Site Locality Identification Study: Hanford Site

MASTER

Volume II: Data Cataloging

Woodward-Clyde Consultants

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Department of Energy
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Rockwell International

Rockwell Hanford Operations
Energy Systems Group
Richland, WA 99352

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Volume II

SITE LOCALITY IDENTIFICATION STUDY:
HANFORD SITE

VOLUME II: DATA CATALOGING

by

Staff

Woodward-Clyde Consultants

July 1980

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SUMMARY

Data compilation and cataloging for the candidate site locality identification study were conducted in order to provide a retrievable data cataloging system for the present siting study and future site evaluation and licensing processes. This task occurred concurrently with and also independently of other tasks of the candidate site locality identification study. Work in this task provided the data utilized primarily in the development and application of screening and ranking processes to identify candidate site localities on the Hanford Site.

The overall approach included two steps: 1) data acquisition and screening; and 2) data compilation and cataloging. Data acquisition and screening formed the basis for preliminary review of data sources with respect to their probable utilization in the candidate site locality identification study and review with respect to the level of completeness and detail of the data. The important working assumption was that the data to be used in the study be based on existing and available published and unpublished literature.

The data compilation and cataloging provided the basic product of the Task: a retrievable data cataloging system in the form of an annotated reference list and key word index and an index of compiled data. The annotated reference list and key word index are cross referenced and can be used to trace and retrieve the data sources utilized in the candidate site locality identification study.

I. INTRODUCTION

1. GENERAL

The task of data compilation and cataloging was performed as a concurrent but relatively independent task within the overall site identification study. The objective of this task was to provide a retrievable data cataloging system for the candidate site locality identification study and for future site evaluation and licensing processes. In particular, this consisted of the collection, review, and cataloging of existing data sources dealing with geology, seismology, tectonics, geotechnical engineering, ecology, land use, socioeconomics, and regulations for siting of nuclear facilities in the Pasco Basin area and surrounding region. These existing data sources were utilized in part or entirely in the candidate site locality identification study, and the collection and review of the data were geared to the data's usefulness to the siting study. This report includes the approach and method of study used to compile and catalog the data sources as well as the results of the cataloging system.

2. KEY ASSUMPTIONS

Three key assumptions that were used to direct the efforts in this task and dealt with data availability, utilization, and detail.

- The data to be collected, reviewed, and cataloged in this task consist of readily available published and unpublished literature generated to the present date.

- The compilation and cataloging of the data will be primarily from the standpoint of their probable utilization in the siting process with the application of present-day technology.
- The coverage and detail of the data could vary depending upon the size of the area under study. The data utilized for a more regional assessment may not be the same as those used for assessing smaller areas such as candidate site localities.

3. OVERALL APPROACH

The overall approach to data compilation consisted of two basic steps; 1) data acquisition and screening, and 2) data compilation and cataloging. However, prior to these basic steps, the basis for data acquisition, compilation, and cataloging was formulated. It involved a preliminary examination of the amount, type, and detail of the available data and provided information needed to scope the work in further steps in this task. The overall approach is illustrated in Figure I-1.

In the first step, existing bibliographies were examined to locate data sources considered useful to the site identification study. These sources were collected and then screened to extract the data considered significant to the siting process. In addition, data not readily available from the literature were developed through special studies involving limited analyses and literature evaluation for use in the site identification study.

In the second step, the data sources were compiled and cataloged in a retrievable cataloging system. Data

FIGURE I-1
OVERALL APPROACH

compilations included data summaries and data map compilations which were used in the site identification process. The retrievable cataloging system includes an annotated reference list, a key word index, and an index of compiled data which were also used in the study to provide for data traceability.

4. ORGANIZATION OF THE REPORT

This volume presents the results of data compilation and cataloging, beginning with Section I which includes the key assumptions, general approach, and relationship of this task to other tasks of the candidate site locality identification study. The approach and method of study for data acquisition and screening are discussed in Section II. Section III includes a description of the data compilation and cataloging systems used for data storage and retrieval. Appendices A, B, C, and D include the annotated references, key word index, index of compiled data, and a discussion of special studies, respectively.

II. DATA ACQUISITION AND SCREENING

1. GENERAL

The first step in the task was data acquisition and screening. Using the key assumptions stated previously (Section I), the objectives of this step were to locate, acquire, and screen those sources of data concerning geology, tectonics, engineering, socioeconomics, environmental science, and nuclear facilities siting, based on the data's probable utilization in the siting process and also based on readily available published and unpublished literature. To achieve this purpose, bibliographies of available literature were scanned for promising articles which were collected. Literature was screened for its significance to the site identification study and pertinent articles were obtained or copied for the project library. Literature screening forms were filed in a notebook for later use in identifying candidate repository site localities and in developing a key word index and an annotated reference list.

2. APPROACH AND METHOD OF STUDY FOR DATA ACQUISITION AND SCREENING

Three substeps were utilized in the approach and method of study for data acquisition and screening for the Pasco Basin and surrounding region:

- Initial review of bibliographies to identify promising sources of data for utilization in the site identification study
- Secondary review of bibliographies and data sources to locate and obtain promising literature sources for utilization in the siting process

- Screening of the data sources to review and extract the information considered to be significant to the site identification study.

The initial review of bibliographies consisted of an examination of several bibliographies dealing with geology, geophysics, tectonics, and other topics of the Pasco Basin and surrounding region of the Columbia Plateau (Summers and Schwab, 1978; Tucker and Rigby, 1978; Roberts, 1970; Roberts and Others, 1973; Tucker, 1978; Reichert, 1969). These bibliographies, some of which contain map indexes, were scanned to compile an initial list of articles and maps to be gathered and reviewed (Figure II-1). Reference lists from pertinent literature were also checked. Using titles as the major guide, literature that appeared significant was ordered or borrowed from libraries.

The secondary review of the literature consisted of a visual examination of the data sources identified in the initial step to determine whether the information contained within was applicable to the site identification study or could be utilized in the various tasks of the siting study. Those literature sources which appeared to be promising were retained for further use and placed in the project files. In both the initial and secondary review of the literature, extensive use was made of the libraries and associated reports available from Rockwell Hanford Operations, Pacific Northwest Laboratory, and Washington Public Power Supply System, Inc.

Screening of the data sources involved the development of a literature screening form for use in reviewing the significant data sources and summarizing the pertinent data. Two general forms were developed: 1) one for geologic/tectonic and

"?"
may be
useful

"+"
marks
possibly
relevant
article
to be
collected

"✓"
article
already in
project
files

"-"
article
does not
appear
to be
useful

Bond, J. C., 1962, Geology of the Clearwater embayment in Idaho:
? Univ. of Washington, Ph.D. thesis.

Brown, R. E.; Brown, D. J., 1958, Surface of the basalt series in the
+ Pasco Basin, Washington: (abs.) Bull. Geol. Soc. Am. v. 69,
no. 12, pt. 2, p. 1677.

Coe, R. S.; Bogue, S.; Myers, C. W., 1978, Paleomagnetism of the Grande
+ Ronde (Lower Yakima) Basalt exposed at Sentinel Gap: potential
use for stratigraphic correlation: Rockwell-Hanford Operations
Rept. RHO-BWI-ST-2, 24 p.

Culver, H. E.; Kirkham, V. R. D., 1927, General geology of eastern
— Washington and northern Idaho: Northwest Sci., v. 1, p. 25-
30, map, 1:500,000.

Hubbard, P. S., 1968, Geology of the Saddle Butte quadrangle, Washington:
— Univ. of Hawaii, M.S. thesis.

Piper, C. V., 1905, The basalt mounds of the Columbia Lava: Science,
— new series 21, p. 824-825.

Portland General Electric Co., 1974, Pebble Springs Nuclear Plant
Units 1 and 2, License Application, PSAR, section 2.5 - geology
✓ + and seismology, section 2.6 - references.

Reidel, S. P., 1978, The stratigraphy and petrogenesis of the Grande
? Ronde Basalt in the lower Salmon and adjacent Snake River
canyons: Washington State Univ. Ph.D. thesis.

Shannon and Wilson, 1973, Geologic studies of the Columbia River
+ Basalt and age of deformation, the Dalles - Umatilla region,
Washington and Oregon, The Boardman Nuclear Project: Report
to Portland General Electric Co., Portland, Oregon.

Steen-McIntyre, Virginia, 1977, A manual for tephrochronology-collection,
preparation, petrographic description and approximate dating
of tephra (volcanic ash): Published by the author, Box 1167,
— Idaho Springs, Colorado, 80452, 167 p.

Thayer, T. P.; Wagner, N. S., 1969, Geology of the Blue Mountain region:
? Oregon Dept. of Geol. & Min. Ind., Bull. 64, p. 68-74.

FIGURE II-1

EXAMPLE OF SCANNED BIBLIOGRAPHY PAGE

geotechnical purposes; and 2) one for environmental science purposes. The forms contain spaces to fill in the reference information, location of the study being described, relevance to the project, key words, and a summary of the article. In addition, the forms for geologic studies contain space for specific information on stratigraphy, structure, hydrology, and economic geology. A sample of how this form was used is illustrated in Figure II-2. The purposes of the forms were to summarize the type of data available, describe the amount of detail in each article or map, and provide a mechanism to trace data sources used in the site identification study. The literature screening forms are maintained in the project files and are continuously updated as data are acquired.

REPOSITORY SITING PROJECT ROCKWELL HANFORD Literature Screening Form	Area: Region _____ Reservation _____ Investigator: Date/Initial _____ Significant: Yes/No/Maybe _____
NOTE: Do not attempt to extract all relevant data - List the type and value of data the paper presents:	
Author(s)/Date: _____ Title: _____ Publication/Report: _____	
1. <u>Regional Location</u> (location map on page _____)	
2. <u>Key words:</u> disciplines, groups or formations, and locations): _____	
3. <u>Stratigraphic data:</u> maps, pages _____, cross sections, pages _____, (list key groups, formations and age dates, etc.) ...	
4. <u>Tectonics/structure/geophysics:</u> maps, pages _____, cross sections, pages _____ (active faults, folds, volcanoes, etc.) ...	
5. <u>Hydrology:</u> basin or aquifer maps, pages _____, logs/cross sections, pages _____, (surface runoff data, dams, gauging) ...	
6. <u>Economic geology:</u> location map, page _____, cross section or log, page _____, mines, dollar value, gravel pit, wells, etc. mentioned on pages, _____	
7. <u>Summary:</u> _____	

A. Sample Screening Form

REPOSITORY SITING PROJECT ROCKWELL HANFORD Literature Screening Form	Area: Region <u>Yes</u> Reservation <u>Yes</u> Investigator: Date/Initial <u>10.16.78</u> Significant: Yes/No/Maybe <u>Yes</u>
NOTE: Do not attempt to extract all relevant data - List the type and value of data the paper presents:	
Author(s)/Date: <u>Bretz, J.H., Smith, Neff</u> <u>1956</u> Title: <u>Channeled Scabland of Washington's</u> <u>New Data and Interpretations</u> Publication/Report: <u>G.S.A. Bull., v. 67, p. 957-1049</u>	
1. <u>Regional Location</u> (location map on page <u>962</u> <u>Wash.</u> <u>northeastern Columbia Plateau</u>)	
2. <u>Key words:</u> disciplines, groups or formations, and locations): <u>geomorphology, glaciofluvial deposits</u> <u>channeled scablands</u> <u>surficial deposits</u> <u>Pasco Basin</u>	
3. <u>Stratigraphic data:</u> maps, pages <u>many</u> , cross sections, pages _____, (list key groups, formations and age dates, etc.) ... <u>maps and descriptions of effects of</u> <u>Spokane flood</u> <u>on Hanford p. 1009-15</u>	
4. <u>Tectonics/structure/geophysics:</u> maps, pages _____, cross sections, pages _____ (active faults, folds, volcanoes, etc.) ... <u>Pasco and Quincy Basins are enclosed structural</u> <u>depressions</u> <u>Quincy not drained until Flood</u>	
5. <u>Hydrology:</u> basin or aquifer maps, pages _____, logs/cross sections, pages _____, (surface runoff data, dams, gauging) ... <u>many maps of channels</u> <u>surface drainage</u>	
6. <u>Economic geology:</u> location map, page _____, cross section or log, page _____, mines, dollar value, gravel pit, wells, etc. mentioned on pages, <u>several economic gravel pits</u>	
7. <u>Summary:</u> <u>Refutes arguments against his theories</u> <u>many maps and photos showing outcrops</u> <u>of scabland features</u>	

B. Sample of Completed Form

RCP 8005-86

FIGURE II-2

EXAMPLE OF USE OF LITERATURE SCREENING FORM

III. DATA COMPILATION AND CATALOGING

1. GENERAL

The data compilation and cataloging step provided the primary product of the task work in the site identification study: a retrievable cataloging system usable during the siting study as well as through subsequent phases of the siting process. The data sources utilized in the site locality identification study included published and unpublished literature and compiled data summaries and data maps. To accommodate the available published and unpublished literature and catalog it in a retrievable manner, two systems were utilized: 1) an annotated list of references; and 2) and a key word index. The annotated references (Appendix A) include all published and unpublished literature screened for use in the siting study. The key word index (Appendix B) was developed to provide a cross reference to the annotated reference list and to provide an additional method to enter the data cataloging system.

Data summaries and data compilation maps evolved from the review and evaluation of the available data sources. This information was used directly or indirectly in the various tasks of the candidate site locality identification study. In addition, where specific information could not be compiled from the existing data sources, special studies were undertaken to develop data that could be utilized in the siting study. Appendix C includes an index of compiled data and Appendix D provides a discussion of two special studies used to develop data.

