). In the 1980s, GAI Consultants (1981) tested the Tennessee Synfuels Associates site. And most recently, Richard Stoops (1988) surveyed two borrow areas on Chestnut Ridge.

In 1974 and 1976 George Fielder conducted an ambitious and extensive inventory and assessment of the prehistoric (1974) and historic (Fielder, Ahler and Barrington 1977) sites within the Oak Ridge Reservation. It appears that the reservation was divided up and sampled according to the tracts of lands delineated by the Federal government in 1942 Land Acquisition Maps. Some tracts were investigated for architectural and archaeological remains while others were not. Unfortunately, the two tracts of land of interest in this project were not inventoried by the 1976 historic sites survey. Therefore, apparently there has been no previous scientific work done on these sites.

Settlement History of the Area

The area now known as Roane County was first permanently settled by Euro-Americans in the late 1780s (Moneymaker 1979). Early settlers consisted of the Scotch-Irish and English pushing west over the mountains from Virginia and North Carolina and Germans moving down the valley from Pennsylvania (Pickel 1971). Although originally part of North Carolina's Washington County, in 1792 this area became part of a newly founded county called Knox. Within four years Knox County became part of Tennessee, this nation's 16th state. By 1799 the residents of this part of Knox County were petitioning state lawmakers to carve out a new county they hoped would be called "Gallatin". In 1801 the lawmakers finally agreed, yet they commissioned the new county "Roane" after Tennessee's newest governor, Archibald Roane (Pickel 1971).

As the 19th century proceeded, the population of Roane County increased. From the beginning, the economy of the county focused on agriculture and remained so well into the 20th century (Johnson and Jackson 1981, Pickel 1971). Corn, potatoes, and tobacco dominated both the subsistence and cash crop economy.

Settlement within the area to become the Oak Ridge Reservation followed closely the general trends of the entire county. The area remained almost entirely rural throughout the 1800s. Only a few small towns, such as Wheat and Scarboro dotted the valleys (Figure 2). It has been estimated that in the 1930s this area was dominated by numerous small farmsteads between 200 to 600 acres in size (Robinson 1950). Few homes had electricity or indoor plumbing (Johnson and Jackson 1981:43). By 1942, around one thousand families--three thousand people--lived within the 59,000 acres that were to become the Oak Ridge Reservation (Johnson and Jackson 1981; Robinson 1950).

In September 1942, the "Manhattan Engineer District", a newly formed wing of the United States Army Corps of Engineers, chose this East Tennessee area in Roane and Anderson counties as one of three secret atomic development zones. Each of these three (the others in Hanford, Washington and Los Alamos, New Mexico) combined to create the atomic bombs that effectively ended World War II on two fateful days in August 1945. On October 6, 1942, the United States District Court for the Eastern District of Tennessee, Northern Division issued a declaration of taking. The residents of 56,000 acres of Roane and Anderson county land were ordered to vacate their properties forthwith. The United States government was assuming control of the land (labelled publicly, but falsely, the "Kingston Demolition Range") vowing to pay the residents a "fair price" for their land. The massive land takeover eventually cost the government nearly $2,500,000. The average price for an acre of land was around $45 (Robinson 1950). The Corps had planned to give people at least six weeks to vacate. However, it appears that many were forced

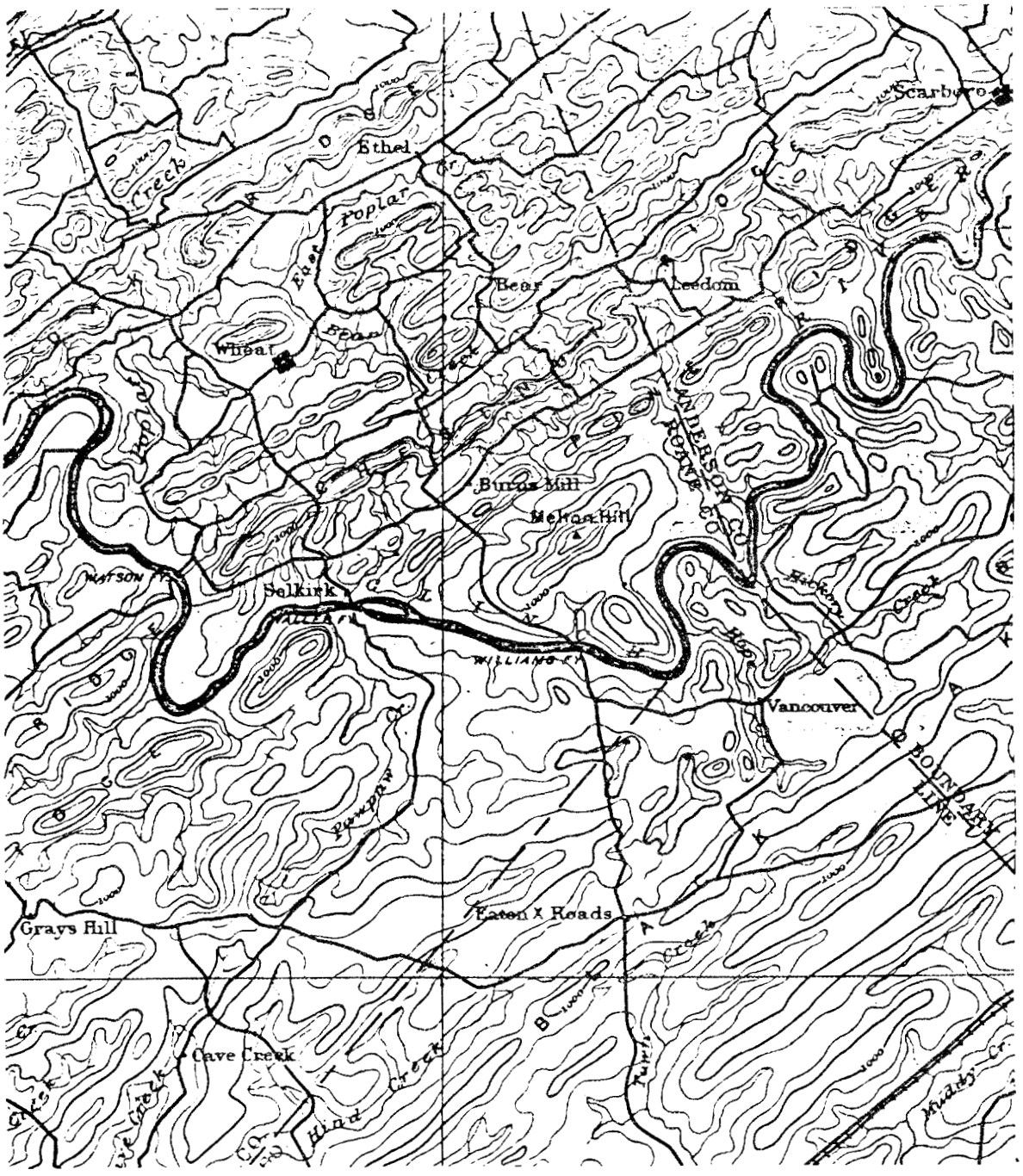


Figure 2. Map of Site Area in 1895. USGS Reconnaisance, Loudon Sheet, 1 cm = 1250 m, north is toward the top.

to leave in as little as two weeks (Overholt 1987). The evacuation proceeded even though many payments to the land owners were not settled upon until long after they had left.

The Jenkins House Site (40Re188)

Site Summary

This site consists of a partially collapsed double entrance singe pen log house (20 X 20 ft) with a well-dressed limestone chimney and an associated partially collapsed log smokehouse (10 X 12 ft) located approximately 35 feet to the west of the house. No other associated outbuildings were located. A modern dirt access road is located 175 feet to the southeast of the house. A bulldozer scrape around ten feet wide branches off the access road to the northwest and runs immediately to the north of both structures (Figures 3 and 4).

The house walls are made of eastern red cedar and poplar logs which show evidence of both ax-hewing and sawing. The corner joinery was half dovetail notching. Some remodeling work has taken place. Interior panelling was fastened by cut and wire nails. The north door frame is secured to the walls by wooden pegs. A possible porch may have extended off the north wall; however, most of the evidence to confirm this may have been lost in the bulldozer scrape. The dressed limestone chimney is partially collapsed. The majority of it is unconsolidated rubble within and to the side of the house.

The smokehouse has one entrance. As with the house, the logs show both ax and saw marks. They appear to be either recycled from another structure or remodeled in place. The structure sits partially on limestone piers and partially on the ground. Joinery consists of half dovetail notching.

Property Ownership

This site is located on property designated as Tract 28 of Section A on the 1942 Final Land Acquisition Maps produced by the United States Army Corps of Engineers in 1942 (Figure 5). Based on a jury verdict on March 10, 1944, the private owners of this tract, D. H. and Lillian T. Jenkins, were paid $3600 for their 234.5 acres. While it is difficult to say whether or not they lived in these buildings, there can be no doubt that the Jenkins' vacated their land long before 1944. More likely, they left with the other residents of the area, sometime in the fall or winter of 1942.