2. DATA CATALOGING

2.1 Annotated References

The annotated reference list present in Appendix A evolved as the need for data developed in each of the other tasks of the site identification study. As such, the reference list was being continuously updated throughout the site identification study. The annotations for each reference are based on the information extracted from the data screening forms discussed in Section II and are generally limited to the pertinent data utilized in the site identification study. Thus, it is likely that other information may also be present in a given source of data, but it was not considered to be significant to the present siting study. The numbers assigned to each reference in Appendix A were developed for cross reference with the key word index and provide for reference list expansion by the use of decimal numbering.

The annotated reference list was designed to provide a system to trace the use of available published and unpublished data in the site identification study and to retrieve a summary of the pertinent information. In addition, when used in conjunction with the filed literature screening forms, more detailed data can be retrieved.

2.2 Key Word Index

All the key words listed on the literature screening forms were compiled into a master list. The list was organized by topic into a preliminary key word list which was reviewed and evaluated for completeness and to eliminate possible redundancies. The preliminary key word index was finalized and is presented in Appendix B. All available published and unpublished data sources (Appendix A) are listed by number

under each key word (Appendix B) used on the data screening form or an equivalent key word.

The key word index was designed to provide an additional source of entry into the annotated reference list and thus provide an additional method of tracing and retrieving sources of data. Using the key word index, a general topic and/or a known key word can be located and the appropriate or pertinent data sources can be traced. An example of how the key word index can be used is shown in Figure III-1.

2.3 Data Summaries and Compilations

Data from available literature that could be mapped and used in the screening of the Pasco Basin was compiled on overlays of the study area. Other maps were compiled to show where surface mapping had been done and where subsurface data existed. In addition, where information was needed, although not necessarily mapped information (e.g., lithology, stratigraphic descriptions), notebooks and small-scale maps were developed to organize and summarize the pertinent data on the Pasco Basin and the surrounding region of the Columbia Plateau. The data compilations have been filed and are accompanied by references to sources, data summaries, working drafts, and so on. Appendix C contains an index of the compiled data placed on file and used (to date) in the screening of the Pasco Basin.

3. SPECIAL STUDIES

When neither the existing data sources nor the compiled data could provide necessary information for the various tasks of the siting study, special studies involving analyses and evaluations of the data were undertaken to obtain such

1. SAMPLE TOPIC

Internal structures of basalt flows

2. LOCATE THE MOST APPROPRIATE KEY WORD

Key words are arranged in outline format
under major subject headings

3. ENTRY IN KEY WORD INDEX

Intrabasalt structures

143 150 184 201 283 447

4. TURN TO APPENDIX A – ANNOTATED REFERENCES
AND LOCATE THE REFERENCES WITH THE NUMBERS
ON THE KEY WORD INDEX

Example from references ➤

143. Hodges, C. A., 1978, Basaltic ring structures of the Columbia Plateau: Geological Society of America Bulletin, v. 89, p. 1281-1289.
The ring structure found in the Roza Member near Odessa is described and features are related to rising ground water as thick flows cooled over a topographic low.
150. Hoyt, C. L., 1961, The Hammond Sill-An intrusion in the Yakima Basalt near Wenatchee, Washington: Northwest Science, v. 35, no. 2, p. 58-64.
The basalt structures in western Douglas County are discussed. The Hammond Sill is an invasive sill with subsidiary dikes within the Rock Island interbed.
184. Long, P. E., 1978, Characterization and recognition of intraflow structures, Grande Ronde Basalt: Rockwell International, Informal Report RHO-BWI-LD-10, prepared for the U.S. Department of Energy, Contract EY-77-C-06-1030.
This report describes various intraflow structures in the Grande Ronde flows and their usefulness in correlating drill hole data.
201. McKee, B., and Stradling, D., 1970, The sag flowout: a newly described volcanic structure: Geological Society of America Bulletin, v. 81, p. 2035-2044.
This article describes the ring structures occurring in the Roza Member near Odessa, Washington. They were formed by fluid lava escaping along concentric dikes in the partly solidified flow.
283. Ryan, M. P., and Sammis, C. G., 1978, Cyclic fracture mechanisms in cooling basalt: Geological Society of America Bulletin, v. 89, p. 1295-1308.
This paper addresses the question of how hexagonal polyhedra are found and how vertical joints grow longer (crack tip deformation) in cooling basalts.
447. Waters, A. C., 1960a, Determining direction of flow in basalts: American Journal of Science, v. 258-A, p. 350-366.
A determination of flow direction using columnar joints, spiracles, pipe vesicles and cylinders, and primary foreset bedding in palagonite.

FIGURE III-1

EXAMPLE OF USE OF KEY WORD INDEX AND ANNOTATED REFERENCES

information. These studies generally involved a review of existing literature plus the development of assumptions and subsequent analyses to reach conclusions necessary to provide the required information. Two such special studies undertaken were to: 1) characterize estimated operational radiation releases from nuclear waste repositories; and 2) characterize underground earthquake ground motion. Adequate information does not exist to characterize either of these subjects, although they are of particular interest to the siting study in terms of the development of screening and ranking guidelines. Appendix D includes detailed discussions of the approaches and methods of study for the particular special studies of repository operational releases and underground earthquake ground motion.

APPENDIX A
ANNOTATED REFERENCES

APPENDIX A
ANNOTATED REFERENCES

The following list of annotated references is the primary product of data cataloging. The type and variety of the list reflect the data needs for the various tasks of the site locality identification study for the Pasco Basin and surrounding region. The annotations for each reference are based on the information extracted from the literature screening forms (discussed in Section III) and, as such, are geared to present a summary of the information considered pertinent to the present siting study. Appendix A and Appendix B (Key Word Index) provide a cross-referenced cataloging system for the available published and unpublished literature used or considered for use in the site locality identification.

1. Adam, J.A. and Rogers, V.L., 1978, A classification system for radioactive waste disposal--What waste goes where?: U.S. Nuclear Regulatory Commission, NUREG-0456.

This classification system is based on the premise that characteristics of radioactive waste should determine the waste disposal method employed.

2. The Aerospace Corporation, 1973a, Washington State Airport System Plan: prepared for the Washington State Aeronautics Commission and the Federal Aviation Administration, ATR-73(7273)-1, v. 1.

This plan describes aviation facility needs in the State of Washington for the next 20 years. An inven-

tory of aviation facilities identifies land-use patterns in the vicinity of the state's airports.

3. The Aerospace Corporation, 1973b, Washington State Airport System Plan: Technical Supplement: prepared for the Washington State Aeronautics Commission and the Federal Aviation Administration, ATR-73(7273)-1, v. 2, Part 1.

This report presents the planning study information developed during the preparation of the Washington State Airport System Plan. It identifies the procedures followed during development of information and presents data, plans, and guidelines directed to county and local planners.

4. The Aerospace Corporation, 1973c, Washington State Airport System Plan: Technical Supplement: prepared for the Washington State Aeronautics Commission and Administration, ATR-73(7273)-1, v. 2, Part 1.

This report presents the planning study information developed during the preparation of the Washington State Airport System Plan. It identifies the procedures followed during development of information and presents data, plans, and guidelines directed to county and local planners.

5. Agapito, J.F., Hardy, M.P., and St. Laurent, D.R., 1977, Geo-engineering review and proposed program outline for the structural design of a radioactive waste repository in Columbia River basalts: Rockwell Hanford Operations, Report RHO-ST-6, Richland Washington.

This geological engineering review program is for a proposed radioactive waste repository in Columbia Plateau basalts.

6. American Nuclear Society, Inc., 1978, Waste management: Nuclear News, v. 21, no. 11, p. 119-130.

A news article summarizing a public hearing on radioactive waste by an interagency task force. Federal proposals are briefly explained by legislators.

7. Anderson, J.V., Bush, J.H., Crobsy, J.W., Kiesler, J.P., and Siems, B.A., 1973, Correlation of Columbia River basalt by geophysical techniques (abs.): Geological Society of America, Abstracts with Programs, v. 5, no. 1, p. 3.

Stratigraphic correlations, based on TiO_2 analysis, gamma and neutron logs, and driller's logs, were performed on the upper 500 feet of basalt in the Horse Heaven Hills. Correlations were made for the Wanapum and Saddle Mountains Formations.

8. Armstrong, B.H., 1969, Acoustic emissions prior to rockbursts and earthquakes: Bulletin of the Seismological Society of America, v. 59, no. 3, p. 1259-1279.

The acoustic emissions prior to earthquakes and rockbursts were examined. Transmission effects and the effect of anelastic absorption (Q -values) are considered. Indications are that highly stressed

areas of mine workings may be identified through the monitoring of acoustics and earthquakes of the mined area.

9. Armstrong, R.L., Taubeneck, W.H., and Hales, P.A., 1977, Rb-Sr and K-Ar geochronometry of Mesozoic granitic rocks and their Sr isotopic composition, Oregon, Washington, and Idaho: Geological Society of America Bulletin, v. 88, p. 397-411.

Orogenic events occurred in the basement complex during Late Triassic to Early Jurassic (200 to 217 m.y.a.) in western Idaho; Late Jurassic (140 to 160 m.y.a.) in Oregon; and Late Cretaceous (70 to 100 m.y.a.) in the Idaho batholith.

10. Atlantic Richfield Hanford Company, 1972, Bibliography of reports related to earthquake studies at Hanford, with synopses of individual reports: Atlantic Richfield Hanford Company, 77 p.

An annotated bibliography to earthquake studies performed at Hanford.

11. Atlantic Richfield Hanford Company, 1976, Preliminary feasibility study on storage of radioactive wastes in Columbia River basalts: ARH-ST-137, v. 1 and v. 2, Richland, Washington.

The geologic, hydrologic, heat transfer, and rock-waste compatibility studies that were used in evaluating radioactive waste disposal sites in Columbia River basalt are discussed. Stratigraphic correlations, degree of aquifer isolation, assessment

of tectonism, heat transfer from radwastes, and geochemistry were studied.

12. Atomic Industrial Forum's Study Group on Waste Management, 1978, Spent fuel and nuclear waste: Atomic Industrial Forum, Inc., Washington, D.C.

This policy statement discusses storing spent nuclear fuels on a short-term basis.

13. Baker, V.R., 1978, The Spokane Flood controversy and the Martian outflow channels: Science, v. 202, p. 1249-1256.

The hypothesis regarding the Spokane Flood and the development of the scablands topography of the Columbia Plateau is presented, and the development of the scablands is compared to the Martian outflow channels morphologic development.

14. Baker, V.R., and Nummedal, D., eds., 1978, The Channeled Scablands: Guide prepared by the National Aeronautics and Space Administration for the Comparative Planetary Geology Field Conference, June 5-8, 1978.

This is a compilation of papers on the Channeled Scablands physiographic region of eastern Washington. The geomorphology is thoroughly described and its inferred origin, including the hydrodynamics of high-velocity flood erosion, is discussed.

15. Baksi, A.K. and Watkins, N.D., 1973, Volcanic production rates: Comparison of oceanic ridges, islands, and the

Columbia Plateau basalts: Science, v. 180,
p. 493-496.

Volcanic production rates for the Colulmbia River basalt may have been two to three times that of volcanic island (oceanic) basalts. Lithospheric plate motions elsewhere along the North American Pacific plate margin are suggested to have triggered the event.

16. Baldwin, E.M., 1966, Geology of the Columbia River gorge: Northwest Science, v. 40, no. 4, p. 121-128.

This article discusses the Tertiary stratigraphy in the Columbia River gorge, specifically the Goble and Skamania Volcanics, Eagle Creek Formation, the Columbia River basalts, Troutdale Formation, Sandy River Mudstone and The Dalles Formation.

17. Battelle, Pacific Northwest Laboratory, 1967, Nuclear power plant siting in the Pacific Northwest: Report for the Bonneville Power Administration, Contract No. 14-03-67868, Richland, Washington, 50 p.

The general characteristics of Pacific Northwest areas selected as potential nuclear power plant sites are presented.

18. Battelle, Pacific Northwest Laboratory, 1971, Bibliography of geological publications supported by the AEC, related to the Columbia River Thermal Effects Studies: BNWL-1543, Richland, Washington.

These papers and publications deal almost exclusively

with salmonids, mainly regarding thermal effects and related topics. Most entries are from 1966 to 1970, but the bibliography covers the period of 1950 to 1970.

19. Battelle, Pacific Northwest Laboratory, 1977, The Hanford 6-7 series, a volume of atmospheric field diffusion measurements: PNL-2433, Richland, Washington.

Meteorological data obtained by taking atmospheric diffusion measurements in the Hanford Site area are presented.

20. Battelle, Pacific Northwest Laboratory, 1979, Defense programmatic environmental impact statement for high-level waste: Release Scenario Analysis (Draft): prepared for Rockwell Hanford Operations, Richland, Washington.

This draft report analyzes Rockwell Hanford Operations' disruptive release scenarios for high-level waste, as well as presenting additional scenarios.

21. Battelle, Seattle Research Center, 1978, Tectonics and seismicity of the Columbia Plateau workshop: Battelle Tectonics Symposium, February 14-16, 1978, Basalt Waste Isolation Program - Rockwell Hanford Operations, Seattle, Washington.

This report summarizes the present knowledge on the Columbia River basalts and their tectonic setting, past and present.

22. Beaulieu, J.D., ed., 1972, Geologic formations of eastern Oregon: Oregon State Department of Geology and Mineral Industries Bulletin 73, 80 p.

A descriptive index of lithologies and mapping of formations in eastern Oregon is provided. (No geologic map is included.)

23. Beaulieu, J.D., ed., 1973, Geologic field trips in northern Oregon and southern Washington: Oregon State Department of Geology and Mineral Industries Bulletin 77, 206 p.