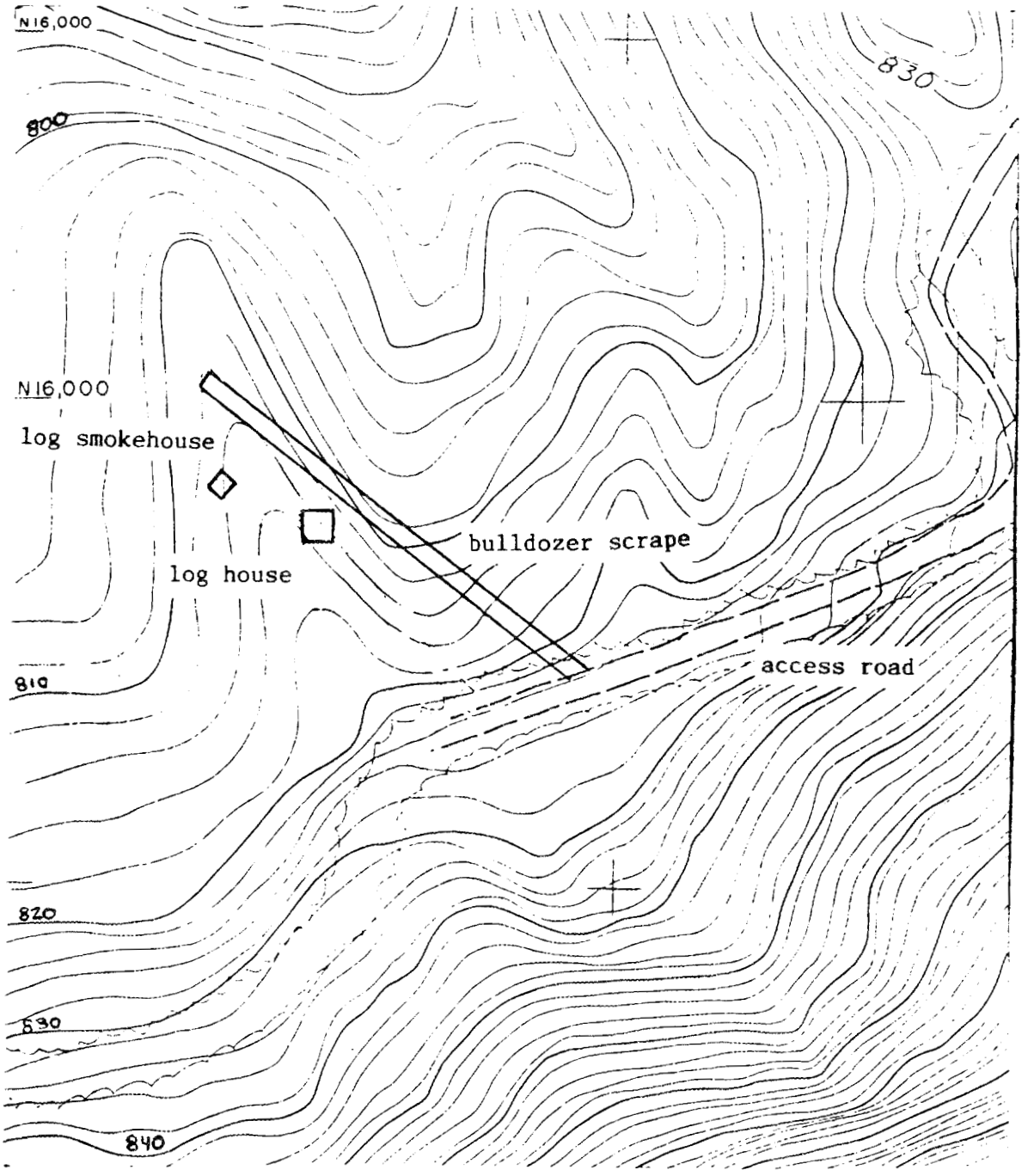


Figure 3. Martin Marietta Engineer map with Jenkins House Site (40Re188)
1 cm = 12 m, north is toward the top.

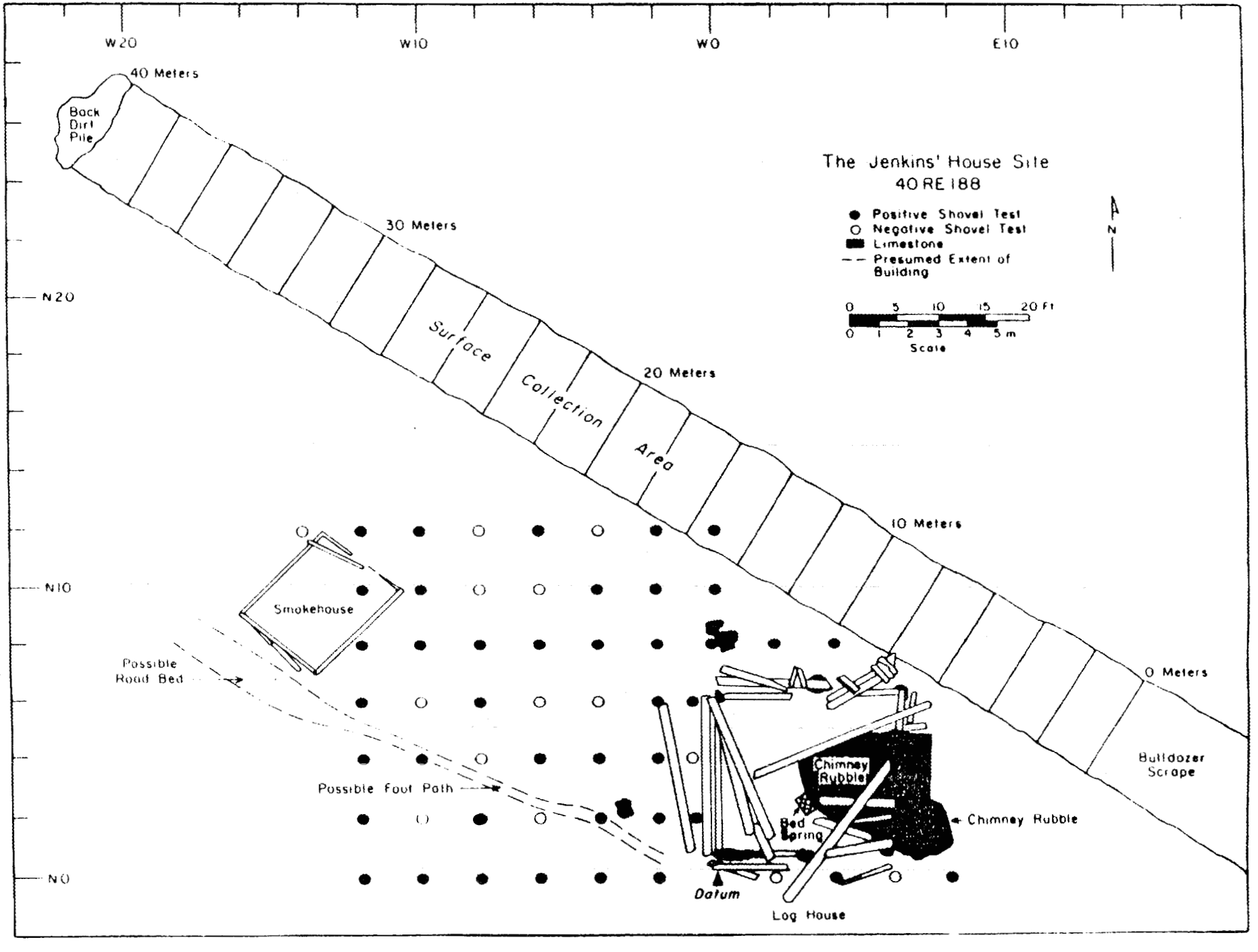


Figure 4. Field Map of The Jenkins House Site (40Re188)

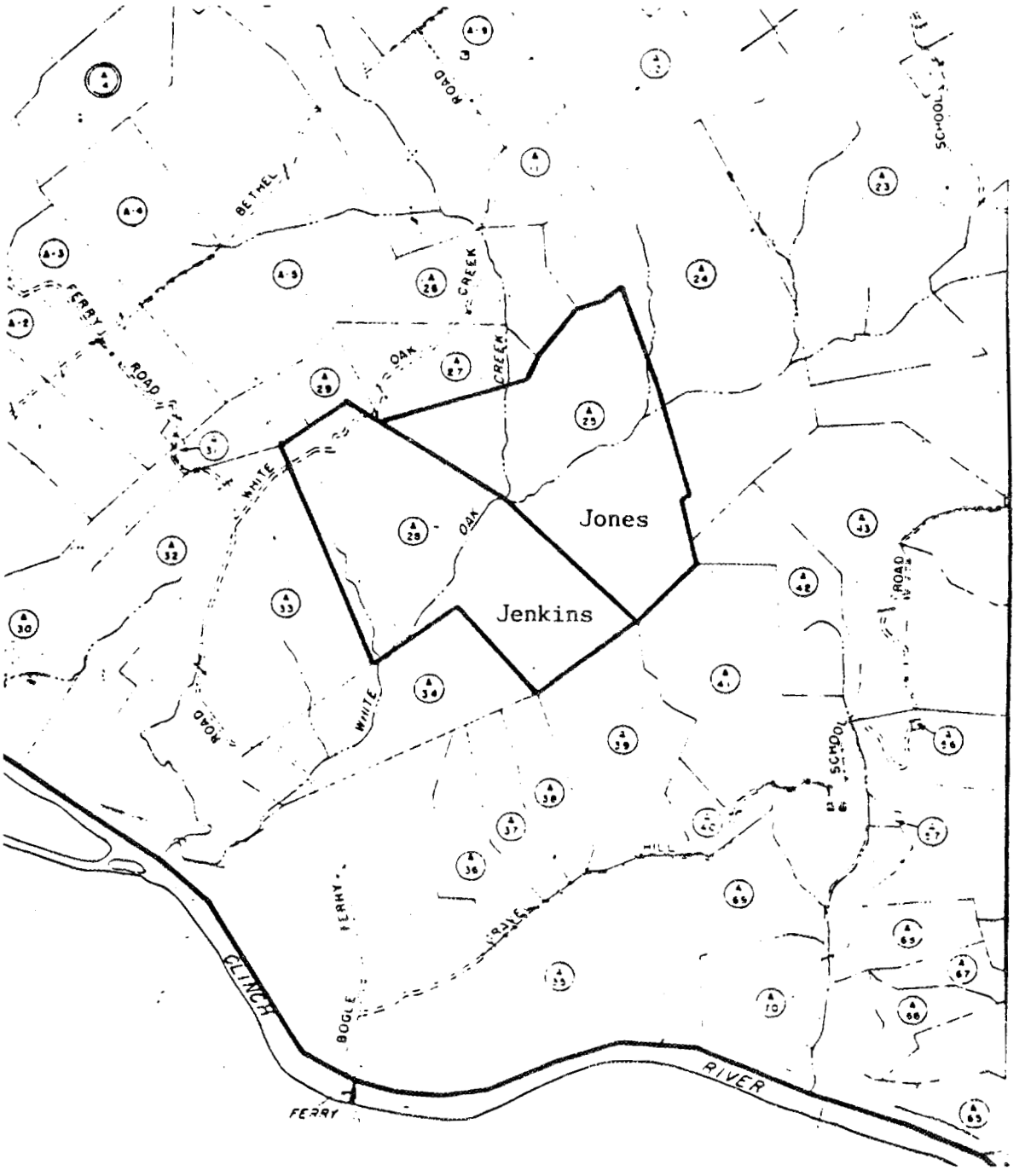


Figure 5. U. S. Army Corps of Engineer Final Land Acquisition Maps, Section A showing Tracts 28 and 25, 1 cm = 225 m, north is toward the top.

This specific property appears in the Roane County deed books (RCDB) in the early 1840s. That is, this is the earliest date that its ownership could be traced. At this time, a Henry J. Welcker was the sole owner of this piece of land. In 1844 he sold his property in two tracts of 140 and 50 acres to William M. Wyatt for $200 cash (RCDB J-1:243). By 1850, 125 acres of the property was again sold to a Thomas Jett for $180 (RCDB L-1:308). On March 6, 1861, William Rogers purchased some real estate from Jett for an unspecified amount of money (RCDB N-1:581). Rogers held on to the properties until 1874, when on January 17th he sold them to John Comer for $2050 (RCDB S-1:323). Interestingly, he sold this property back to Rogers only eight years later for $800 (RCDB Z-1:365).