Pre-Columbia River basalt formations in Oregon are discussed, including limited stratigraphic information, on the Columbia River Plateau.

24. Beaulieu, J.D., 1978, Surficial geologic hazard concepts for Oregon: The Ore Bin, v. 40, no. 3, p. 41-56.

Various types of surficial geologic hazards are discussed with (non-referenced) examples.

25. Beck, M.E., Jr., 1978, Summary of tectonic models for the origin of the Columbia River Plateau: Paper presented at Battelle Tectonics Symposium, February 14-16, 1978, Seattle, Washington, 8 p.

This paper discusses several tectonic models and theories for the origin of the Columbia River basalt.

26. Becraft, G.E. and Weis, P.L., 1957, Preliminary geologic map of part of the Turtle Lake quadrangle, Lincoln and Stevens Counties, Washington: U.S. Geological Survey,

Mineral Inventory Field Studies Map MF-135.

This map shows basement rock formations and surficial deposits. Very little of the Columbia River basalt is exposed. No correlation of flows is given.

27. Becraft, G.E. and Weis, P.L., 1963, Geology and mineral deposits of the Turtle Lake quadrangle, Washington: U.S. Geological Survey Bulletin 1131, 73 p.

This bulletin describes the structure, stratigraphy, and mineral deposits in Lincoln and Stevens Counties on the northern edge of the Columbia Plateau. There are sparse exposures of the Columbia River basalt and no direct correlations of the flows are made; however, there are data on basement and surficial deposits.

28. Beeson, M.H., Bentley, R.D., and Moran, M.R., 1976, Preliminary correlation of Lower Yakima Basalt flows in western Oregon with the type area in central Washington (abs.): Geological Society of America, Abstracts with Programs, v. 8, no. 3, p. 353-354.

This abstract discusses the possible correlation of some Grande Ronde Basalt flows between central Washington and the Portland area.

29. Benson, L.V., 1978, Secondary minerals, oxidation potentials, pressure, and temperature gradients in the Pasco Basin of Washington State: Topical Report No. 1: RHO-BWI-C-34, Lawrence Berkeley Laboratory, University of California at Berkeley, for Rockwell Hanford Operations, Richland, Washington.

This report presents the lithostatic pressure-temperature versus depth gradients, oxidation potential measurements and interpretations, and a review of secondary mineralization phases present at depth in the Pasco Basin.

30. Bentley, R.D., 1977a, Stratigraphy of the Yakima Basalts and structural evolution of the Yakima ridges in the western Columbia Plateau (Field Trip no. 12), in Geological Excursions in the Pacific Northwest; Geological Society of America 1977 Annual Meeting, Seattle, Washington, p. 339-389.

Stratigraphic and structural cross sections, field locations with descriptions, photographs, and geologic maps of the western Columbia Plateau are provided.

31. Bentley, R.D., 1977b, Western Columbia Plateau margin studies Tieton River to Yakima River: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RD, Chapter 6.0.

This report describes the nature and character of the contact between the Columbia River basalt and underlying units, documents, structures intersecting this contact and presents the results of the evaluation of the age of deformation of geologic structures in the western Columbia Plateau.

32. Benton, Franklin, and Walla Walla County Air Pollution Control Board Staff, 1973, Regulation II - Air Quality Standards: Benton, Franklin, and Walla Walla County Air Pollution Control Board, Washington.

This document contains a listing of official air quality standards as of 1973 for Benton, Franklin, and Walla Walla Counties, Washington.

33. Bierschenk, W.H., 1957, Hydraulic characteristics of Hanford aquifers: Hanford Atomic Products Operation, General Electric, HW-48916, Richland, Washington.

Three analytical techniques are applied to aquifer test data at the Hanford Site: (1) non-equilibrium "type-curve" method; (2) non-equilibrium "straight-line" method; (3) "image well" technique. These techniques are described and discussed as they apply to the Hanford Site area aquifers.

34. Bingham, J.W. and Grolier, M.J., 1966, The Yakima Basalt and Ellensburg Formation of south-central Washington: U.S. Geological Survey Bulletin 1224-G, 15 p.

Type locations and a bibliography of measured stratigraphic sections are given for Saddle Mountains Basalt, Roza Member, Sentinel Gap flow, and Frenchman Springs Member.

35. Bingham, J.W., Londquist, C.J., and Baltz, E.H., 1970, Geologic investigation of faulting in the Hanford region, Washington: U.S. Geological Survey Open-File Report, 103 p.

The report states that the block gliding on the Smyrna bench last occurred at least 12,000 years ago. Gable Mountain fault has not moved in at least 40,000 years and probably not for more than 100,000 years, and the Wallula Gap fault is probably active.

36. Bingham, J.W. and Walters, K.L., 1965, Stratigraphy of the upper part of the Yakima Basalt in Whitman and eastern Franklin Counties, Washington: U.S. Geological Survey Professional Paper 525c, p. C87-C90.

This paper discusses the stratigraphy of the Yakima Basalt Subgroup and contains cross sections, tables, and maps correlating flows.

37. Bishop, W.P., Frazier, D.H., McGrath, P.E., Metlay, D.S., Stoneman, W.C., and Watson, R.A., 1978, Proposed goals for radioactive waste management: U.S. Nuclear Regulatory Commission, NUREG-0300.

For policy development, the goals for radioactive waste management are set forth with respect to time of nuclear use, management and permanent isolation, government organizations, costs, technical problems, health and safety.

38. Bishop, W.P., Hoos, I.R., Hilberry, N., Metlay, D.S., and Watson, R.A., 1978, Essays on issues relevant to the regulation of radioactive waste management: U.S. Nuclear Regulatory Commission, NUREG-0412.

Essays discuss the history of radioactive waste management, credulity, methods, managerial errors, public participation, problems, and goals of radioactive waste management.

39. Blume, John A. and Associates, 1971a, A summary report, seismic evaluation and development of ground accel-

eration and response spectra for FFTF site: Report prepared for WADCO, JABE-WADCO-03, Richland, Washington.

This summary report indicates a maximum credible earthquake on the Rattlesnake-Wallula fault of M 6.8 and acceleration of 0.25 g at the FFTF site.

40. Blume, John A. and Associates, 1971b, Supplementary geologic investigations for seismic evaluation of the FFTF site near Richland, Washington: Report prepared for WADCO, JABE-WADCO-04, Richland, Washington.

This summary geologic investigation report for the Hanford Site evaluates seismicity hazards of the Fast Flux Test Facility (FFTF) site, geology, and surface faulting.

41. Board, M.P., 1978, Rock mechanics methods and in situ heater tests for design of a nuclear waste repository in basalt: RHO-BWI-LD-2, Rockwell Hanford Operations, Richland, Washington, 49 p.

A discussion on how in situ data from the near-surface test facility will be integrated into the overall waste isolation program. The rock mechanics program is discussed.

42. Bond, J.G., 1962, Geology of the Clearwater Embayment in Idaho: Ph.D. thesis, University of Washington, Seattle, Washington, 193 p.

The tectonic development of the area is discussed, and stratigraphic information for the eastern Columbia

Plateau and pre-basalt flow geology and topography are provided.

43. Bonilla, M. G., 1967, Historic surface faulting in continental United States and adjacent parts of Mexico: A factor in nuclear facility siting and design: USGS National Center for Earthquake Research, prepared for USAEC as TID-24124, Reactor Technology.

This report summarizes and evaluates basic data on the amounts and kinds of historic surface faulting in the United States and adjacent parts of Mexico. Indicated fault displacement values are given.

44. Bonini, W.E., Hughes, D.W., and Danes, Z.F., 1974, Complete Bouguer gravity anomaly map of Washington: Washington State Division of Geology and Earth Resources Map GM-11.

This gravity map has a 10-milligal-contour interval showing approximately 50-milligal readings near the Hanford area.

45. Boore, D.M., 1977, Strong-motion recording of the California earthquake of April 1906: Bulletin of the Seismological Society of America, v. 67, no. 3, p. 561-577.

The values of inexpensive techniques to simulate ground motion are illustrated, and the importance of directivity and rupture velocity to the sensitivity of ground motion are shown.

46. Brekke, T.L. and Glass, C.E., 1973, Some considerations related to underground siting of nuclear power plants in rock. Department of Civil Engineering, University of California, Berkeley.

The importance of expansive coupling of system structures to floor, walls, or roof of rock cavities are examined.

47. Bretz, J.H., 1933, The Channeled Scabland: Guidebook 22, Excursion C-2, International Geological Congress, 16th Session, U.S. Government Printing Office, 16 p.

This is a field guide to the glacial flood features and deposits of the scablands of the Columbia Plateau.

48. Bretz, J.H., 1959, Washington's Channeled Scabland: Washington State Division of Mineralogy and Geology, Bulletin No. 45, 57 p.

This bulletin describes the various glacial flood features, discharge routes, and rates of discharge of the Channeled Scabland physiographic area.

49. Bretz, J.H., Smith, H.T.U., and Neff, G.E., 1956, Channeled Scabland of Washington: New data and interpretations: Geological Society of America Bulletin, v. 67, p. 957-1049.

This bulletin discusses several geomorphic features relating to the Pasco and Quincy Basins and the overall Scabland physiographic area. Many maps and photographs that show outcrops in support of the catastrophic flooding theory are provided.

50. Brock, M.R. and Grolier, M.J., 1973, Chemical analysis of 305 basalt samples from the Columbia River Plateau, Washington, Oregon, and Idaho: U.S. Geological Survey Open-File Report No. 1889.

A computer printout of geochemical data on Columbia River basalt samples. Sample location listings are provided.

51. Brooks, W.E., Jr., 1974, Stratigraphy and structure of the Columbia River basalt in the vicinity of Gable Mountain, Benton County, Washington: M. S. thesis University of Washington, Seattle, Washington.

Data on the stratigraphy and structural geology of the Columbia River basalt in the vicinity of Gable Mountain are presented.

52. Brown, C.E. and Thayer, T.P., 1966, Geologic map of the Canyon City quadrangle, northeastern Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-447.

This map shows Columbia River basalt geology and general basement geology. A description of map units and a tectonic map of the area are also presented.

53. Brown, D.J., 1965, Correlation of sediments overlying the Columbia River basalt in southeastern Washington (abs.): Geological Society of America, Special Paper No. 82, p. 321.

This abstract discusses Late Tertiary and Quaternary sedimentation.

54. Brown, J.C., 1978, Discussion of geology and ground-water hydrology of the Columbia Plateau, with specific analysis of the Horse Heaven, Sagebrush Flat, and Odessa-Lind areas, Washington: Washington State University, College of Engineering, Research Report No. 78/15-23.

This report mainly discusses relationships of geologic units and structures to hydrology of the areas.

55. Brown, R.E., 1960, The use of geophysics and geochemistry to confirm geological interpretations of the Hanford works of the Atomic Energy Commission, U.S.A.: 21st International Geological Congress, Copenhagen, Part 2, p. 75-82.

A study of geohydrology at the Hanford Site is provided for use in planning waste disposal.

56. Brown, R.E., 1965, Problems associated with the extension of the stratigraphic units of south-central Washington, Part 1: The late basalt flows, Ellensburg and Lower Ringold Formations: Presentation at Annual Meeting of the Northwest Scientific Association, Portland, Oregon, 11 p.

This geologic report provides information on stratigraphy of the Saddle Mountains Basalt, the Ellensburg Formation, and the lowest part of the Ringold Formation.

57. Brown, R.E., 1966, The stratigraphy of the uppermost part of the basalt sequence and its implications: BNWL-235, Battelle, Pacific Northwest Laboratory, Richland, Washington, v. 3, p. 1-4.

This report provides some information on the near-surface hydrology in the Beverly Member of the Ellensburg Formation and the sequence of Tertiary-Quaternary folds in the Hanford Site area.

58. Brown, R.E., 1968a, The incidence of earthquakes at Hanford as deduced from geological features: Battelle Pacific Northwest Laboratory, BNWL-481, v. 3, p. 3-5. Richland, Washington.

This report discusses earthquakes, landslides, and faulting. It is noted that major faulting occurs, and landslides are probably not triggered by earthquakes.

59. Brown, R.E., 1968b, The Yakima Basalt Formation and its relationships to the Columbia River in aquifer development: BNWL-SA-481, Battelle, Pacific Northwest Laboratory, Richland, Washington, v. 3, p. 1-2.

The influence of basalt flow advancement on the flow regime of the Columbia River is discussed. Due to basining, the former river course would return to the east, having been previously diverted to the west by advancing basalt flows.

60. Brown, R.E., 1968c, Reported faulting in the Pasco Basin: BNWL-SA-1704, Battelle, Pacific Northwest Laboratory, Richland, Washington, 14 p.

This summary report emphasizes the role of active faulting and the role of folding of basalt in the Pasco Basin. The role of faulting between Wallula Gap and Rattlesnake Hills is de-emphasized. The conclusion is made that faults associated with folds are aseismic.

61. Brown, R.E., 1968d, A study of reported faulting in the Pasco Basin: BNWL-662, Battelle, Pacific Northwest Laboratory, Richland, Washington.

Faulting is secondary to folding, with maximum 500-foot offsets. Evidence for the Olympic-Wallowa Lineament or of very recent faulting were not found.

62. Brown, R.E., 1969, Hydrologic inter-area relationships as indicated by rising heads in confined aquifers, Pasco Basin, Washington: BNWL-SA-686, Battelle, Pacific Northwest Laboratory, Richland, Washington.

This report contains diagrams of the complex hydrologic flow system with cross sections showing changes in the configuration of anticlines and synclines during the period of deposition of the Saddle Mountains Basalt.