From this point and on into the 1900s the property becomes involved in a series of legal entanglements. By March 1907, Ben F. Hagler seems to have acquired the property through a series of real estate purchases. This tract was purchased at public auction for only $200 following the death of William Rogers (RCDB Q-3:282). Unfortunately, Ben Hagler died sometime in the mid 1930s without leaving a will. His siblings filed a court action to divide up his properties. The Roane County Chancery Court decided on October 23, 1936 that all properties owned by the late Ben F. Hagler would be sold. The proceeds of the sale would be divided between his children (Roane County Chancery Court Minutes Book 32:272).

By April 22, 1937, the Court had sold five of Hagler's properties -- including the "Rogers Farm" as this property became known as -- to F. P. and Iris Johnson for $2500 (RCDB I-5:499). Within 19 months the Johnsons had sold it to E. H. Tedford and J. R. Seay for one dollar, assumption of the $1400 mortgage and other "valuable considerations" (RCDB N-5:240). In turn, they sold it within six months! On May 29, 1939 D. H. and his wife Lillian T. Jenkins took over the property for $1112.50 in cash and $1400 in mortgages and taxes for 1939 (RCDB N-5:95). The Jenkins' owned the "Rogers Farm" until its official sale to the United States Government in 1944.

Archaeology

The archaeology of this site consisted of selected surface collections and a sequence of shovel tests on points laid out in the metric grid system aligned to the log house (see Figure again). The bulldozer scrape to the north of both the log house and log smokehouse has partially disturbed the in situ context of any possible secondary peripheral midden. A systematic surface collection within the scrape was carried out to sample the artifacts present. An arbitrary starting point was selected to the northeast of the house chimney. Twenty, two meter lengths of the scrape (along with the back dirt pile at the end) were collected. Selective "grab" samples from the house, the smokehouse and around the site were also collected. Table 1

has a summary of the artifacts recovered in all of the surface collections.

Fifty-nine shovel tests were excavated. These were deliberately placed around the entrances of both the log house and log smokehouse and between the buildings. The topsoil on the site was quite shallow. No test went below two levels (20 cm). A summary of the artifacts recovered from the shovel tests are in Table 2. One possible midden was uncovered at North 8 West 0. The enormous numbers of cut and wire nails recovered leads to the belief that this area was a "nail concentration" formed from the dumping of material from an episode of building repair. The proportion of cut to wire nails makes it likely that this episode took place sometime in the early 1900s. Despite this concentration, however, no specific cultural features were located. Therefore, no 1 X 1 meter units were excavated.

Although artifact density was sparse throughout the site, the artifacts recovered do provide some specific information about the dating of the construction and occupation of the structures and the socio-economic status and activities of their occupants. Three artifact classes dominated the material collected from the entire site: container glass, ceramics, and iron nails.

Dating

Glass can be used for the dating of an archaeological site in a variety of ways. For example, the color of container glass can indicate quite clearly the time range during which it was made. Most container glass until the 1880s is often colored to some extent. This color can range from a natural blue-green to most any bright or rich hue. In the 1880s the decolorization of glass became popular. Up to around 1915 the decolorizer mangenese oxide (MnO) was added to glass. While this process worked very well initially; however, the glass turns "pinkish" when exposed to sunlight. Glass collectors have labelled this type of glass "amethyst". In 1915 manufacturers began to add selenium (Se) to the glass instead. This, as well as arsenic (As) added in the 1930's, worked well to decolorize glass permanently.

By being aware of this background, looking at the percentages of colored to amethyst to clear glass can give some idea as to the dating of a site. At this site, 53 % (n=80) of the glass sherds are clear, 11 % (n=17) are amethyst, and 31 % (n=47) are colored. Indications are, then, that the major occupation of this site took place after 1915 with some occupation before this date.

Window glass thickness has also been claimed to be a reliable dating technique (Roenke 1978). Later window glass is consistently thicker than earlier glass. At this site the average thickness of the window glass recovered (n=20) is 2.18 mm with

Historic Artifacts From The Jenkins House Site (40Re188)
Surface Collection

Provenance	Artifact Des.	Count	Group	Date	Comments
SC 0-2m	Sterile				
SC 2-4m	Ironstone	3	K	1840-1900+	1 base, 2 rim
	Whiteware	1	K	1820-1900+	unid.
	Iron stove part?	1	K	?	
SC 4-6m	Stoneware	1	K	1880-1900+	Bristol-glazed
	Whiteware	2	K	1830-1900+	1 plate, 1 unid.
	Brass cartridge	1	G	?	38 cal.
SC 6-8m	Ironstone	1	K	1840-1900+	unid.
	Whiteware	4	K	1820-1900+	1 cup, 1 plate, 1 saucer, 1 unid.
SC 8-10m	Whiteware	4	K	1820-1900+	unid.
	Ironstone	1	K	1840-1900+	unid.
	Bev. bottle glass	2	K	1880-1915 1915+	1 amethyst, neck 1 clear, unid.
	Glassware	1	K	?	clear bowl, embos.
	Container glass	3	K	?	blue/green, unid.
	Milk glass	1	K	?	lid liner frag.
SC 10-12m	Whiteware	1	K	1820-1900+	plate base
	Iron lid?	1	K	?	
	Milk glass	3	K	?	2 bowl base 1 lid liner
	Bev. bottle glass	3	K	1880-1915 1915+	1 amethyst, rim 1 clear base 1 embossed
	Glassware	1	K	1920-1940	"depression" glass bowl rim
	Container glass	5	K	?	3 blue/green,unid. 2 clear, unid.
	Window glass	2	R	?	blue/green
	Peach pits	3	E		
SC 12-14m	Ironstone, plain	3	K	1840-1900+	1 plate, 2 unid.
	Ironstone, embos.	2	K	1840-1900+	1 bowl, 1 unid.
	Whiteware	15	K	1820-1900+	2 bowl, 2 plate, 3 cup, 1 saucer, 7 unid.
	Jar glass	2	K	?	1 rim, 1 unid.
	Container glass	14	K	?	2 blue/green,unid; 9 clear(3 burned), unid. 3 amethyst, 1 rim, 2 unid.
	Window glass	3	R	?	blue/green
	Lamp chimney glass	1	F	?	
	Windshield glass	3	A	1900+	yellow
	Peach pits	2	E		
SC 14-16m	Porcelain	1	K	1880-1900+	American?

Table 1

	Whiteware	3	K	1820-1900+	1 plate, embos. 2 unid.
	Ironstone	7	K	1840-1900+	1 saucer rim, 1 plate base,5 unid.
	Bev. bottle glass	2	K	1915+	clear
	Jar glass	1	K	1915+	clear rim/neck
	Glassware	1	K	1920-1940	"depression" rim tumbler
	Container glass	3	K	1915+	clear, 2 base, 1 unid.
	Iron nail	1	R	1890+	wire
	Wrought iron	1	R	?	unid., bent frag.
	Plaster frag?	1	R	?	
	Turtle shell	1	B	?	
SC 16-18m	Unid. bone frag.	1	B	?	
SC 18-20m	Whiteware	2	K	1820-1900+	1 flatware?, 1 embos. rim
	Container glass	1	K	1915+	clear,from bottle?
	Window glass	1	R	?	blue/green
	Metal	1	R?	?	unid.
	Bone	3	B	?	
SC 20-22m	Ironstone	2	K	1840-1900+	1 cup rim, 1 flatware
	Whiteware	2	K	1820-1900+	1 cup, 1 embos. gravy boat?
	Container glass	2	K	?	1 blue/green
				1915+	1 clear
SC 22-24m	Whiteware	2	K	1820-1900+	1 saucer rim, 1 unid. embos.?
	Ironstone	4	K	1840-1900+	1 cup handle, 1 saucer, 2 unid.
	Bev. bottle glass	4	K	?	2 blue/green base
				1915+	2 clear (1 base)
	Jar glass	1	K	1915+	clear rim
	Container glass	3	K	1915+	clear (1 burned)
	Turtle shell	1	B	?	
SC 24-26m	Stoneware	1	K	1830-1900+	salt-glazed exter. Albany slip inter.
	Whiteware	4	K	1820-1900+	2 saucer base, 1 rim, large bowl?, 1 unid.
	Ironstone	1	K	1840-1900+	unid.
	Bev. bottle glass	1	K	pre 1915?	amber
	Turtle shell	2	B	?	
	Metal	1	R?	?	unid. frag.
	Milk glass	1	P	?	button
SC 26-28m	Sterile				
SC 28-30m	Whiteware	2	K	1820-1900+	plate (same one)
	Milk glass	1	K	?	lid liner
	Jar glass	1	K	?	lt. green
	Container glass	6	K	?	4 lt. green, 1 blue slagtown
				1915+	1 clear
	Window glass	1	R	?	lt. green

Table 1 continued

	Iron wire	1	A?	?	
SC 30-32m	Stoneware	1	K	1880-1900+	Bristol-glz exter. Albany slip inter.
	Whiteware	3	K	1820-1900+	1 saucer, 2 unid.
	Glassware	1	K	1915+	clear, pressed
	Metal	2	A?	?	unid.
SC 32-34m	Whiteware	1	K	1820-1900+	unid.
	Bev. bottle glass	1	K	pre 1915?	amber
	Jar glass	2	K	?	1 clear, 1 cobalt blue
	Glassware	1	K	1915+	clear
	Container glass	6	K	1880-1915	1 amethyst
				1915+	5 clear
	Window glass	2	R	?	lt. green
SC 34-36m	Porcelain	1	K	1880-1900+	American?, plain, saucer
	Stoneware	1	K	1830-1900+	Albany slip inter.
	Container glass	2	K	?	1 cobalt blue
				1880-1915	1 amethyst
	Metal pipe	1	R	?	6" long
SC 36-38m	Ironstone, undec.	1	K	1840-1900+	cup
	Ironstone, dec.?	1	K	1840-1900+	grey design
	Whiteware	1	K	1820-1900+	flatware
	Bev. bottle glass	2	K	?	1 blue/green
				1915+	1 clear, base
	Glassware	2	K	1915+	clear,1 rim embos, 1 compote? base
	Container glass	3	K	?	2 blue/green
				1915+	1 clear
	Brick frag.	1	R	?	
SC 38-40m	Whiteware	1	K	1820-1900+	flatware
	Container glass	3	K	1880-1915	2 amethyst
				1920-1940	1 "depression"
SC rd end	Ironstone	5	K	1840-1900+	1 saucer base, 1 plate,embos. rim 2 flatware
				1880-1900+	1 Albany inter. Bristol exter.
	Whiteware	2	K	1820-1900+	1 cup rim, 1 plate base
	Bev. bottle glass	1	K	?	blue/green, base
	Container glass	4	K	1880-1915	1 amethyst
				1915+	3 clear
	Iron nail	1	R	1890+	wire
	Metal	2	R?	?	unid.
	Chimney lamp glass	1	F	?	
	Plastic frag.	1	A?	?	black, unid.
SC grab	Porcelain	1	K	1880-1900+	plain, plate American?
	Ironstone	4	K	1840-1900+	1 saucer, 1 flatware, 2 unid.
	Whiteware	3	K	1820-1900+	2 saucer, 1 unid.
		1	K	1870-1900	sponge; rim, red

Table 1 continued

					and green, plate?
	Metal	1	K	?	jar lid (BALL)
	Milk glass	1	K	?	lid liner
	Turtle shell	1	B	?	
	Metal	1	R	?	hinge?
	Metal	1	A	?	harness? block and tackle frag.?
	Med. bottle glass	1	K	?	base
	Container glass	3	K	?	2 base, 1 unid.
SC house	Stoneware	1	K	1830-1900+	"frog skin", salt-glazed exterior, unglazed interior
	Ironstone	1	K	1840-1900+	plate rim, embos.
	Metal	1	K	?	jar lid
	Med. bottle glass	1	K	1915+	complete, clear
	Jar glass	1	K	?	lt. blue, (Mason?)
	Container glass	2	K	?	1 base, 1 unid.
	Window glass	1	R	?	clear
SC s'house	Iron wheel	1	?	?	small, spoked, child's bike? wheelbarrow?

Table 1 continued

Historic Artifacts From The Jenkins House Site (40 RE 188)
Shovel Tests

Provenance	Artifact Des.	Count	Group	Date	Comments
ST N0E2	Sterile				
ST N0E4	Container glass	2	K	?	1 blue/green
				1915+	1 clear
	Iron nails	31	R	pre 1890	2 early cut (1 small, 1 spike)
				1890+	29 wire
ST N0E6	Sterile				
ST N0E8	Container glass	2	K	?	1 lt. green
				1915+	1 clear
	Iron nail	1	R	1890+	wire, large
ST N0W2L1	Porcelain	2	K	?	1 saucer(rim, gold band over glaze), 1 flatware (band under glaze)
	Whiteware	1	K	1820-1900+	1 saucer(footring)
	Container glass	3	K	?	1 lt. blue
				1880-1915	1 amethyst
				1915+	1 clear
	Iron nail	1	R	1890+	wire, head
ST N0W2L2	Ironstone	2	K	1840-1900+	1 holloware,1 unid
	Iron nails	2	R	1830-1900	cut
ST N0W4L1	Whiteware	1	K	1820-1900+	unid.
	Container glass	1	K	1880-1915	amethyst
	Window glass	1	R	?	blue/green
	Iron nail	1	R	1830-1900	cut
	Metal	1	R?	?	unid. frag.
ST N0W4L2	Whiteware	1	K	1820-1900+	unid.
	Iron nail	1	R	1890+	wire
	Window glass	1	R	?	lt. green
	Peach pit	1	E	?	
ST N0W6L1	Container glass	1	K	1915+	clear
	Iron nail	1	R	?	unid., 1" length
ST N0W6L2	Container glass	1	K	1880-1915	amethyst
	Iron nail	1	R	1830-1900	cut
ST N0W8	Whiteware	2	K	1820-1900+	unid.
	Container glass	3	K	?	1 burned
	Iron nail	1	R	1830-1900	cut
ST N0W10L1	Tin(?) sheet metal	2	R?	?	unid.
ST N0W10L2	Container glass	4	K	?	3 blue/green
				1915+	1 clear
ST N0W12L1	Iron nail	2	R	1830-1900	cut (same nail)
ST N0W12L2	Container glass	1	K	1880-1915	amethyst
ST N2W0/1	Whiteware	1	K	1820-1900+	flatware
	Container glass	2	K	?	lt. blue
	Window glass	1	R	?	blue/green
ST N2W2	Ironstone	1	K	1840-1900+	unid.
	Container glass	1	K	?	lt. blue

Table 2

	Iron nail	1	R	1890+	wire, large
ST N2W4	Jar glass	1	K	1880-1915	amethyst, rim with thread
	Window glass	1	R	?	blue/green
	Iron nail	1	R	1830-1900	cut
ST N2W6	Sterile				
ST N2W8	Glassware	1	K	?	etched frag.
	Window glass	1	R	?	blue/green
ST N2W10	Sterile				
ST N2W12	Whiteware	1	K	1820-1900+	flatware
	Milk glass	1	K	?	lid liner (Mason?)
	Container glass	6	K	?	1 blue/green,embos
				1915+	5 clear
	Window glass	1	R	?	blue/green
	Iron nails	4	R	1830-1900	cut
	Iron, unid.	2	R?	?	1 bar, bent
					1 frag., flat
	Brass cartridge	1	G	?	38 cal. Sm. & Wes.
	Gizzard stone(?)	1	A	?	small, rounded
ST N4W0/1	Sterile				
ST N4W2	Bev. bottle glass	2	K	1915+	clear
	Const. hardware	1	R	?	fiber roofing mat.
	Wood samples	7	E	?	
ST N4W4	Bev. bottle glass	1	K	1880-1915	amethyst
	Window glass	2	R	?	blue/green
	Iron nail	1	R	1890+	wire
ST N4W6	Bev. bottle glass	1	K	?	blue/green
ST N4W8	Sterile				
ST N4W10	Window glass	1	R	?	blue/green
ST N4W12	Stoneware	1	K	1880-1900+	banded, cobalt blue and white, Albany slip inter. Bristol glaze ext.
	Whiteware	1	K	1820-1900+	flatware
ST N6W0/1	Container glass	7	K	pre 1915?	1 amber
			K	1915+	6 clear (2 with checked embossing)
	Window glass	2	R	?	blue/green
	Iron nails	10	R	1830-1900	6 cut
				1890+	2 wire
				?	2 unid.
	Iron, unid.	1	R?	?	bar
ST N6W2	Iron, unid.	1	R?	?	
	Lamp chimney glass	1	F	?	
ST N6W4	Sterile				
ST N6W6	Sterile				
ST N6W8	Metal wire	3	A?	?	unid.
ST N6W10	Sterile				
ST N6W12	Bev. bottle glass	1	K	1915+	clear, embossed "half gallon"
	Med. bottle glass	1	K	?	rim, partial neck
ST N8E2	Shoe heel	1	C	?	rubber
ST N8E4	Whiteware	1	K	1820-1900+	flatware
	Container glass	1	K	1915+	clear, rim, thread

Table 2 continued

	Iron nails	2	R	1890+	wire
ST N8W0	Whiteware	1	K	1820-1900+	saucer
	Yellow Ware	1	K	1830-1930	unid.
	Jar glass	1	K	?	rim, blue/green
	Glassware	2	K	1915+	rims, clear, embos
	Container glass	2	K	?	1 blue/green
				1915+	1 clear
	Bone	1	B	?	
	Iron buckle	1	C	?	
	Iron nails	245	R	1800-1820	1 early cut
				1830-1900	14 cut
				1890+	145 11/2", 19 2", 24 21/2", 13 3", 1 4", 28 unid wire
	Iron chain link	1	R	?	
	Iron, unid.	1	R?	?	
ST N8W2	Container glass	2	K	1915+	clear,(1 edge dec)
	Lamp chimney glass	2	F	?	
ST N8W4	Whiteware	1	K	1820-1900+	unid.
	Iron nail	1	R	1890+	wire
ST N8W6	Milk glass	1	P	?	c. cream jar base
	Barb wire frag.	1	A	?	
ST N8W8	Container glass	1	K	?	lt. blue
ST N8W10	Whiteware	3	K	1820-1900+	1 plate,2 flatware
ST N8W12	Container glass	3	K	?	1 lt. blue
				1880-1915	1 amethyst
				1915+	1 clear
	Window glass	1	R	?	blue/green
	Iron nail	1	R	1890+	wire
ST N10W0	Med. bottle glass	1	K	?	neck & shoulder, lt. green
	Iron nails	2	R	1890+	wire
ST N10W2	Whiteware	1	K	1820-1900+	hollow ware
ST N10W4	Iron nails	3	R	1830-1900	1 cut
				1890+	2 wire
ST N10W6	Sterile				
ST N10W8	Sterile				
ST N10W10	Stoneware	1	K	1830-1900	crock, rim Albany slip inter. salt-glazed exter.
ST N10W12	Iron nails	6	R	1890+	wire, 4 small, 1 med., 1 large
ST N12W0	Container glass	2	K	?	1 lt. blue
				1915+	1 clear
	Wood sample	2	E	?	
ST N12W2	Whiteware	1	K	1820-1900+	plate
	Iron nail	1	R	1830-1900	cut
	Metal wire	1	A?	?	unid.
ST N12W4	Sterile				
ST N12W6L1	Iron nail	1	R	1890+	wire
ST N12W6L2	Iron nail	1	R	1890+	wire
ST N12W8	Sterile				
ST N12W10 L1	Container glass	2	K	?	blue/green

Table 2 continued

	Tooth fragments	3	B	?	
ST N12W10					
L2	Whiteware	1	K	1820-1900+	plate
	Window glass	1	R	?	blue/green
	Iron nail	1	R	1890+	wire
ST N12W12	Container glass	2	K	1915+	clear
ST N12W14	Sterile				
ST N14W8	Sterile				
ST N14W10	Sterile				

Table 2 continued

the range being 1.3 to 3.1 mm. Ideally, this indicates a later site, probably post 1900. However, since the thickness of window glass can vary even within the same pane, this average does not have the reliability that other dating techniques do.

The extremely fragmentary nature of almost all the container glass recovered has made the precise dating of individual sherds nearly impossible. No recognizable manufacturer or seller marks on bottle sherds could be identified. However, three sherds of a type of glassware known as "depression" glass were recovered here. As its name implies, the height of its use was during the depression (actual date range is 1920-1940). Its popularity may be overwhelmingly due to its affordability. The existence of this glass is a good indication that a site was occupied in the 1930s.

The simple comparison of the number of glass vs ceramic sherds on the site can also be used as a relative dating technique. The principle of this technique is based on the general trend that glass containers become more abundant in the 20th century as compared to ceramic vessels. At this site, glass sherds, by 58 % (n=168) to 42 % (n=124), are more abundant. Therefore, although the percentage is not overwhelming, this suggests that major occupation of this site was in the early 1900s.

Two major types dominate the ceramic assemblage. Plain whiteware, which can date from 1820 to 1900+ but most probably dates here from the late 1800s to the early 1900s, accounts for 58 % (n=71) of the assemblage. Ironstone, dating from the 1840s into the early 1900s, constitutes 32 % (n=39) of the total ceramics collected. Together they indicate a possible occupation from the late 1800s into the early 1900s. Other more tightly dateable ceramics support this range, but also may push these dates a little earlier. Individual sherds of sponge decorated whiteware (1870-1900), stick-spatter decorated whiteware (1850-1900), and yellowware (1830-1930) all indicate occupation as early as the last quarter of the 19th century.