63. Brown, R.E., 1970a, Interrelationships of geologic formations and processes affecting ecology as exposed at Rattlesnake Springs, Hanford Project: BNWL-B-29, Battelle, Pacific Northwest Laboratory, Richland, Washington, 39 p.

This report disagrees with other theories on previously hypothesized faults. It contains a

description of drainage patterns, faults, and other structural features.

64. Brown, R.E., 1970b, Some effects of irrigation in the Pasco Basin, Washington (abs.): Geological Society of America, Abstracts with Programs, v. 2, no. 5, p. 326-327.

This abstract discusses some geologic hazards (landslides, local flooding) resulting from irrigation in the Pasco Basin.

65. Brown, R.E. and McConiga, M.W., 1960, Some contributions to the stratigraphy and indicated deformation of the Ringold Formation: Northwest Science, v. 34, no. 2, p. 43-54.

The stratigraphy and structure of the Ringold Formation indicate gentle Quaternary folding toward the Pasco syncline and post-depositional warping of the Ringold and underlying basalt. Possible continuation of warping is suggested.

66. Brown, R.E. and Raymond, J.R., 1963, A geophysical seismic evaluation study of the Hanford Works, Washington: HW-SA-3280, General Electric Company, Hanford Atomic Products Operations, Richland, Washington, 17 p.

This feasibility study tested the value of seismic methods for data compilation and correlation purposes. Results show the surface of the basalt and the Ringold Formation.

67. Brunton, G.D. and McClain, W.C., 1977, Geological criteria for radioactive waste repositories: Office of Waste Isolation, Union Carbide Corporation-Nuclear Division, Oak Ridge, Tennessee.

This is a listing of geologic criteria and factors that can be used to derive specifications for application to each step of a geologic evaluation process.

68. Bush, J.H. and Siems, B.A., 1973, Basalt stratigraphy of the Jameson Lake area, Douglas County, Washington (abs.): Geological Society of America, Abstracts with Programs, v. 5, no. 1, p. 19.

The stratigraphy of seven Columbia River basalt flows (757 feet total thickness) is discussed in this abstract.

69. Bush, J.H., Jr., Anderson, J.V., Crosby, J.W., and Siems, B.A., 1972, Test-observation well near Mansfield, Washington, description, stratigraphic relationships and preliminary results: Washington State University, College of Engineering Research Division, Research Report No. 72/11-128, Project No. 3811-1184.

Aquifer and stratigraphic data obtained in Douglas County are presented.

70. Bush, J.H., Jr., Morton, J.A., Anderson, J.V., Crosby, J.W., and Siems, B.A., 1973, Test-observation well near Walla Walla, Washington: Description, stratigraphic relationships and preliminary results: Washington State University, College of Engineering Re-

search Division, Research Report No. 73/15-66, Project No. 3811-1184.

This is a report describing aquifer data obtained in S18, T6N, R35E.

71. Byerly, G. and Swanson, D., 1978, Invasive Columbia River basalt flows along the northwestern margin of the Columbia Plateau, north-central Washington (abs.): Geological Society of America, Abstracts with Programs, v. 10, p. 98.

This abstract indicates that invasive sills can be traced, showing gradational changes to surface flows.

72. Camp, V.E., 1976, Petrochemical stratigraphy and structure of the Columbia River basalt, Lewiston Basin area, Idaho-Washington: Ph.D. thesis, Washington State University, Pullman, 201 p.

Data on the stratigraphy and petrochemical correlation of Columbia River basalt in the Lewiston Basin are presented. A generalized geologic map and discussion of the tectonic development of the area are also provided.

73. Campbell, N.P., 1975, A geologic road log over Chinook, White Pass and Ellensburg to Yakima highways: Washington State Division of Geology and Earth Resources, Information Circular 54, 79 p.

This road log contains photographs and drawings of the western edge of the Columbia Plateau showing basalt and underlying formations.

74. Campbell, N.P., 1976, Geologic map of the Yakima area: Washington State Department of Natural Resources, Division of Geology and Earth Resources Open-File Report 76.11.

This large-scale geologic map of the Yakima area portrays geologic structures and stratigraphic units from the Grande Ronde Basalt to deposits of Quaternary age.

75. Carrell, D.J. and Jones, G.L., 1978, Proposed format and content of environmental report for deep geologic terminal repositories for radioactive material: RHO-BWI-CD-18, Rockwell Hanford Operations, Richland, Washington.

This document is Rockwell's proposed guide for preparation of environmental reports and is to be used as a basis for discussions with the NRC to develop a 4.2-type document for repositories.

76. Carter, L.J., 1978, Nuclear wastes: The science of geologic disposal seen as weak: Science, v. 200, p. 1135-1137.

This article questions the scientific feasibility of disposing radioactive waste in geologic formations, especially salt formations.

77. Clayton, D.N., 1977, Western Columbia Plateau margin studies, Wenatchee to Alameda Flat: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RD, Chapter 8.0.

The report presents results of literature review and reconnaissance level mapping to define the nature of the contact between the Columbia River basalt and underlying rocks, to document structures in the basalt and evaluate their age of deformation, and to evaluate any evidence of deformation of Quaternary deposits along the Columbia River.

78. Cline, D.R., 1969, Ground-water resources and related geology of north-central Spokane and southeastern Stevens Counties: Washington State Department of Water Resources Bulletin No. 27.

The ground-water resources, primarily in unconsolidated Quaternary deposits in parts of Spokane and Stevens Counties, are discussed.

79. Cline, D.R., 1976, Reconnaissance of the water resources of the upper Klickitat River Basin, Yakima Indian Reservation, Washington: U.S. Geological Survey Open-File Report.

Well water data and general water resource information for the area are presented.

80. Coe, R.S., Bogue, S., and Myers, C.W., 1978, Paleomagnetism of the Grande Ronde (Lower Yakima) Basalt exposed at Sentinel Gap: Potential use for stratigraphic correlation: RHO-BWI-ST-2, Rockwell Hanford Operations, Richland, Washington.

This report describes the potential for age dating of basalt flows in the Columbia Plateau by paleomagnetic correlation.

81. Cohen, B.L., 1977, The disposal of radioactive wastes from fission reactors: Scientific American, v. 236, no. 6, p. 21-31.

This article describes the nature of radioactive wastes produced by reactors, evaluates their environmental impact, and outlines current plans for disposal in subsurface repositories.

82. Columbia Basin Interagency Committee, 1965, Bibliography of published climatological data, Columbia Basin states: Columbia Basin Interagency Committee, Portland, Oregon.

This bibliography lists sources of published climatological data for the states of Washington, Idaho, and Oregon.

83. Columbia-North Pacific Technical Staff, 1970a, Appendix IV: Land and mineral resources, comprehensive framework study: Submitted by Pacific Northwest River Basins Commission, Vancouver, Washington, 2 volumes.

In this report, climate, ground water, and surface water in the Columbia Plateau area are discussed.

84. Columbia-North Pacific Technical Staff, 1970b, Appendix V: Water resources, comprehensive framework study: Submitted by Pacific Northwest River Basins Commission, Vancouver, Washington, 2 volumes.

This report contains maps, charts, and tables describing land and mineral resources of the Columbia Plateau region.

85. Columbia-North Pacific Technical Staff, 1971a, Appendix IX: Irrigation, comprehensive framework study: Submitted by Pacific Northwest River Basins Commission, Vancouver, Washington.

This report summarizes the present status of, and future needs for, irrigation in the Columbia drainage area. It includes detailed information regarding present and projected available water supplies, acreages under irrigation, and crop yields.

86. Columbia-North Pacific Technical Staff, 1971b, Appendix XII: Water quality and pollution control, comprehensive framework study: Submitted by Pacific Northwest River Basins Commission, Vancouver, Washington.

This document describes existing water quality in the Columbia River-North Pacific area, the means for satisfying future water needs, flow requirements, treatment costs, and management practices.

87. Columbia-North Pacific Technical Staff, 1971c, Appendix XIV: Fish and wildlife comprehensive framework study: Submitted by Pacific Northwest River Basins Commission, Vancouver, Washington.

This document describes freshwater wildlife species in the Columbia River-North Pacific region, the extent and quality of available habitats, and the demand for wildlife resources.

88. Committee on Radioactive Waste Management, 1978a, Geological criteria for repositories for high-level radioactive wastes: Panel on Geological Site Criteria from the Committee on Radioactive Waste Management, National Academy of Sciences, Washington, D.C., 19 p.

This report summarizes geologic, tectonic, hydrologic, geochemical, and economic criteria for assessing the suitability of sites for storage or disposal of high-level radioactive wastes.

89. Committee on Radioactive Waste Management, 1978b, Radioactive wastes at the Hanford Reservation: A technical review: National Academy of Sciences, Washington, D.C., 269 p.

This document is a review of technological aspects of radioactive waste management at Hanford.

90. Cook, N.G., 1977, An appraisal of hard rock for potential underground repositories of radioactive wastes: prepared for the U. S. Department of Energy, Contract W-7405-ENG-48, by University of California, Lawrence Berkeley Laboratory.

Potential engineering stress and stability factors, interaction between adjacent excavations, and the consequences of thermal loading are examined with respect to underground radioactive waste disposal in hard rock.

91. Coombs, H.A., Milne, W.G., Nuttli, O.W., and Slemmons, D.B., 1977, Report of the review panel on the December 14, 1872 earthquake: Washington Public Power

Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RA.

This report presents conclusions of the review panel: 1) the epicenter was in the region bounded by MM VIII isoseismal (the area including and north of Lake Chelan), 2) the highest intensity was MM VIII, 3) the focal depth was likely deeper than 10 km, 4) earthquakes probably had low stress drop, and 5) landslides outside the epicentral region probably were due to secondary effects.

92. Cornwall, H.R., 1966, Nickel deposits of North America: U.S. Geological Survey Bulletin 1223.

This report contains descriptions of two small nickel deposits near Cle Elum and Winesap at the western edge of the Columbia Plateau.

93. Crosby, J.W. and Mellott, J.C., 1973, Physical characteristics of basalt aquifers: Completion report for OWRR project No. A-C21-WASH, Washington State University Water Research Center, Pullman, Washington

This report summarizes a research project which was conducted to ascertain the physical characteristics of basalts which influence transmission and storage of ground water.

94. Culver, H.E. and Lupper, R.L., 1937, The bearing of post-Paleozoic sedimentary record on the occurrence of gas in the Rattlesnake gas field, Washington: Northwest Science, v. 11, no. 3, p. 71-74.

This report discusses the occurrence and source of oil and gas in porous basalt near Wenatchee, Washington.

95. Cushing, C.E. and Watson, D.G., 1973, Aquatic studies of Gable Mountain Pond: BNWL-1884, Battelle, Pacific Northwest Laboratory, Richland, Washington.

Radiation levels were measured in fish, ducks, and other organisms at a Hanford Site cooling pond to assess ecosystem uptake of radioactive materials.

96. Danehy, E.A., Swanson, O.E., and Hitchcock, D.M., 1976, Structural elements of the Pasco Basin, south-central Washington (abs.): Geological Society of America, Abstracts with Programs, v. 8, no. 3, p. 366-367.

In the geologic structures in the Pasco Basin, minor faults were found, but no evidence of the reported Olympic-Wallowa Lineament was cited.

97. Davis, G., 1977, Tectonic evolution of the Pacific Northwest - Precambrian to present: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RC.

This report summarizes the tectonic evolution of the Pacific Northwest based on a review of the available data. It briefly treats pre-Mesozoic history. The later history is developed with emphasis on convergent and transcurrent deformation in North Cascades and evolution and migration of arc volcanism. The discussion of Quaternary deformation deals with evidence for Pleistocene and Holocene subduction of the Juan de Fuca plate.

98. Davis, N.F., 1947, Relief features of southern British Columbia, in Freeman, O.W. and Martin, H.H., eds., The Pacific Northwest: John Wiley and Sons, Inc., New York, p. 97-103.

A map and descriptions of physiographic features in southern British Columbia and a summary of the geologic history of the region are presented.

99. DeBuchananne, G.D., 1974, Geohydrologic considerations in the management of radioactive waste: Nuclear Technology, v. 24, p. 356-361.

This article discusses geohydrologic considerations for managing radioactive waste, including the importance of water in transporting radioactive materials, considerations for near-surface and deep disposal, and uniformitarianism as a method for evaluating the geohydrologic suitability of waste disposal sites.

100. Deju, R.A., 1976, Feasibility of storing radioactive waste in Columbia River basalts: ARH-SA-281, Atlantic Richfield Hanford Company, Richland, Washington.

This paper summarizes the results of an incomplete study that was conducted by the Atlantic Richfield Hanford Company to assess the feasibility of storing radioactive wastes in deep caverns constructed in the Columbia River basalt.

101. Deju, R.A., 1978, Evaluation of basalt flows as a waste isolation medium: RHO-BWI-SA-16-A, Rockwell Hanford Operations, Richland, Washington.

This paper briefly describes the Basalt Waste Isolation Program within Rockwell Hanford Operations and includes studies of geology, hydrology, systems integration, engineered barriers, engineering testing, and the construction of a near-surface test facility.

102. Deju, R.A., Eddy, P.A., Grutzeck, M.W., and Myers, C.W., 1977, Environmental factors needed to establish the geotechnical feasibility of storing radioactive waste in Columbia River basalt: RHO-ST-8, Rockwell Hanford Operations, Richland, Washington.

The geologic and hydrologic factors that must be considered to assess the feasibility of storing radioactive waste in Columbia River basalt are discussed. An extensive bibliography with several hundred entries is provided.