Iron nail manufacture can also provide construction date(s) for a historic structure. Fully hand or machine cut nails were used in the United States from ca. 1830 - ca. 1890s. They began to be replaced by machine wire nails in the 1890s. A comparison of cut to wire nails recovered can therefore help to date an archaeological site. At this site, wire nails dominate the assemblage 88 % (n=285) to 11 % (n=36). Only 1 % (n=3) of the iron nails could not be identified. This puts the major construction on this site well after 1890. One early cut nail (1800-1820) appears to be out of place. No explanation can be given for this.

After consideration of the above dating evidence, it can be reasonably forwarded that the occupation of this site took place between the 1880s and the 1930s and even possibly into the early 1940s. Main activity at the site seems to date between 1900 and

1920. These dates indicate that perhaps John Comer or more likely William Rogers was the original builder of these structures in the early 1880s. By 1907, Ben Hagler had bought the property and perhaps made a major renovation (accounting for the early 1900s "nail concentration") of the log house. He or some segment of his family probably lived in these buildings up until his death in the mid 1930s. It is difficult to say whether or not F. P. Johnson, E. H. Tedford, J. R. Seay, or even D. H. Jenkins actually lived in the same buildings. No specific artifacts recovered could be directly linked to these people or their families.

Socioeconomic Status

The artifacts collected indicate a lower class status for the occupants of these structures. The ceramics are dominated by plain whiteware and ironstone. These wares are quite common in the late 1800s and into the early 1900s. Porcelain is only represented by five sherds. Glassware is just as unspectacular. In addition, the "depression" glass is a good socio-economic indicator. Generally, there is a lack of any unusual or expensive material that may hint at any wealth. It appears that the occupants were a lower socio-economic class farm family. This situation is not unlike the general conditions prevailing upon most of the residents of the area in the late 19th and early 20th century.

Conclusions and Recommendations

The recommendation of the management of this cultural property is broadly based upon its potential for future enjoyment and/or research by professionals and the general public. The factors that go into this determination include: (1) the nature, extent, and integrity of the structures and their associated archaeological site; (2) the possibility of future significant archaeological or architectural research; and (3) the unusualness (or commonness) of the structures in both the region and the immediate area. Are there any similar structures in the area that are more deserving of preservation?

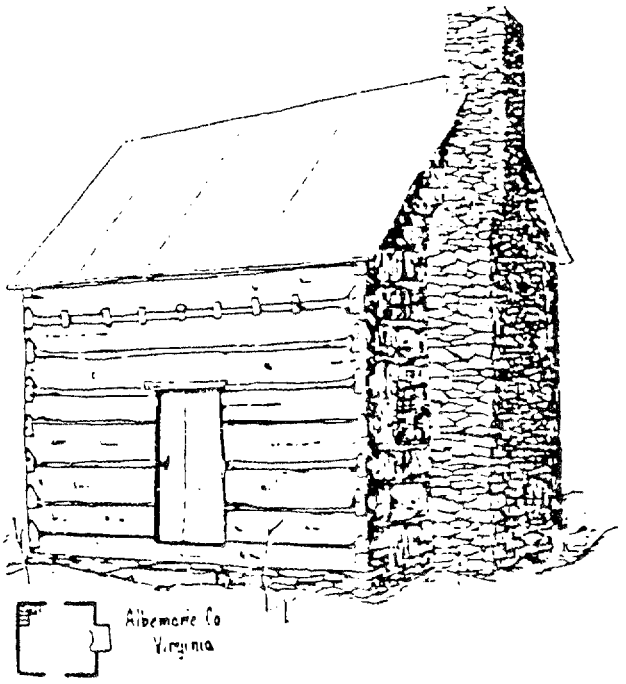
The Jenkins House Site (40Re188) has been irreversibly and adversely affected by modern activity. Bulldozing and other land alterations have disturbed a significant amount of in situ archaeological remains. In addition, the site's natural surroundings have been compromised. Other anticipated out-buildings, such as a barn, could not be located. Both the log house and the log smokehouse, while certainly in their original locations, are partially collapsed. Only the limestone chimney is in fairly good shape.

The architectural documentation of these buildings is fairly extensive. Measurements, photos, and verbal descriptions of many crucial aspects of the structures have been done. In addition, accurate field maps were produced. All these documents, as well

as the artifacts recovered, are on file at the University of Tennessee Department of Anthropology, Knoxville, Tennessee. The surface collection and shovel test procedures have greatly sampled the potential archaeological remains at the site. No specific cultural concentrations or deposits, besides the nail concentration, were located. Therefore, the archaeology performed at this site points to the lack of any special activity areas or concentrated dumping areas. Perhaps, the discarding of trash consisted only of the indiscriminate throwing of material out the log house door.

According to Henry Glassie (1965:147-153), the "Square Cabin" is a common log house type in Southern Appalachia. It has its roots perhaps as far back as Anglo-Saxon England but certainly within the English colonies of the New World. His reconstruction (1963:7, Figure 4) could be very similar to what this log house may have looked like when it was occupied (Figure 6). George Fielder's (Fielder, Ahler and Barrington 1977) historic site survey within the Oak Ridge Reservation examined 415 structures (this is only a sample of all the standing historic structures within the reservation), 87 of which were either partially or completely standing. Although no dimensions were given for each structure, there seems no doubt that many were square or nearly square. In addition, given the number of standing log structures in the areas examined by Fielder, there appears to be many examples of the types of construction techniques present at this site. Surprisingly, however, the construction techniques are remarkably good for such a late site. Both buildings and especially the chimney are very well made.

Therefore, the Jenkins House site (40Re188) is not deemed significant enough to warrant its inclusion on the National Register of Historic Places. Many other comparable buildings within the Oak Ridge Reservation would be better candidates architecturally and perhaps archaeologically. However, the best management policy for any cultural property is one of avoidance. Preservation in place for the future enjoyment and research by professionals and the general public is strongly encouraged. If it is at all possible to shift any proposed disturbance away from this site then it should be done. On the other hand, if disturbance or wholesale destruction of the cultural property is unavoidable, then no further architectural or archaeological work can be justified at this time. It is hoped, however, that as the time nears for the actual destruction of these buildings and their associated archaeological site, the developers of this piece of land will voluntarily seek the advise of professional archaeologists as to the final deposition of these remains.



Appalachian Log Cabin

Figure 6. A possible reconstruction of The Jenkins House Site's (40Re188). Taken from Glassie (1963).

The Jones House Site (40Re189)

Site Summary

The focus of this site is a totally collapsed two pen rectangular log house (25 X 50 ft). One pen has a cellar and a limestone block chimney. The second pen is set to the west of the first pen. It has a brick chimney but no cellar. A porch extends off the south of this pen. A partially collapsed associated log smokehouse (10 X 12 ft) lies 50 feet to the north-northeast of the log house (Figure 7). A partially collapsed associated log barn (20 X 50 ft) is located some 200 feet to the northeast of the house (Figure 8). It is a double crib structure with a probable overhang extension on its north side (Figure 9).

The house walls were constructed of oak logs. Most show evidence of extensive remodelling. Both ax and saw marks are present. Sawed planks run the length of the building. Cut and wire nails are found interchangeably within the structure. Joinery is half dovetail. The eastern pen of the log house is only ca. 15 X 15 feet square. A limestone chimney opens north onto the cellar. An interior partition doorway on the west wall leads to the west pen. This larger pen is around 25 X 30 feet when the porch is included. A completely fallen brick chimney with a limestone base is located on the west wall. There appears to be no cellar beneath this pen. Limestone piers support the entire structure. Outside entrances are from the porch and out the north wall towards the smokehouse. The smokehouse is also a log structure. The logs are mainly ax hewn and the corner joinery is half dovetail notching.

The log barn is assumed to be associated with these structures as it is on the same property and appears to date roughly to the same time period. It consists of two equally sized log cribs with an open passageway between them. Limestone piers which support the entire structure also indicate that an overhang extended off the north walls. The barn has an odd mixture of hand wrought hinges and nails along with both cut and wire nails. It appears that this structure was originally built quite early on this site and was remodelled, rebuilt and repaired many times over the years.

Unfortunately, the east crib is almost totally collapsed. The location of the doors is difficult to determine. The majority of the logs are ax hewn on both sides. Notching is half dovetail. Only wire nails are found. Perhaps this crib was the last to be remodelled. The west crib is in fairly good condition. All four walls are standing. The walls consist of horizontal hewn and sawn logs connected by half dovetail joinery. Many aspects of this crib deserve mention. The south wall includes a doorway sawed through the horizontal logs. The door frame is secured to the logs with a mixture of wooden pegs, cut and wire nails. A hand wrought strap hinge is also present.

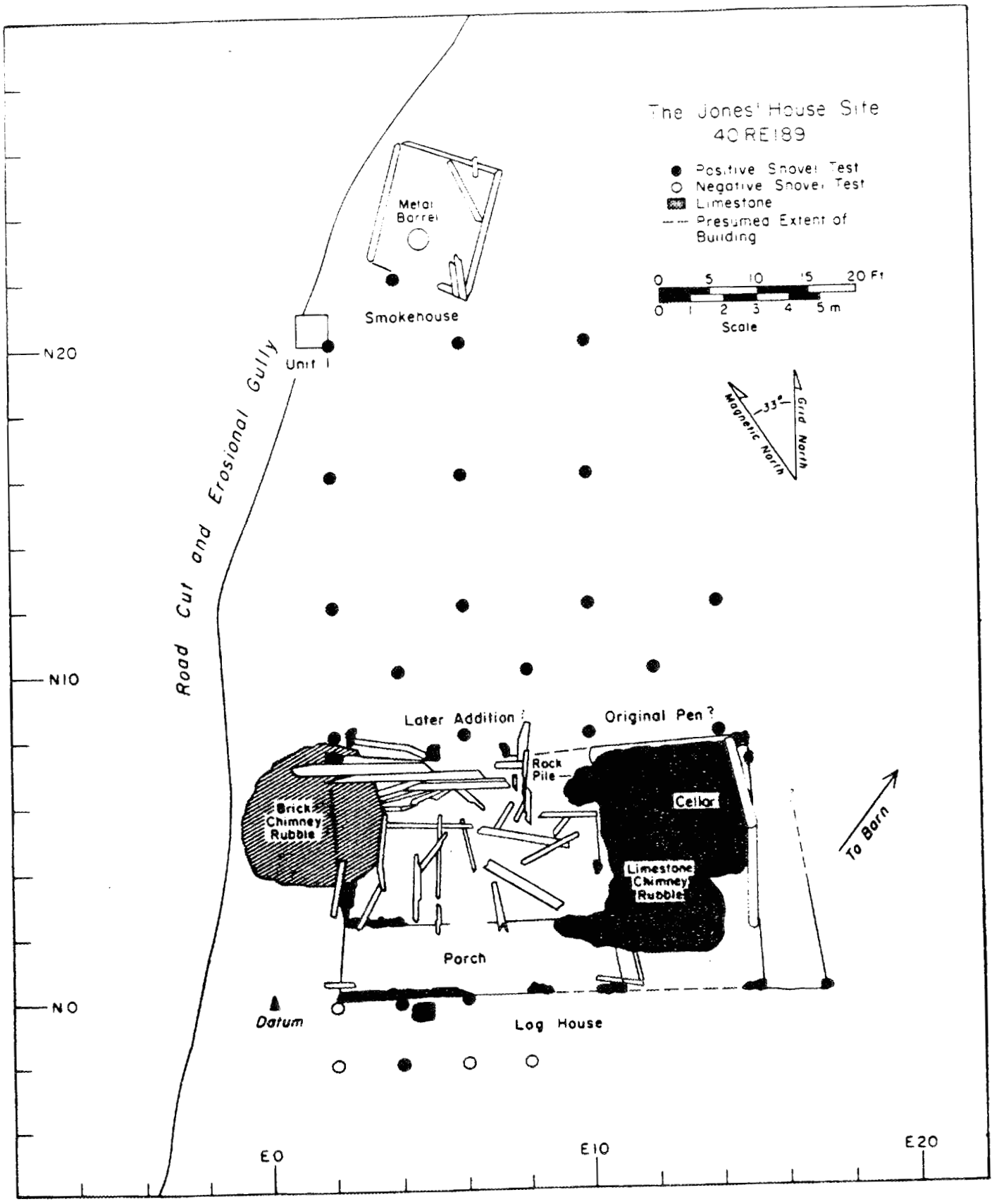


Figure 7. Field Map of the Jones House Site (40Re189), log house and log smokehouse.

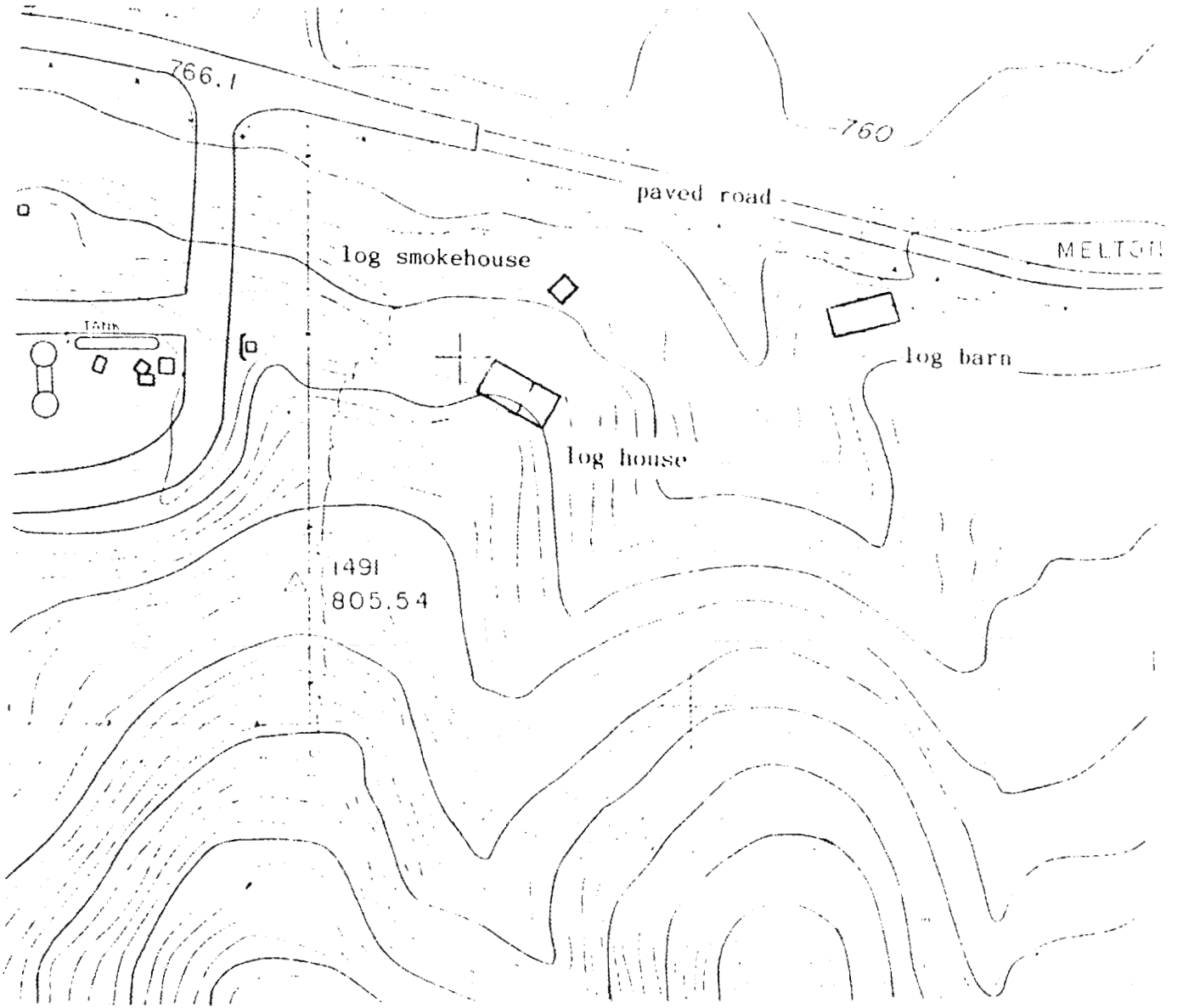


Figure 8. Martin Marietta Engineer map with Jones House Site (40Re189), 1 cm = 12 m, north is toward the top.

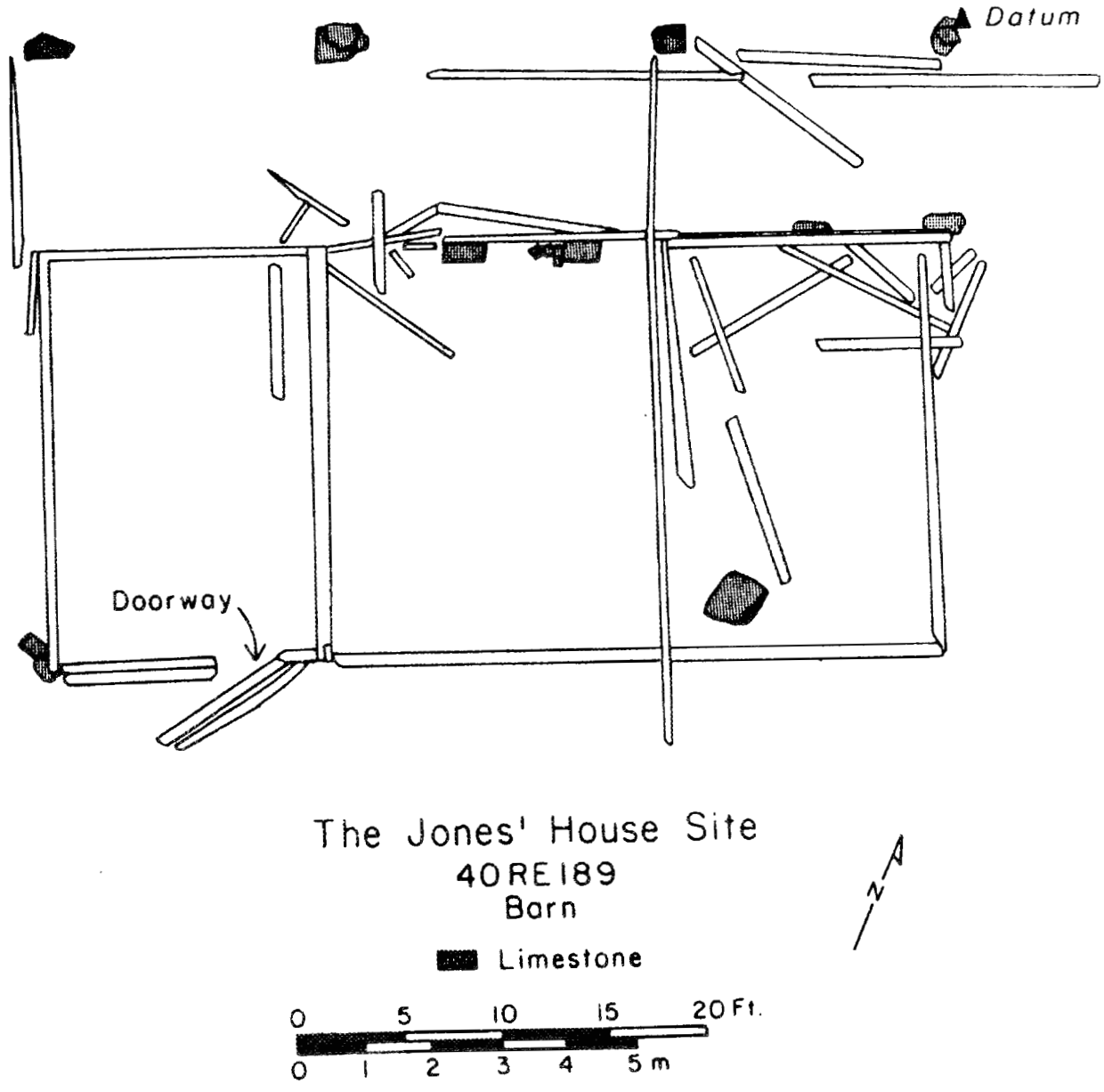


Figure 9. Field Map of the Jones House Site (40Re189), log barn.

Three large ceiling joist notches nearly six feet off the ground are located above the door. A similar set of three is located in the same place on the north wall. There seems no doubt that ceiling joists were at one time slid across to support the loft and perhaps the overhang. The east wall of the crib has two large 8 X 4 feet sawed openings a foot off the ground. These do not appear to be doorways but rather barn "windows" for limited access for the animals. The logs are hewn but also show clear evidence of drilling to support the fastening of support beams across the openings.

Property Ownership

This site is located on property designated as Tract 25 of Section A on the 1942 United States Army Corps of Engineers Final Land Acquisition Maps (Figure 5). By May 19, 1943, the owners, J. B. and Mary Jones, sold their 222.0 acres to the Federal government for an undetermined amount of money. It is uncertain whether or not they actually resided on their property or within these structures in the early 1940s. Regardless, according to the Roane County deed books they were in possession of the land and had been since 1932 when they purchased it -- then 235 acres -- from Louis and Minnie Jestice for one dollar and a "further consideration of four purchis (sic) money notes..." (RCDB C-5:32). No value for the notes were listed. The Jestices had held the land for 13 years after the purchase from J. W. Pyott and J. M. Jones. On March 17, 1919 the Jestices bought the land agreeing to pay $1000 cash and a series of six, $500 payments due on the 17th of March for the years 1921 through 1926 (RCDB M-4:230).