103. Deju, R.A., Board, M.P., Gephart, R.E., and Myers, C.W., 1978, Structural considerations in the design of a repository to store radioactive waste in basalt formations: RHO-SA-10, Rockwell Hanford Operations, Richland, Washington.

Structural design considerations for radioactive waste repositories in basalt are discussed, and the structural and thermomechanical properties of basalt are summarized.

104. deLaguna, W., 1962, Engineering geology of radioactive waste disposal: Reviews in Engineering Geology I, Geological Society of America, p. 129-160.

This paper contains one of the early literature discussions of the geologic requirements of a waste repository. An assumption of zero defects was implied, and a case was made for storage in salt formations, supposedly a "water-tight" media.

105. Diery, H.P. and McKee, B., 1969, Stratigraphy of the Yakima Basalt in the type area: Northwest Science, v. 43, no. 2, p. 47.

The geologic map and stratigraphic sections, covering the Ellensburg-Roza area, correlate many of the Columbia River basalt flows on the basis of lithologic and petrographic features.

106. Durrani, S.A., 1975, Nuclear reactor in the jungle: Nature, v. 256, no. 5515, p. 264.

The geologic environment, which concentrated a natural reactor fuel and caused a naturally moderated nuclear reactor to function, was briefly described. A change in concentration of nuclides in the Oklo mine led to the discovery of the reactor. Because most fission products remained in place for over 1.5 to 5 billion years, the phenomena has relevance to waste disposal problems; the plutonium generated by the reactor has hardly moved.

107. Easterbrook, D.J., Baker, V.R., and Waite, R., 1977, Glaciation and catastrophic flooding of the Columbia

Plateau Washington, (Field Trip No. 13), in
Geological Excursions in the Pacific Northwest:
Geological Society of America, 1977 Annual Meeting,
Seattle, p. 390-414.

This is a field guide to locations and descriptions
of glacial and glaciofluvial features on the Columbia
Plateau.

108. Eddy, P.A., 1970, Geology and ground-water availability,
Selah area, Washington: Washington State Department
of Ecology, Olympia, Washington.

The Ellensburg Formation is shown to provide the
major portion of the ground water to the Selah area.

109. Eddy, P.A., 1976, Description, preliminary results, and
pumping tests of test-observation well #13 near
George, Washington: Washington State Department of
Ecology, Olympia, Washington, 43 p.

The hydrologic, stratigraphic, and structural
relations obtained from test well results are
presented.

110. Farkas, S.E., 1971, Stratigraphic and structural analysis
of Columbia River basalt flows, Umtanum Ridge, Yakima
and Benton Counties, Washington (abs.): Geological
Society of America, Abstracts with Programs, v. 3,
no. 6, p. 380.

The Umtanum flow is assessed to be greater than 400
feet near the base of Umtanum Ridge, and northward-
thrusting imbricate sheets are indicated on the
ridge.

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111. Farkas, S.E., 1972, Structural relationships of folds and faults in Yakima Basalt and Ellensburg Formation, central Washington (abs.): Geological Society of America, Abstracts with Programs, v. 4, no. 6, p. 375-376.

The variation in the number of flows in the Frenchman Springs Member over the plateau area is discussed. From one to nine flows exist in various localities over the area. Normal faulting is shown in fold and thrust belts of the Wanapum Basalt and in the Ellensburg Formation.

112. Farooqui, S.M., 1977a, Geologic studies of the Wallula Gap fault as exposed in the trench: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RH, Chapter 4.0.

This report presents results of geologic trenching and areal mapping in the vicinity of the Wallula Gap fault. These studies were to describe the character of the fault in terms of stratigraphic units involved, amounts and sense of motion, and to determine the age of movement.

113. Farooqui, S.M., 1977b, Geologic studies - Wallula Gap to Badger Coulee: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RH, Chapter 50.

The report presents results of detailed stratigraphic and tectonic studies to develop data on extent, association, and nature of faulting, to document the

character of the Rattlesnake Hills - Wallula lineament and to evaluate minimum ages of faulting based on overlying Quaternary formations.

114. Farooqui, S.M. and Kienle, C.F., 1976, Structural implications of the Yakima Basalt in north central Oregon and south central Washington (abs.): Geological Society of America, Abstracts with Programs, v. 8, no. 3, p. 372-373.

This abstract indicates the predominance of east-west and northwest structural trends, minor pre-Roza member deformation, minor pre-Selah member deformation, and major post-Elephant Mountain member deformation.

115. Federal Aviation Administration, 1978, Airport Statistics Handbook for 1977, Tower-Operated Airports: Advanced Technology, Inc., Report No. FAA-AVP-78-10.

A handbook of computerized listings of specific air traffic statistics including means, standard deviations, and peak occurrences computed for individual and multiple airport groupings. Histograms and time curves are presented for FAA-towered airports.

116. Fenix and Scisson, Inc., 1978, Hole history for rotary hole DC-5, Hanford, Washington: RHO-BWI-C-7, Rockwell Hanford Operations, Richland, Washington.

This drilling and test boring report summarizes the stratigraphic section intersected by the boring of hole DC-5. The top of the basalt is at approximately 600 feet. The Vantage Member is at approximately

2,600 feet. The total depth is 3,990 feet in the Grande Ronde Basalt.

117. Fisher, R.V., 1967, Early Tertiary deformation in north-central Oregon: American Association of Petroleum Geologists Bulletin, v. 51, no. 1, p. 111-123.

Rock formations deposited prior to the Columbia River basalt are presented in a structural framework.

118. Fitzner, R.E, and Price, K.A., 1973, The use of Hanford waste ponds by waterfowl and other birds: BNWL-1738, Battelle, Pacific Northwest Laboratory, Richland, Washington.

Graphs and charts showing weekly and seasonal species counts are provided with summaries, lists, and references of species.

119. Forrester, J.D., 1947, Rocky Mountain Province, in Freeman, O.W. and Martin, H.H., eds., The Pacific Northwest: John Wiley and Sons, Inc., New York, p. 80-96.

This outline summary of physiographic groupings or subprovinces within the Rocky Mountains Physiographic Province includes the Okanogan Highlands.

120. Foster, R.J., 1958, The Teanaway Dike swarm of central Washington: American Journal of Sciences, v. 256, p. 644-653.

Data on the pre-Columbia River basalt tectonic setting of the western edge of the Columbia Plateau are provided.

121. Foxworthy, B.L., 1962, Geology and ground-water resources of the Ahtanum Valley, Yakima County, Washington: U.S. Geological Survey Water-Supply Paper 1598.

This hydrogeologic report discusses aquifers in the Ahtanum Valley.

122. Foxworthy, B.L. and Washburn, R.L., 1963, Ground water in the Pullman area, Whitman County, Washington: U.S. Geological Survey Water-Supply Paper 1655.

Maps and cross sections of the Pullman area of Whitman County, Washington are provided.

123. Franklin, J.F., Hall, F.C., Dyrness, C.T., and Maser, C., 1972, Rattlesnake Hills Research Natural Area, separate from Federal Research Natural Areas in Oregon and Washington - A guidebook for scientists and Educators: Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, 18 p.

The Rattlesnake Hills Research Natural Area was established for research and educational purposes. This area is ecologically significant because it is the last piece of natural shrubsteppe vegetation of this size in the Pacific Northwest.

124. Freeman, O.W., 1947, Columbia lava basins and plateaus, in Freeman, O.W. and Martin, H.H., eds., The Pacific Northwest: John Wiley and Sons Inc., New York, p. 59-79.

This is a simplified source reference for physiographic and geomorphological provinces, with a short geologic history and a summation of regional geology.

125. Frutchter, J.S. and Baldwin, S.F., 1975, Correlations between dikes of the Monument Swarm, central Oregon, and Picture Gorge basalt flows: Geological Society of America Bulletin, v. 86, p. 514-416.

A chemical analysis of dike swarms, many having composition similar to the Picture Gorge Basalt flows is presented. Tables and chemical data are also included.

126. Fryxell, R., 1962, A radiocarbon limiting date for Scabland flooding: Northwest Science, v. 36, no. 4, p. 113-119.

A date of $31,600 \pm 900$ years before present was obtained from peat deposits in glacial debris near Vantage. This debris was not from the most recent glacial flood.

127. Gard, L.M. and Waldron, H.H., 1954, Geologic map of the Starbuck Quadrangle, Washington: U.S. Geological Survey Map GQ-38.

This map shows Palouse soil and Columbia River basalt.

128. Geological Society of America, 1977, Geological excursions in the Pacific Northwest: 1977 GSA Annual Meeting, Seattle, Field Trips No. 12 and 13.

This is a geologic field trip guidebook for northern Oregon and southern Washington.

129. Gibson, I.L., 1966a, Crustal flexures and flood basalts: Tectonophysics, v. 3, no. 5, p. 447-456.

The tectonics of the Columbia River basalt in southwest Idaho are discussed, and cross sections of flexures associated with volcanism and faulting are presented.

130. Gibson, I.L., 1966b, Grande Ronde dike swarm and its relation to the Columbia River basalts (abs.): Geological Society of America Special Paper 87, p. 204.

A swarm of 40 dikes, each approximately 35 feet thick, that cut the Columbia River basalt may be feeder dikes to some lava flows.

131. Gilmour, E.H. and Stradling, D., eds., 1969, Proceedings of the Second Columbia River basalt Symposium: Eastern Washington State College, Cheney, Washington, EWSC Press, 333 p.

This compilation of papers covers petrology, mineralogy, geochemistry, palynology and tectonics relating to the Columbia River basalt.

132. Glass, C.E., 1977, Remote sensing analysis of the Columbia Plateau: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RK.

This is a final report discussing a three-part study utilizing remote sensing techniques in assessing the potential for earthquakes along active faults within the Columbia Plateau.

133. Glass, C.E. and Slemmons, D.B., 1977, Imagery and topographic interpretation of geologic structures in central Washington: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RF.

The report presents results of a remote sensing imagery analysis to identify structures that could be related to the 1872 earthquake. The area studied was north - central Washington and southern British Columbia. Identified lineaments are plotted on maps and discussed.

134. Goldstein, P., Hultgren, G.O., and Nelson, R.W., 1978, A model of contaminant diffusion from a finite line source in a dense basalt stratum to an overlying permeable interbed: RHO-BWI-C-3, BCS Richland, Inc., for Rockwell Hanford Operations, Richland, Washington.

This report presents a mathematical model for the diffusion of radioactive wastes located in dense rock stratum bounded above and below by permeable interbeds.

135. Gray, D.A., Greenwood, P.B., Bisson, G., Cratchley, C.R., Harrison, R.K., Mather, J.D., Ostle, D., Poole, E.G., Taylor, B.J., and Willmore, P.L., 1976, Disposal of highly active, solid radioactive wastes into

geological formations--relevant geological criteria for the United Kingdom: Republic Institute Geological Science, v. 76, no. 12, 4 p.

This series of a priori criteria applies to the selection of areas containing formations suitable for the disposal of high-level wastes within the United Kingdom.

136. Gray, J. and Kittleman, L.R., 1967, Geochronometry of the Columbia River basalt and associated floras of eastern Washington and western Idaho: American Journal of Science, v. 265, p. 257-291.

Age dating and stratigraphic relations of the Latah Formation, Picture George Basalt, Columbia River basalt, and Ellensburg Formation in the Columbia Plateau are discussed.

137. Greensfelder, R.W., 1976, Maximum probable earthquake acceleration on bedrock in the State of Idaho: Idaho State Division of Highways Research Project No. 79.

This summary report of Late Quaternary faulting in Idaho provides discussion of regional seismicity and levels of maximum probable accelerations.

138. Gregg, D.O. and Laird, L.B., 1975, A general outline of the water resources of the Toppenish Creek Basin, Yakima Indian Reservation: U.S. Geological Survey Open File Report 75-19.

This report broadly summarizes the water resources and includes a water budget scheme and summary of the geology of the area.

139. Gregg, D.O. and Lum, W.E., II, 1973, Dry Creek exploration test well: U.S. Geological Survey Open File Report, prepared in cooperation with the Confederated Tribes and Bands of the Yakima Indian Nation, 9 p.

This hydrogeologic report of the Dry Creek Basin is based on test well data. The drilling of the 700-foot test well revealed dense basalt flows and less dense interflow aquifer layers.

140. Griggs, A.B., 1973, Geologic map of the Spokane Quadrangle: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-768.

This map represents the geology of the Spokane area.

141. Griggs, A.B., 1976, The Columbia River Basalt Group in the Spokane Quadrangle, Washington, Idaho, and Montana: U.S. Geological Survey Bulletin 1413, 39 p.

This report contains a series of cross sections showing basalt thickness and underlying formations. It also presents well log data and outcrop data for the area. Petrographic and geochemical analyses may be useful for flow correlations.

142. Grolier, M.J. and Bingham, J.W., 1969, Geology and ground-water conditions in parts of Grant, Adams and Franklin Counties, Washington: U.S. Geological Survey Professional Paper, with a section on chemical quality of the ground water by A.S. VanDenburgh.

The authors discuss the geology and hydrology of the Ellensburg Formation, Wanapum Basalt, Saddle Mountains Basalt, and the Ringold Formation.

143. Grolier, M.J. and Bingham, J.W., 1971, Geologic map and sections of parts of Grant, Adams, and Franklin counties, Washington: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-589.

Hydrologic, structural, and geologic data on the Columbia River basalt, and the Ringold and Ellensburg Formations are shown on this map.

144. Grolier, M.J. and Bingham, J.W., 1978, Geology of parts of Grant, Adams, and Franklin Counties, east-central Washington: Washington State Division of Geology and Earth Resources Bulletin No. 71, 91 p.

This report is the text to accompany Grolier and Bingham's 1971, U.S. Geological Survey Map I-589. It contains descriptions of stratigraphic units and structures and presents stratigraphic data from well logs.