From this point, this property becomes impossible to trace. Property bought and sold by a J. M. Jones before this time seems to not be recorded. John W. Pyott bought and sold a series of very similarly described properties from the mid 1800s on. Devoid of familiar and permanent landmarks, few direct correlations between the properties can be substantiated. Undoubtedly, many properties were continually subdivided and recombined. This property, that he eventually sold to the Jestices, was one of the many he dealt with. J. W. Pyott had bought and inherited a series of nameless properties as a young man from his father, Samuel Pyott. Samuel Pyott died in 1865 after accumulating large tracts of land throughout the area that was to become the Oak Ridge Reservation.

Archaeology

The archaeological methodology of this site closely followed the procedures applied to the Jenkins House Site (40Re188). Unsystematic surface collections were conducted within the cellar depression and west pen of the log house and around the log barn. Artifacts recovered during this collection are documented in Table 3. Twenty-six shovel tests ranging from two to four meters apart were placed on the metric grid aligned with the log house.

Historic Artifacts From The Jones House Site (40Re189)
Surface Collection

Provenance	Artifact Des.	Count	Group	Date	Comments
SC house main	Bev. bottle glass	1	K	?	neck, partial shoulder, embossed
	Container glass	6	K	?	2 lt. blue, unid.
				1915+	4 clear, unid.
	Metal			?	lid liner, (Ball)
	Window glass	20	R	?	1 blue/green
				1915+	7 clear
				?	12 clear, burned
	Iron nails	28	R	1830-1900	18 cut
				1890+	10 wire
	Iron door hinges	3	R	1890+	2 butterfly type, has 16 wire nails 1 strap type, 2 wire nails present
	Windshield glass	1	A	1900+	
	Peach pit	1	E	?	
SC house cellar	Whiteware	1	K	1820-1900+	saucer,green embos
	Milk glass	1	K	?	lid liner for Ball Mason jar zinc lid
	Metal	1	K	?	jar lid
	Med. bottle glass	1	K	1903+	base
	Jar glass	14	K	?	1 cobalt blue, 2 lt. blue
				1880-1915	10 amethyst
				1915+	1 clear
	Container glass	13	K	?	3 lt. blue
				1880-1915	3 amethyst
				1915+	7 clear
	Window glass	3	R	?	blue/green
	Iron nails	5	R	1830-1900	3 cut
				1890+	2 wire
	Lamp chimney glass	1	F	?	
	Leather	1	C	?	circular, unid.
	Metal, unid.	42	A?	?	
SC barn	Iron hinge	1	R	mid 1800's?	hand wrought
	Iron bar	1	R	mid 1800's?	hand wrought, possible horseshoe altered for other purposes
	Iron pick head	1	A	mid 1800's?	hand cast

Table 3

The tests were deliberately placed around the entrances to the log house and between the log house and the log smokehouse. Table 4 lists the artifacts recovered from each shovel test. No shovel tests were placed near the barn. Generally, no shovel test extended below one level (10 cm) except for North 20 East 2. This shovel test produced cultural material down through Level Four. In addition, the topsoil in this test was browner, looser, and deeper than any of the surrounding tests. Given this situation, it was decided that a 1 X 1 meter unit would be placed to the northwest of the shovel test at North 20-21, East 1-2.

This unit produced some of the earliest artifacts on the site (Table 5). Excavated in five 10 cm levels, this unit extended to 43 cm in depth before the lighter subsoil was encountered. From the placement of the artifacts it appears that this unit was placed either within a disturbed trash pit or a naturally filled depression containing mixed soil. To illustrate, wire nails and amethyst glass were found below cut nails and at the same level as pearlware which dates before 1830. The apparent mixing of widely dateable artifacts points to a lack of contextual integrity for this unit.

Dating

As with The Jenkins House Site (40Re188), the artifact assemblage at The Jones House Site (40Re189) is dominated by container glass, ceramics and iron nails. Each lends a specific insight into the date range of this site. Iron hardware also can provide some interesting clues into the construction and occupation of these structures. Glass color suggests a date range from perhaps the late 1800s into the early 1920s. Colored glass (n=30) at 38 % and amethyst glass (n=29) at 37 % are nearly equally represented at the site. Clear glass (n=20) represents only 25 % of the glass assemblage. Seventy-five percent of the glass recovered from this site was thus probably manufactured before 1915. Few glass sherds were large enough to reveal any manufacturer or seller marks that could be tightly dated. Of those with marks on them most were "Ball" mason jars. Window glass (n=30) thickness ranged from 1.9 to 3.3 mm with the mean being 2.48 mm. This glass is quite thick and could represent a manufacture date after 1900. However, again, this conclusion is tenuous.

Container glass is far more prevalent at this site in comparison to ceramics. Only 16 ceramic sherds constituting 17 % of the glass-ceramic totals were recovered. In comparison, 80 glass sherds (83 % of the total) were found. This indicates that the main activity at the site was well after 1900 -- perhaps from 1910 into the 1920s. Of the 16 ceramic sherds recovered, 11 of them were plain whiteware which probably dates to the late 1800s. Surprisingly, three of the remaining five sherds are quite early compared to other artifacts excavated and in some ways is contradictory to the trends set by the other methods. One sherd is a lead glazed redware probably manufactured and used sometime

Historic Artifacts From The Jones House Site (40Re189)
Shovel Tests

Provenance	Artifact Des.	Count	Group	Date	Comments
ST S2E2	Sterile				
ST S2E4	Whiteware	1	K	1820-1900+	plate footring
	Iron nails	4	R	1830-1900	2 cut
				1890+	2 wire
ST S2E6	Sterile				
ST S2E8	Sterile				
ST N0E2	Sterile				
ST N0E4	Whiteware	1	K	1820-1900+	unid.
	Iron nails	3	R	1830-1900	2 cut
				1890+	1 wire
	Leather shoe piece	1	C	?	
ST N0E6	Whiteware	2	K	1820-1900+	1 plate footring, 1 unid.
	Milk glass	2	K	?	lid liners
	Iron nails	10	R	1830-1900	4 cut
				1890+	6 wire
	Metal	1	R?	?	unid.
ST N6E12	Container glass	2	K	?	1 lt. green,embos.
				1915+	1 clear
	Iron nails	27	R	1830-1900	21 cut
				1890+	6 wire
	Peach pit	1	E	?	
ST N8E2	Window glass	1	R	?	clear
	Iron nails	2	R	1830-1900	cut
ST N8E6	Container glass	1	K	?	lt. blue
	Window glass	3	R	?	clear
	Iron nails	2	R	1890+	1 wire
				?	1 roofing
ST N8E10	Container glass	2	K	1880-1915	1 amethyst
				?	1 polished/embos.
	Iron nails	4	R	1830-1900	cut
ST N8E14	Iron nails	10	R	1830-1900	cut
ST N10E4	Container glass	5	K	?	1 lt. green, 1 cobalt blue
				1880-1915	3 amethyst
ST N10E8	Porcelain	2	K	1830-1900+	overglaze enamelled Chinese export
	Iron nail	1	R	1830-1900	cut
ST N10E12	Window glass	1	R	?	clear
ST N12E2	Whiteware	1	K	1820-1900+	saucer footring
ST N12E6	Whiteware	1	K	1820-1900+	saucer rim
	Container glass	1	K	1880-1915	amethyst
	Iron nails	2	R	1830-1900	1 cut
				1890+	1 wire
	Lamp chimney glass	1	F	?	
	Bullet cartridge	1	G	?	unid. caliber

Table 4

	Shell fragment	1	B	?	unid.
ST N12E10	Container glass	1	K	1880-1915	amethyst
	Iron bar	1	R?	?	hand cast?
ST N12E14	Container glass	1	K	?	lt. blue
	Iron nails	2	R	1830-1900	1 cut
				1890+	1 wire
	Metal, unid.	1	R?	?	
ST N16E2	Container glass	4	K	?	1 lt. green embos.
					1 lt. blue
				1915+	2 clear
	Window glass	1	R	?	clear
	Iron nail	1	R	1830-1900	cut
ST N16E6	Container glass	1	K	1880-1915	amethyst
	Iron nails	2	R	1890+	wire
	Metal, unid.	1	R?	?	
ST N16E10	Container glass	1	K	?	burned
ST N20E2L1	Sterile				
ST N20E2L2	Container glass	1	K	1915+	clear, burned
	Iron nail	1	R	1830-1900	cut
ST N20E2L3	Sterile				
ST N20E2L4	Bone	3	B	?	
	River cobble	1	O	?	
ST N20E6	Container glass	2	K	?	lt. blue
	Iron nails	2	R	1890+	wire
ST N20E10	Container glass	1	K	?	lt. blue
	Iron nail	1	R	1890+	wire
	Metal wire, unid.	2	R?	?	
ST N22E4	Whiteware	2	K	1820-1900+	unid.
	Container glass	2	K	?	1 lt. green
				1880-1915	1 amethyst
	Iron nails	5	R	1830-1900	2 cut
				1890+	3 wire

Table 4 continued

Historic Artifacts From The Jones House Site (40Re189)
Unit One

Provenance	Artifact Des.	Count	Group	Date	Comments
U N20-21					
E1-2					
L1	Whiteware	2	K	1820-1900+	1 saucer footring 1 unid., embossed
	Container glass	4	K	?	lt. blue
	Bone fragment	1	B	?	
	Tooth fragment	1	B	?	
L2	Container glass	7	K	?	2 blue/green, 1 embossed
				1880-1915	5 amethyst
	Window glass	1	R	?	clear
	Iron nails	2	R	1830-1900	cut
	Button, synthetic	1	C	?	"... Rubber Co." inscribed on it
L3	Pearlware	2	K	1795-1815	1 underglaze polychrome, saucer
				1780-1830	1 undecorated, unid.
	Container glass	3	K	?	2 lt. blue
				1880-1915	1 amethyst, rim
	Iron nails	10	R	1830-1900	7 cut
				1890+	3 wire
	Bone fragments	2	B	?	
L4	Redware	1	K	pre 1850	Lead glazed, unid.
	Container glass	5	K	?	3 blue/green
				1880-1915	2 amethyst, both embossed rims
	Iron nail	1	R	1830-1900	cut
	Metal, unid.	2	R?	?	
	Bone fragment	1	B	?	
	Tooth fragment	1	B	?	
L5	Sterile				

Table 5

before 1850. Two sherds are pearlware. One is undecorated and dates to around 1780 to 1830 while the other is underglaze polychrome popular between 1795 and 1815. The fact that these early types of ceramics are at this site points strongly to the possibility of an occupation of this area (perhaps not these buildings) as early as the 1820s. The presence of hand wrought construction hardware on the barn also helps to support this conclusion. Other iron hardware, such as the cut vs wire nail percentage, however, support an 1880 to 1900 date for major construction or remodeling activity. Cut nails (n=83) are slightly more abundant (at 58 % to 42 %) than wire nails (n=60).