145. Grolier, M.J. and Foxworthy, F.L., 1961, Geology of the Moses Lake north quadrangle, Washington: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-330.

This geohydrologic map shows Quaternary stratigraphy, ground-water development data, and structure of the area.

146. Hamilton, W., 1962, Late Cenozoic structure of west-central Idaho: Geological Society of America Bulletin, v. 73, p. 511-516.

Possible tectonic creep on faults near Seven Devils Mountains (southeast border of the Columbia Plateau) is inventoried. In the Columbia Plateau province, normal faults strike west to northwest and some may indicate movement in the Quaternary period.

147. Hamilton, W. and Myers, W.B., 1966, Cenozoic tectonics of the Western United States: Reviews of Geophysics, v. 4, no. 4, p. 509-549.

With respect to the Columbia Plateau, the authors suggest that the western part of the plateau is underlain by oceanic crust.

148. Hardy, H.R., 1977, Some current applications of microseismic techniques: Proceedings of Dynamic Methods in Soil and Rock Mechanics (DMSR) 77/Karlsruhe, September 5-16, 1977, v. 3, p. 173-199.

Some techniques and applications of acoustic emission/microseismic activity to geomechanics for mining and other underground cavity excavations are presented in this article.

149. Hardy, M.P., St. John, C.M., and Hocking, G., 1978, Numerical modelling of rock stresses within a basaltic nuclear waste repository: RHO-BWI-C-32, University of Minnesota for Rockwell Hanford Operations, Richland, Washington.

This report summarizes the numerical modelling of rock stresses within a basalt rock nuclear repository for Rockwell Hanford Operations. The types of thermo-mechanical problems analyzed using numerical models are identified and discussed.

150. Hedlund, J.D. and Rogers, L.E., 1976, Characterization of small mammal population inhabiting the B-C cribs environs: BNWL-2181, Battelle, Pacific Northwest Laboratory, Richland, Washington.

This is a bibliography of small mammal population studies on the Hanford Site.

151. Hill, D.P., 1972, Crustal and upper mantle structure of the Columbia Plateau from long-range seismic-refraction measurements: Geological Society of America Bulletin, v. 83, p. 1639-1648.

Previous seismic studies of the Columbia Plateau are compared to present study data.

152. Hinds, W.T. and Thorp, J.M., 1971, Annual summaries of microclimatological data from the Arid Lands Ecology Reserve, 1968-1970: BNWL-1629, Battelle, Pacific Northwest Laboratory, Richland, Washington.

Air quality data tabulation of precipitation and temperature ranges on the Hanford Site are presented.

153. Hodges, C.A., 1978, Basaltic ring structures of the Columbia Plateau: Geological Society of America Bulletin, v. 89, p. 1281-1289.

The ring structures found in the Roza Member near Odessa are described, and features are related to rising ground water as thick flows cooled over topographic lows.

154. Hoffer, J.M., 1967, The Rock Creek Flow of the Columbia River basalt: Northwest Science, v. 41, no. 1, p. 23-31.

A detailed report covers the physical and petrographic properties of the Rock Creek Member of the Imnaha Basalt.

155. Hogenson, G.M., 1964, Geology and ground-water of the Umatilla River Basin, Oregon: U.S. Geological Survey Water-Supply Paper No. 1620.

Basic well log and geologic data are provided, and structural relations of the basalt are described.

156. Holden, G.S. and Hooper, P.R., 1976, Petrology and chemistry of a Columbia River basalt section, Rocky Canyon, west-central Idaho: Geological Society of America Bulletin, v. 87, p. 215-225.

The geochemistry and petrography of the Imnaha Basalt and Columbia River basalt are described.

157. Holmgren, D.A., 1969a, Columbia River basalt patterns from central Washington to northern Oregon: Ph.D. thesis, University of Washington, Seattle, Washington.

A multiple-criteria comparison of Columbia River basalt near Yakima, central Washington and The

Dalles, northern Oregon is provided, and their successional identity is demonstrated.

158. Holmgren, D.A., 1969b, Columbia River basalt stratigraphic pattern near Yakima and Columbia Gorge areas, Washington and Oregon (abs.): Geological Society of America, Abstracts with Programs, v. 2, no. 3, p. 26.

The flow succession and magnetism near Yakima and The Dalles is summarized. Thickness was measured to be between 2,000 and 2,750 feet.

159. Hooper, P.R., Camp, V.E., Kleck, W.D., Reidel, S.P., and Sundstrom, C.E., 1976, Magnetic polarity and stratigraphy of the southeastern part of the Columbia River Basalt Plateau (abs.): Geological Society of America, Abstract with Programs, v. 8, no. 3, p. 383.

Paleomagnetic and stratigraphic data on the Columbia River basalt of southeastern Washington showed nine polarity intervals. Thicknesses greater than 4,500 feet of exposed basalt were indicated in the Snake River Canyon and Salmon River Canyon, with greater than 1,300 feet of Imnaha Basalt.

160. Hoyt, C.L., 1961, The Hammond Sill: An intrusion in the Yakima Basalt near Wenatchee, Washington: Northwest Science, v. 35, no. 2, p. 58-64.

The basalt structures in western Douglas County are discussed. The Hammond Sill is an invasive sill with subsidiary dikes within the Rock Island interbed.

161. Hunt, C.B., 1974, Natural Regions of the United States and Canada: W.H. Freeman and Company, San Francisco, 725 p.

The physiography, geology, stratigraphy, tectonics, and Quaternary geologic processes of the Columbia Plateau are summarized and the Spokane floods and regional erosion rates are discussed.

162. Huntting, M.T., 1949, Perlite and other volcanic glass occurrences in Washington: Washington State Department of Conservation and Development, Report of Investigations No. 17.

This is a report on perlite and other volcanic glasses occurring on the Columbia River Plateau.

163. Huntting, M.T., 1956, Inventory of Washington minerals, Part I: Metallic minerals: Washington State Department of Conservation and Development, Division of Mines and Geology Bulletin No. 37, v. 1-Text, v. 2-Maps.

This report shows a deposit of gold and silver near Prosser. No other metallic minerals are shown on the plateau.

164. Huntting, M.T., Bennett, W.A.G., Livingston, V.E., and Moen, W.S., 1961, Geologic map of Washington (scale 1:500,000): Washington Department of Conservation, Division of Mines and Geology, 2 sheets.

This map depicts and describes the geologic formations of the State of Washington.

165. Idaho State Department of Highways, 1974, Official Highway Map.

This is the official Idaho state road map.

166. Idaho State Department of Parks and Recreation, undated.

This map shows the locations of Idaho State parks and provides information on specific parks.

167. Jackson, D.B., 1975, Description of the geoelectric section, Rattlesnake Hills Unit 1 well, Washington: Journal of Research, U.S. Geological Survey, v. 3, no. 6, p. 665-669.

The interpretive discussion of basalt stratigraphy is derived from electric log data. A major change in rock type occurs between 4,000 and 7,000 feet in the Rattlesnake Hills well.

168. Jahns, R.H., 1967, Geologic factors relating to engineering seismology in the Hanford area, Washington: DUN-1300, prepared for Douglas United Nuclear, Inc., Richland, Washington.

The recent seismicity in the Saddle Mountains and Wallula Gap area is discussed. Evidence of recent faulting was examined. The report is essentially a rebuttal to Jones and Deacon, 1966.

169. Jones, F.O. and Deacon, R.J., 1966, Geology and tectonic history of the Hanford area and its relation to the geology and tectonic history of the State of

Washington and the active seismic zones of western Washington and western Montana: Douglas United Nuclear, Inc., Richland, Washington.

This literature review summarizes the geologic history, tectonics, and seismicity of the Hanford Site area and provides structural cross sections and water and gas well data.

170. Jones, M. G. and Landon, R.D., 1978, Geology of the Nine Canyon map area: RHO-BWI-LD-6, Rockwell Hanford Operations, Richland, Washington.

This is a detailed study of part of the southern Pasco Basin. Stratigraphy and structural geology of the Priest Rapids Member, Saddle Mountain Basalt, Ellensburg Formation, and Quaternary deposits, as well as the Rattlesnake Hills-Wallula Gap lineament and other folds and faults in the vicinity are discussed.

171. Jones, R. W. and Ross, S.H., 1972, Moscow Basin ground water studies (abs.): Idaho State Bureau of Mines and Geology Pamphlet No. 153.

This is a summary article on past water use in Moscow Basin, and on present studies of the amounts of pumpage and recharge and the quality of the ground-water supply.

172. Judson, S. and Ritter, D.F., 1964, Rates of regional denudation in the United States: Journal of Geophysical Research, v. 69, no. 16, p. 3395-3401.

This is a summary article of various regional rates of erosion or denudation throughout the United States. Included is the rate calculated for the Columbia Plateau, based on stream sediment calculations.

173. Kanai, K., Tanaka, T., and Yoshizawa, S., 1959, Comparative studies of earthquake motions on the ground and underground (multiple reflection problem): Bulletin of the Earthquake Research Institute, v. 37, p. 53-87.

Spectral analyses were carried out on seismograms of earthquakes recorded underground and at the surface of two mines. These analyses indicated that the amplitude on the ground increased relative to depth due to multiple reflection in the surface layer.

174. Kanai, K., Tanaka, T., Yoshizawa, S., Morishita, T., Osada, K., and Suzuki, T., 1966, Comparative studies of earthquake motions on the ground and under ground, II: Bulletin of the Earthquake Research Institute, v. 44, p. 609-643.

Empirical relations for strong motions in bedrock are compared to empirical data from recorded motions of 22 earthquakes. Velocity and acceleration spectra are shown for recordings from four stations.

175. Kaufman, S.K., Reuben, P.A., and Wyss, M., 1978, Focal mechanism and stress drops for mining-induced micro-earthquakes in Idaho (abs.): 74th Annual Meeting of the Seismological Society of America, October-December, 1978, v. 49, no. 4.

Focal mechanisms and stress drops have been determined for earthquakes occurring in an Idaho mine. Stress fields around the mine are compared to the regional field.

176. Keeney, R.L. and Nair, K., 1977, Evaluating potential nuclear power plant sites in the Pacific Northwest using decision analysis: Energy Policy, v. 5, no. 1.

The use of decision analysis in the selection and ranking of suitable future sites for nuclear power generating facilities in the Pacific Northwest is described.

177. Kienle, C.F., Jr., 1972, The Yakima Basalt in western Oregon and Washington (abs.): Geological Society of America, Abstracts with Programs, v. 4, no. 7, p. 561-562.

This paper discusses paleomagnetism, geochemistry, petrography, and geomorphology as methods of stratigraphic correlation of the Columbia River basalt.

178. Kienle, C.F., Jr., 1977a, Detailed mapping of the bend of the Rattlesnake Hills structure: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RH, Chapter 6.0.

This report presents the results of detailed geologic mapping in the area of the bend in the Rattlesnake Hills structure in order to provide data on how the bend area relates to other segments of the structure, to determine the relationship between the bend area

and the Yakima Ridge anticline and to evaluate the extent, nature, and age of faulting in the area.

179. Kienle, C.F., Jr., 1977b, Reconnaissance mapping of the Rattlesnake - Wallula lineament, eastern Rattlesnake Hills and Yakima Ridge: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RH, Chapter 7.0.

The report presents results of mapping to delineate major structures, determine their ages of movement, and to evaluate the possible relationship between the Yakima Ridge and Rattlesnake Hills anticlines.

180. Kienle, C.F., Jr., Bentley, R.B., and Anderson, J.L., 1977, Geologic reconnaissance of the Cle Elum-Wallula Lineament and related structures: Shannon and Wilson, Inc., Portland, Oregon, Report no. WNP-1/4, 33 p.

Each structural feature along the CLEW is described, and detailed mapping of several areas in the Yakima Ridge area is provided. A model for structural deformation is discussed.

181. Kienle, C.F., Jr., Newcomb, R.C., Deacon, R.J., Farooqui, S.M., Bentley, R.D., Anderson, J.L., and Thoms, R.E., 1978, Western Columbia Plateaus: tectonic structures and their age of deformation: Paper presented at Battelle Tectonics Symposium, February 14-16, 1978, Seattle, Washington.

Tectonic features of the plateau are described and the ages of deformation are approximated using dated volcanics and sedimentary deposits.

182. Kohler, J.E., Kennecke, A.P., and Grimes, B.K., 1974, Population distribution considerations in nuclear plant siting: American Nuclear Society Conference, August 1974.

A method for calculating a site population factor, which measures cumulative population distribution around nuclear power plant sites, is presented. A distance decay function that simulates average atmospheric diffusion of radionuclides released from power reactors is used in this method.

183. Kuno, H., 1969, Plateau Basalts, in Hart, P.J., ed., Earth's Crust and Upper Mantle: American Geophysical Union, Washington, D.C., p. 495-501.

The tectonics of plateau basalts are discussed along with a proposed mechanism for slow and continuous magma genesis of the Columbia River basalt.

184. Laval, W.N., 1956, Stratigraphy and structural geology of portions of south-central Washington: Ph.D. thesis, University of Washington, Seattle, Washington, 208 p.

Mapping, measured sections, and correlations of middle and upper basalt in the Horse Heaven Hills area are presented.

185. Laval, W.N., 1957, Primary structures of the Columbia River basalt flows, south-central Washington (abs.): Geological Society of America Bulletin, v. 68, p. 1867.

The flow structures in Wanapum and Saddle Mountains Basalts are discussed.

186. Laval, W.N., 1958, Anticlines of the southwestern Columbia Basin (abs.): Geological Society of America Bulletin, v. 69, no. 12, pt. 2, p. 1734.