The combination of all these various dating methods points to a broad date range for activity and construction at this site. There apparently has been activity at this site as early as the 1820s (or earlier), lasting until the 1920s. Artifact evidence does not conclusively support an occupation at the time of government takeover in 1942. Within this broad time range there seems to be two phases of activity represented the most: one from the mid 1800s to 1900 and another from around 1910 into the late 1920s. If this is correct then perhaps some family member of Samuel or John Pyott occupied these structures in the 1800s. The Jestice's, in turn, may have renovated or remodelled the buildings after they bought the property in 1919. According to all indications, J. B. and Mary Jones may not have lived in these buildings.

Socioeconomic Status

The artifacts recovered point to a typical lifestyle that was shared with many other families in the area. No special, exotic, or expensive items were recovered. The ceramic assemblage produced only 2 sherds of porcelain. Activities revolved around building upkeep and domestic affairs. Certainly the farm families that lived in these structures were of a lower socio-economic status with few luxuries.

Conclusions and Recommendations

As with the Jenkins House Site (40Re188), the recommendations towards the management of this cultural property are broadly based upon its potential for the future enjoyment and/or research by professionals and the general public. The factors that go into this determination include: (1) the nature, extent, and integrity of the structures and their associated archaeological site; (2) the possibility of future significant archaeological and architectural research; and (3) the unusualness (or commonness) of the structures in both the region and the immediate area. Are there any similar structures in the area that are more deserving preservation?

The Jones House Site (40Re189) has remained remarkably undisturbed. Good association exists between the log house, log smokehouse, and log barn. In addition, the site's natural

surroundings are well preserved. The road cut to the west of the site is original and dates to at least a portion of the site's occupation (Figure 10). Unfortunately, the structures, while in their original locations, are not as well preserved. The log house is collapsed except for portions of the limestone chimney. The log smokehouse and the east crib of the log barn are partially collapsed. The west crib of the barn is in fairly good condition.

Architecturally, the structures show a curious mixture of old and new hardware and construction styles. Hand wrought iron hinges and bars are found many times in close proximity with cut or wire nails. Although the exact construction sequence of these buildings is difficult to assess and beyond the goals of this project, further investigations may reveal more detailed knowledge as to the expertise of their builders. Therefore, this aspect warrants more research, as does the question of the dating and relationship between the two pens of the log house. Can we conclusively tell which one is built first and which is added later? Were they build at the same time?

The archaeological testing of this site has thrown little light onto these questions. In addition, the excavation has failed to locate artifact concentrations around and between the log house and log smokehouse, except for the deposit sampled by Unit 1. Unfortunately, few things can be decided about that deposit. Given that the earliest artifacts, besides the hand wrought hardware, were found here, this unit may have been placed in an early trash midden that has been disturbed by later activity. Further investigation into this deposit is strongly recommended, as is the placement of either shovel tests or units inside the log house. There are many facets of the archaeology of this site that warrant further investigation. There may well be an entirely different occupation of this site that predates these standing structures or perhaps these structures may actually date to the early 1800s.

The "Rectangular Cabin", as defined by Glassie (1965:153-159), is a common log house of the Southern Appalachians that shows influence from the English or perhaps the Scotch-Irish. Additions were usually added onto the end of a house (Glassie 1965: 159-160). If the east pen at this site was the built first, then the side addition would be unusual. Fielder's (Fielder, Ahler and Barrington 1977) survey of historic house remains within the Oak Ridge Reservation records many of these types of buildings. It is, however, unclear how many of those that are partially or fully standing structures are built in this way.

With the possibility that this site could date as early as the 1820s or earlier, have a long occupational history and given its undisturbed natural and cultural surroundings, we recommend that the Jones House Site (40Re189) be considered for inclusion on the National Register of Historic Places. Avoidance is the

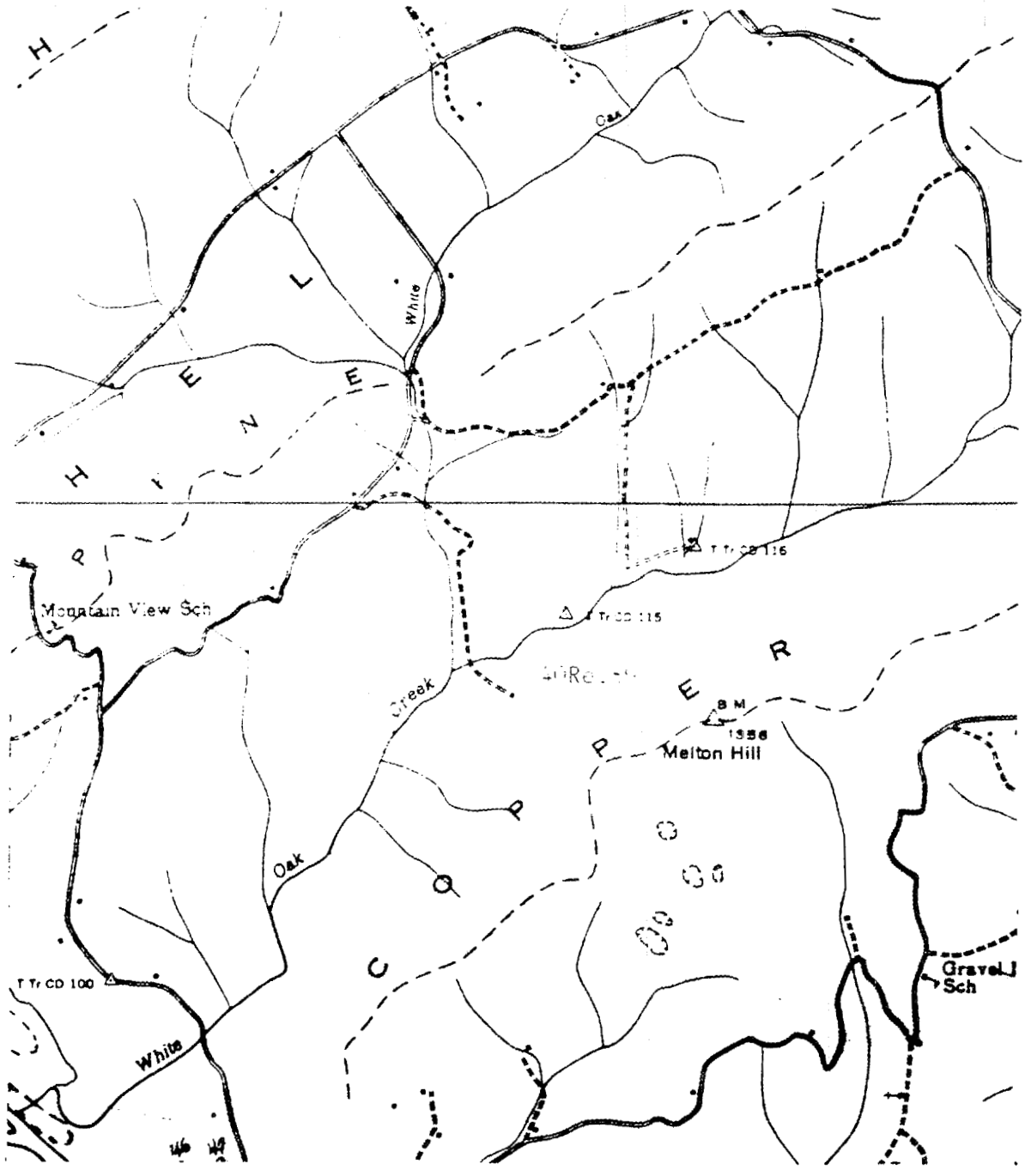


Figure 10. The Jones House Site (40Re189), Kingston Demolition Range Map, 1942, 1 cm = 415m , north is toward the top.

strongly recommended management policy for this site. However, if this area -- which includes all the buildings and land between them -- cannot be completely avoided by destructive activity then further architectural and archaeological research, as justified and outlined above, is recommended for this site.

INTERNAL DISTRIBUTION

1. L. D. Bates
2. T. A. Boden
3. H. M. Braunstein
4. G. E. Butterworth, III
5. G. F. Cada
6-15. A. W. Campbell
16. J. B. Cannon
17. S. A. Carnes
18. C. E. Davis
19. R. Dreier
20. S. P. Dumont
21. N. W. Durfee
22. W. Fulkerson
23. M. A. Faulkner
24. M. A. Green
25. T. Grizzard
26. S. G. Hildebrand
27. C. M. Kendrick
28. R. H. Ketelle
29. B. L. Kimmel
30. J. D. Lawrence
31. D. L. Lennon
32. L. N. McCold
33. R. B. McLean
34. L. E. McNeese
35. J. W. Moore
36. T. E. Myrick
37. E. Newman, Jr.
38. C. E. Nix
39. P. T. Owen
40. R. M. Reed
41. D. E. Reichle
42. P. S. Rohwer
43. R. D. Roop
44. T. H. Row
45. R. E. Saylor
46. T. F. Scanlan
47. J. A. Setaro
48. F. E. Sharples
49. R. B. Shelton
50. C. F. Sigmon
51. J. H. Smith
52. R. C. Stewart
53. L. E. Stratton
54-63. J. H. Swanks
64. D. W. Turner
65. L. D. Vorhees
66. T. J. Wilbanks
67. L. C. Williams
68. E. D. Wright
69. G. T. Yeh
70. E. T. Rogers
71. ORNL Patent Office
72-74. Central Research Library
75. Document Reference Section
76. Laboratory Records
77. Laboratory Records - RC

EXTERNAL DISTRIBUTION

78. J. J. Cuttica, Vice President of Research and Development, Gas Research Institute, 8600 W. Bryn Mawr Avenue, Chicago, IL 60631
79. J. P. Kalt, Professor of Economics, Kennedy School of Government, Harvard University, 79 John F. Kennedy Street, Cambridge, MA 02138
80. D. E. Morrison, Professor of Sociology, Michigan State University, 201 Berkey Hall, East Lansing, MI 48824-1111
81. R. L. Perrine, Professor, Engineering and Applied Sciences, Civil Engineering Department, Engineering I, Room 2066, University of California, Los Angeles, CA 90024
82. Paul R. Pike, Union Electric Company, 1901 Gratiot Street, St. Louis, MO 63166
83. J. J. Wargo, 62 Wyoming Street, Lee Park, Wilkes-Barre, PA 18702

84. Office of Assistant Manager for Energy Research and Development, DOE-ORO, P.O. Box 2001, Oak Ridge, TN 37831

85-94. OSTI, U.S. Department of Energy, P.O. Box 62, Oak Ridge, TN 37831

95. S. E. Everette, 3411 Cendelaria, N.E., S. M. Stoller Corp., Albuquerque, NM 87107

96. J. E. Stumbaugh, Westinghouse - WIPP, P.O. Box 2078, Carlsbad, NM 88220

97. J. R. Harvill, Westinghouse - WIPP, P.O. Box 2078, Carlsbad, NM 88220