The structural geology and history of the southwestern Columbia Basin are discussed.

187. Ledgerwood, R.K. and Deju, R.A., 1976, Hydrogeology of the uppermost confined aquifers underlying the Hanford Reservation: ARH-SA-253, Atlantic Richfield Hanford Company, Richland, Washington.

This comprehensive hydrogeology report contains tables of transmissivity and conductivity and well log data and structural interpretations on the upper confining aquifers underlying the Hanford Site.

188. Ledgerwood, R.K., Myers, C.W., and Cross, R.W., 1978, Pasco Basin stratigraphic nomenclature: RHO-BWI-LD-1, Rockwell Hanford Operations, Richland, Washington.

This chart and discussion of the stratigraphic nomenclature and age dating parameters of the Columbia River basalt and younger units in the Pasco Basin uses the most current data available.

189. Lillie, J.T. and Richard, B.H., 1977, An analysis of selected gravity profiles on the Hanford Reservation, Richland, Washington: RHO-BWI-C-6, Rockwell Hanford Operations, Richland, Washington.

Two-dimensional models were constructed using gravity values. Indications of buried valleys cut into bedrock were found; however, distinguishing these valleys from sedimentary contacts would be difficult.

190. Lillie, J.T., Tallman, A.M., and Caggiano, J.A., 1978, Preliminary geologic map of the Late Cenozoic sediments of the western half of the Pasco Basin: RHO-BWI-LD-8, Rockwell Hanford Operations, Richland, Washington.

This is a detailed (1 mile to 1 inch) map of Quaternary deposits in the Pasco Basin.

191. Lindsley, D.H., 1960, Geology of the Spray Quadrangle, Oregon: Ph.D. thesis, The Johns Hopkins University, Baltimore, Maryland, 235. p.

This thesis primarily discusses the stratigraphy and petrography of the Picture Gorge Basalt and its magnetic properties and the stratigraphy of the Early Tertiary Clarno and John Day Formations.

192. Livingston, T., 1978, Origin of the Grand Coulee and Dry Falls: Washington Geologic Newsletter, v. 6, no. 3.

The geology and geomorphic processes relating to the development of some of the structures in the Columbia Plateau are discussed.

193. Long, P.E., 1978, Characterization and recognition of intraflow structures, Grande Ronde Basalt:

RHO-BWI-LD-10, Rockwell Hanford Operations, Richland, Washington.

This report describes various intraflow structures in the Grande Ronde flows and their usefulness in correlating drill hole data.

194. Lowry, W.D. and Baldwin, E.M., 1952, Late Cenozoic geology of the Columbia River Valley, Oregon and Washington: Geological Society of America Bulletin, v. 63, p. 1-24.

This bulletin focuses only on the westernmost portion of the Columbia Plateau and summarizes the Late Cenozoic geologic history of the area.

195. Luzier, J.E., 1969, Groundwater occurrence in the Goldendale area, Klickitat County, Washington: U.S. Geological Survey, Hydrologic Investigations Atlas HA-313.

This is a general geologic map and a water level contour map. Well logs of the Goldendale area are included.

196. Luzier, J.E., Bingham, J.W., and Burt, R.J., 1969, Ground-water survey, Odessa-Lind area, Washington: Washington State Department of Water Resources, Water Supply Bulletin No. 36.

This bulletin presents generalized hydrogeologic data from the Odessa-Lind area, Washington.

197. Luzier, J.E. and Burt, R.J., 1974, Hydrology of basalt aquifers and depletion of ground water in east-central Washington: U.S. Geological Survey, Water Supply Bulletin No. 33.

This bulletin presents hydrologic characteristics of the basalt aquifers in east-central Washington, the variability of heads in different aquifers, and recharge-discharge rates. Ground-water barriers may be related to tectonic structures.

198. Mackin, J.H., 1961, A stratigraphic section in the Yakima Basalt and the Ellensburg Formation in south-central Washington: Washington Division of Mines and Geology Report of Investigations No. 19, 45 p.

A stratigraphic history is presented of the Wanapum Basalt and Ellensburg Formation within the area bounded at corners by Yakima, Ellensburg, Vantage, and Priest Rapids.

199. Maddox, George, and Associates, Inc., 1978, Ground-water hydrology and proposed water management policy--Quincy and Odessa subareas: Report (Job no. 77-08101) prepared by George Maddox and Associates, Inc., Yakima, Washington, for Eastern Big Bend Resources.

The discovery that what was thought to be a large ground-water province was actually four hydraulically discontinuous provinces indicates that present water management policies need to be reevaluated.

200. Maddox, G.E., and Fox, F.M., and Associates, Inc., 1976, A proposed structural control of surface and ground

water in the eastern portion of the Columbia River basalt (abs.): Geological Society of America, Abstracts with Programs, v. 8, no. 3.

Markedly different transmissibility values on each side of a hypothesized lineament may be indicative of structurally controlled ground-water flow.

201. Malde, H.E., 1968, The catastrophic Late Pleistocene Bonneville flood in the Snake River Plain, Idaho: U.S. Geological Survey Professional Paper 596, 52 p.

The glacial flood deposits and paths along the Snake River in Idaho are discussed.

202. Martin, J.E., 1977, Western Columbia Plateau margin studies, Yakima River to Wenatchee: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RD, Chapter 7.0.

The report presents results of a literature review and detailed and reconnaissance-level geologic mapping of structures of the western Columbia Plateau. The emphasis of the study was on interpreting the relationship between basement structures of the Cascades to those in the overlying basalt and evaluating the age of deformation of structures in the basalt.

203. Matsuda, T., 1976, Empirical rules on sense and rate of recent crustal movements: Journal of the Geodetic Society of Japan, v. 22, no. 4, p. 252-263.

This article compares geologic evidence of Quaternary

rates of uplift, folding, and horizontal strain with geodetic data of recent crustal movements in Japan. Sample calculations are made for the rate of anticlinal folding.

204. Mattinson, J.M., 1972, Ages of zircons from the northern Cascade Mountains, Washington: Geological Society of America Bulletin, v. 83, p. 3769-3784.

Two metamorphic events that occurred in the northern Cascades during the Middle Paleozoic (approximately 415 m.y.a.) and in the Late Cretaceous period are examined. The rock formations remained deeply buried into the Eocene epoch and some may be as old as 2 billion years.

205. Maynard, W.S., and others, 1976, Public values associated with nuclear waste disposal: Battelle Memorial Institute, Human Affairs Research Centers, Seattle, Washington, Document No. BNWL-1997.

This report summarizes public response to a questionnaire on nuclear waste disposal issues, such as long- and short - term safety, accident detection/recovery, and cost factors.

206. McCarthy, G.J. and Grutzeck, M.W., 1978, Preliminary evaluation of the characteristics of nuclear wastes relevant to geologic isolation in basalt: RHO-C-12, The Pennsylvania State University for Rockwell Hanford Operations, Richland, Washington.

This report reviews and discusses physical and chemical characteristics of radioactive waste. This

information has bearing on the concept of geologic storage in basalt.

207. McCarthy, G.J., Komarneni, S., Scheetz, B.E., Freeborn, W.P., White, W.B., and Smith, D.K., 1978, Hydrothermal stability of spent fuel and high-level waste ceramics in the geologic repository and environment: RHO-BWI-SA-12 A, The Pennsylvania State University for Rockwell Hanford Operations, Richland, Washington.

This report focuses on waste-rock hydrothermal interaction and closed system waste-water reaction in basalts and shales.

208. McDougall, I., 1976, Geochemistry and origin of basalt of the Columbia River Group, Oregon and Washington: Geological Society of America Bulletin, v. 87, p. 777-792.

The strontium ratios of coeval coastal basalts and Columbia Plateau basalts are the same; different parent magmas gave rise to the Picture Gorge and the Grande Ronde and Wanapum Basalts.

209. McGarr, A., 1971, Violent deformation of rock near deep-level: Tabular excavations-seismic events, Bulletin of the Seismological Society of America, v. 61, no. 5, p. 1453-1466.

Modeling that uses two-edge dislocations are presented for elastic deformation of the rock near the edges of thin, tabular excavations (stopes) of

deep-level mines. The results compare favorably to energies released during observed tremors.

210. McGarr, A.M. and Wiebols, G.A., 1977, Influence of mine geometry and closure volume on seismicity in a deep-level mine (abs.): International Journal of Rock Mechanics, Mineral Sciences and Geomechanics, v. 14, p. 139-145.

Seismicity and volume of closure relationships are studied in three mines. Indications are that by planning mine geometrics, problems associated with large tremors can be kept to a predictable level by controlling the convergence.

211. McGarr, A.M., Green, R.W., and Spottiswoodie, S.M., 1978, Strong ground motion of tremors recorded in a deep mine (abs.): 74th Annual Meeting of the Seismological Society of America, October-December, 1978, v. 49, no. 4.

Accelerogram recordings were analyzed for event location, peak acceleration, stress drop, and magnitude.

212. McGhan, V.L., Myers, D.A., and Damschen, D.W., 1976, Hanford wells: BNWL-1981, Battelle, Pacific Northwest Laboratories for the U.S. Energy Research and Development Administration.

General information on wells drilled on the Hanford Site is provided; however, data from wells such as depth to basalt or purpose of well are not included.

213. McKee, B. and Stradling, D., 1970, The sag flowout: A newly described volcanic structure: Geological Society of America Bulletin, v. 81, p. 2035-2044.

This article describes the ring structures occurring in the Roza Member near Odessa, Washington. They were formed by fluid lava escaping along concentric dikes from the partly solidified flow.

214. Mercer, J.W. and Orr, B.R., 1977, Review and analysis of hydrogeologic conditions near the site of a potential nuclear-waste repository, Eddy and Lea Counties, New Mexico: U.S. Geological Survey Open-File Report 77-123, 35 p.

This report focuses on hydrology, salt beds, and radioactive waste management in southeastern New Mexico.

215. Miller, F.K. and Engels, J.C., 1975, Distribution and trends of discordant ages of the plutonic rocks of northeastern Washington and northern Idaho: Geological Society of America Bulletin, v. 86, p. 517-528.

This report contains information on four episodes of intrusion during the Mid-Mesozoic and Cenozoic eras. The major events occurred during the Mid-Cretaceous and Early Eocene. Useful information is provided regarding the pre-basalt tectonic setting.

216. Milne, P.C. and Walker, C.W., 1978, Directory of Washington mining operations for 1977: State of

Washington Department of Natural Resources, Division of Geology and Earth Resources, Information Circular No. 63.

This directory summarizes and identifies metallic and non-metallic mining operations in the State of Washington by name of operator, product, and property (mine) location.

217. Milne, C. and Vonheeder, E.R., 1979, Metallic and nonmetallic mineral exploration and mining highlights, 1978: Washington, State Department of Natural Resources, Division of Geology and Earth Resources, Washington Geologic Newsletter, v. 7, no. 1.

This article summarizes metallic and nonmetallic mineral exploration, including a discussion of energy exploration, in the State of Washington.

218. Moen, W.S., 1978, Mineral resource maps of Washington: Washington State Department of Natural Resources, Division of Geology and Earth Resources Map GM-22.

This publication contains several location maps and provides up-to-date information. Few economic mineral deposits are on the Columbia Plateau except sand, gravel, rock, and diatomite.

219. Molenaar, D., 1968, A geohydrologic reconnaissance of northwestern Walla Walla County, Washington: Washington State Department of Water Resources Monograph No. 1.

A reconnaissance map of Eureka Flats and vicinity, Washington, showing well locations and hydrologic data.

220. Molenaar, D., 1977, Outline of the water resources of the Satus Creek Basin, Yakima Indian Reservation, Washington: U.S. Geological Survey Open File Report 76-808.

The general hydrology and a water budget analysis of the area are presented.

221. Monahan, C.J., 1962, John Day lock and dam: Foundation investigations: Journal of the Power Division, Proceedings of the Society of Civil Engineers, v. 3344, no. 4, p. 29-45.

Engineering and geologic studies of foundation conditions are described for a 5-mile section of the lower Columbia River near the western edge of the Columbia Plateau.

222. Monahan, C.J., 1969, Reservoirs in volcanic terrain: Association of Engineering Geologists Bulletin, v. 6, no. 1, p. 53-60.

Requirements of and guidelines for investigating reservoirs, including lava flow characteristics and their effects on structural permeability, are discussed.

223. Myers, C.W., 1973, Yakima Basalt flows near Vantage and from core holes in the Pasco Basin, Washington: Ph.D. thesis, University of California, Santa Cruz.

This thesis provides detailed stratigraphic, petrographic, and chemical information on the Grande Ronde and Wanapum Basalts, including the Museum, Frenchman Springs, and Roza Members. Drill hole correlations were described for the Grande Ronde, Wanapum, and Saddle Mountains Formations.

224. Myers, D.A., 1972, Test-observation well near Davenport, Washington, description and preliminary results: U.S. Geological Survey Open-File Report, 23 p.

This well description identifies several aquifers.

225. Nair, K., Brogan, G.E., Cluff, L.S., Idriss, I.M., and Mao, K.T., 1975, An approach to the siting of nuclear power plant facilities: A report prepared by Woodward-Clyde Consultants for International Atomic Energy Agency.

This report describes a regional approach to nuclear power plant siting by using exclusionary criteria (i.e., active faults, population centers) to eliminate areas from consideration and identify likely candidate areas. Candidate sites are then ranked by decision analysis methods.

226. National Academy of Sciences, 1978, Radioactive wastes at the Hanford Reservation; A technical review: Document No. ISBN 0-309-02745-3, Washington, D.C., 269 p.

The radioactive wastes at Hanford are briefly characterized, and storage facilities, equipment, and methods are summarized. This report suggests that a

deep repository in basalt may be preferable to the present methods of surface storage.

227. National Geographic Society, 1977, Wild and Scenic Rivers Map of the United States: Supplement to National Geographic, July 1977, v. 152, no. 1--Wild and Scenic Rivers of the United States, p. 2a.

This is a series of schematic location maps of national and state wild and scenic rivers (designated and proposed).

228. National Oceanic and Atmospheric Administration, 1979, Seattle Sectional Aeronautical Chart, 1:500,000 scale: U.S. Department of Commerce.

Airports, jet routes, and restricted airspace of the Pacific Northwest are shown on this map.

229. National Research Council, 1978, Geologic criteria for repositories for high-level radioactive wastes: National Academy of Sciences pamphlet, Washington, D.C.

Criteria for high-level radioactive waste disposal sites are presented. The factors considered were related to host-rock geometry, long-term stability, hydrology, geochemistry, and economics.

230. Newcomb, R.C., 1951, Preliminary report on the ground-water resources of the Walla Walla Basin, Washington-Oregon: U.S. Geological Survey Open-File Report.

This report contains basic well inventory, well log, and water level data from the Walla Walla Basin.

231. Newcomb, R.C., 1958, Ringold Formation of Pleistocene age in type locality, the White Bluffs, Washington: Washington Division of Mineralogy and Geology, reprint no. 1 (from American Journal of Science, v. 256, p. 328-340).

This report describes the Quaternary stratigraphy and geology of the Ringold Formation.

232. Newcomb, R.C., 1961a, Structural barrier reservoirs of ground water in the Columbia River basalt: U.S. Geological Survey Professional Paper 424-B, p. B213-B215.

Structural ground-water barriers in the upper Cold Creek Valley and the Walla Walla Valley at College Place are discussed.

233. Newcomb, R.C., 1961b, Age of the Palouse Formation in the Walla Walla and Umatilla River Basins, Oregon and Washington: Northwest Science, v. 35, no. 4, p. 122-127.

The Palouse Formation is differentiated from younger loess. It is of Middle to Late Pleistocene age, and closely follows the Ringold deposition and pre-Wisconsin glacial stage.

234. Newcomb, R.C., 1961c, Storage of ground water behind subsurface dams in the Columbia River basalt,

Washington, Oregon, and Idaho: U.S. Geological Survey, Professional Paper 383-A, 15 p.

This is a good, general paper on the permeability of faults, structural ground-water reservoirs, and fault barriers in synclinal basins of the Columbia River basalt.

235. Newcomb, R.C., 1965, Geology and ground-water resources of the Walla Walla River Basin, Washington-Oregon: Washington State Division of Water Resources, Water Supply Bulletin No. 21.

This is a hydrogeologic bulletin of the Walla Walla River Basin. Well inventories and stratigraphic descriptions of the Columbia River basalt, Pleistocene clays and gravels, and Ringold and Palouse Formations are provided.

236. Newcomb, R.C., 1966, Lithology and eastward extension of The Dalles Formation, Oregon and Washington, U.S. Geological Survey Professional Paper 550-D, p. 59-63.

This paper correlates The Dalles Formation to parts of the Arlington Lake Beds, Shutler Formation, and Pliocene fanglomerates, suggesting an Early to Middle (?) Pliocene age for The Dalles Formation.

237. Newcomb, R.C., 1967, The Dalles-Umatilla syncline, Oregon and Washington: U.S. Geological Survey Professional Paper 575-B.

This paper describes the structure of The Dalles-Umatilla syncline and the stratigraphy of the area.

238. Newcomb, R.C., 1969, Effect of tectonic structure on the occurrence of ground-water in the basalt of the Columbia River Group of The Dalles area, Oregon and Washington: U.S. Geological Survey Professional Paper 383-C, 33 p.

The geohydrology of the Columbia River basalt and general tectonics which influence ground-water parameters in the Dalles area are described. The mapped area includes parts of the White Salmon, The Dalles, and Wishram quadrangles. Many maps and cross sections are provided.

239. Newcomb, R.C., 1970, Tectonic structure of the main part of the basalt of the Columbia River Group, Washington, Oregon, and Idaho: U.S. Geological Survey Miscellaneous Geological Investigations Map I-587.

This is a tectonic map showing fold axes, faults, Quaternary basins of deposition and extent of the Columbia River basalt.

240. Newcomb, R.C., 1971, Geologic map of the proposed Paterson Ridge pumped-storage reservoir, south-central Washington: U.S. Geological Survey Miscellaneous Geological Investigations Map I-653.

This geologic map of the reservoir area provides a general description of the geology and a discussion

of the stratigraphic and petrographic characteristics of the bedrock.

241. Newcomb, R.C., 1972, Quality of the ground water of the Columbia River group, Washington, Oregon and Idaho: U.S. Geological Survey Water Supply Paper 1999-N, p. N1-N71.

This regional ground-water quality investigation has implications on transit time, transit path, location, and mechanism of recharge for the Columbia River Basalt Group.

242. Newcomb, R.C., Strand, J.R., and Frank, F.J., 1972, Geology and ground-water characteristics of the Hanford Reservation of the U.S. Atomic Energy Commission, Washington: U.S. Geological Survey Professional Paper 717, 78 p.

This paper describes the geologic and hydrologic characteristics of the Hanford Site. Geologic structures and stratigraphy are correlated with ground-water characteristics. Maps and cross sections are provided.

243. Newcomb, R.C. and others, 1953, Seismic cross sections across the Spokane River Valley and Hillyard Trough, Idaho and Washington: U.S. Geological Survey, Water Research Division, Tacoma, Washington, Open-File Report.

Basic seismic data, showing profiles and velocities of valley fill, Latah Formation, glaciofluvial

deposits, and basement rock of the area are presented.

244. Norris, J.A., 1974, Selected environmental considerations and their measuring parameters: Paper presented to the American Nuclear Society, Portland, Oregon.

This paper provides a general discussion of selected environmental considerations, (ecology, land use, aesthetics, water supply, meteorology) with regard to nuclear power plant siting.

245. Northwest Energy Policy Project, 1978, Energy futures northwest, Northwest Energy Policy Project: Final report, sponsored by Pacific Northwest Regional Commission, Vancouver, Washington.

An overview of energy policy options available to the Pacific Northwest states that might influence future patterns of energy production and consumption in the region.

246. Oak Ridge National Laboratory, 1972, Federal waste repository, site selection factors and criteria: Internal Report, central file number 72-3-4. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Problems concerning "criteria" for construction of radioactive waste repositories in salt are discussed in this report.

247. Office of Waste Isolation, Union Carbide Corporation, 1976, National waste terminal storage program information meeting: Y/OWI/TM-11/1 Union Carbide

Corp., Office of Waste Isolation, Oak Ridge, Tennessee, v. I, .

This booklet contains a short discussion of Union Carbide Corporation's (UCC) project to find repositories in various rock formations. It also contains abstracts or copies of viewgraph slides relating to early in-house and subcontracted investigations administered by OWI (a branch of UCC). Much of the emphasis is on repositories in salt or shale formations.

248. Office of Waste Isolation, Union Carbide Corporation, 1977, Conceptual design criteria for facilities for geologic disposal of radioactive waste in salt formations: Y/OWI/TM-9, Union Carbide Corporation, NP Engineering, Oak Ridge, Tennessee, Document No. X-OE-17.

This document contains both general and specific criteria for the facilities and systems for a repository built in salt.

249. Olson, T.M., 1975, Geology and ground-water resources of part of Harryman and Marshall Creek drainage basins: M.S. thesis, Eastern Washington State College, Cheney, Washington.

Approximately 1,000 existing wells provide yields of several hundred gallons per minute from basalt rock in Spokane County. Less than 25 gallons per minute are provided from wells tapping overlying sediments.

250. Oregon Department of Transportation, 1974a, Oregon Parks Map: Travel Information Section, Oregon State Department of Transportation, Salem, Oregon.

This map shows the general locations of federal, state, and county parks and land areas of inherent scenic, historic, recreational, and economic quality.

251. Oregon Department of Transportation, 1974b, Official Highway Map of Oregon, State Highway Division, Oregon State Department of Transportation, Salem, Oregon.

This highway map shows culturally important and land use areas such as highways, airports, and state parks.

252. Oregon Department of Transportation, 1974c, Summary of Oregon aviation system plan: Oregon State Department of Transportation and Oregon Aeronautics Division, Salem, Oregon.

This is a listing of specific air traffic statistics for airports in Oregon.

253. Packer, D.R., 1978, Review of paleomagnetic studies of the Columbia Plateau basalts: Paper presented at Battelle Tectonics Symposium, February 14-16, 1978, Seattle, Washington.

Various paleomagnetic studies that have been conducted on the Columbia River basalt are discussed and reviewed.

254. Patton, P.C. and Baker, V.R., 1978, New evidence for pre-Wisconsin flooding in the channeled scabland of

eastern Washington: *Geology*, v. 6, p. 567-571.

This paper presents stratigraphic evidence for the pre-Wisconsin flood history of the channelled scabland in the eastern portion of the State of Washington.

- 251a. Patwardhan, A.S., Tocher, D., and Savage, E.D., 1975, Relationships between earthquake magnitude and length of fault rupture surface based on aftershock zones (abs.): *Geological Society of America, Abstracts with Programs*, v. 7, no. 3, p. 419.

This paper presents empirical data from aftershock zones, relating fault rupture length and rupture surface to earthquake magnitude.

- 252a. Pearson, H.E., 1973, Test-observation well near Paterson, Washington, description and preliminary results: *U.S. Geological Survey Water Resources Investigations* 9-73, 23 p.

Information presented includes data on aquifer characteristics and water quality obtained from a test-observation well in Benton County, Washington.

- 253a. Pearson, R.C. and Obradovich, J.D., 1977, Eocene rocks in northeastern Washington - radiometric ages and correlation: *U.S. Geological Survey Bulletin* 1433, 41 p.

This article describes the Eocene basement rocks in the Okanogan Highlands region of northeastern Washington.

- 254a. Peck, D.L., 1961, Geologic map of Oregon west of the 121st meridian: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-325.

This is a regional geologic map of Oregon, west of the 121st meridian, and includes cross sections.

255. Pitt, A.M., 1972, Seismic activity in the Hanford region, Washington, March 23, 1969 to June 30, 1971: U.S. Geological Survey Open-File Report 72-298.

This report contains the preliminary results from the U.S. Geological Survey seismograph network for the Hanford Site area during time period March 23, 1969 to June 30, 1971. Distribution, number, and magnitude of earthquakes are discussed, and events are listed.

256. Portland General Electric Company, 1974, Pebble Springs nuclear plant: Preliminary Safety Analysis Report, v 2.

This volume contains detailed maps and geologic information on the study area for the Pebble Springs Nuclear Plant in Oregon.

257. Pratt, H.R., Hustrulid, W.A., and Stephenson, D.E., 1978, Earthquake damage to underground facilities: AT(07-2)-1, prepared by DuPont-Savannah River Laboratory, Aiken, South Carolina for U.S. Department of Energy.

The use of ground motion measurements of nuclear explosions are discussed to provide constraints on parameters important for siting an underground nuclear waste repository. Seismological data

(primarily from Japan) on ground motions (underground relative to aboveground) are examined.

258. Price, C.E., 1961, Artificial recharge through a well tapping basalt aquifers, Walla Walla area, Washington: U.S. Geological Survey Water Supply Paper 1594-A.

This paper provides a general stratigraphic description of the Walla Walla valley in Washington. Transmissivity and the effects of artificial recharge on the Columbia River basalt are discussed.

259. Price, D., Hart, D.H., and Foxworthy, B.L., 1962, Artificial recharge in Oregon and Washington: U.S. Geological Survey Water Supply Paper 1594-C.

This article provides a brief description of artificial recharge operations in Oregon and Washington.

260. Price, S.A., 1977, An evaluation of dike-flow correlations indicated by geochemistry, Chief Joseph Swarm, Columbia River basalt: Ph.D. thesis, University of Idaho, Moscow, Idaho.

This thesis presents the results of a detailed study of geochemical correlation of basalt flows and dikes in the eastern Columbia Plateau, Oregon. Stratigraphic information on basalt flows within the formations and information on tectonic development of the area are provided.

261. Price, W.H. and Fecht, K.R., 1976a, Geology of the 241-AX Tank Farm: ARH-LD-128, Atlantic Richfield Hanford Company, Richland, Washington.

This is an informal geologic report with accompanying maps of the 241-AX Tank Farm on the Hanford Site, Washington.

262. Price, W.H. and Fecht, K.R., 1976b, Geology of the 241-B Tank Farm: ARH-LD-129, Atlantic Richfield Hanford Company, Richland, Washington.

This is an informal geologic report with accompanying maps of the 241-B Tank Farm on the Hanford Site, Washington.

263. Price, W.H. and Fecht, K.R., 1976c, Geology of the 241-BX Tank Farm: ARH-LD-130, Atlantic Richfield Hanford Company, Richland, Washington.

This is an informal geologic report with accompanying maps of the 241-BX Tank Farm on the Hanford Site, Washington.

264. Price, W.H. and Fecht, K.R., 1976d, Geology of the 241-BY Tank Farm: ARH-LD-131, Atlantic Richfield Hanford Company, Richland, Washington.

This is an informal geologic report with accompanying maps of the 241-BY Tank Farm on the Hanford Site, Washington.

265. Raiffa, H., 1968, Decision Analysis, Introductory Lectures on Choices Under Uncertainty: Addison-Wesley Publishing Co., Reading, Massachusetts.tts.

This is a textbook on decision analysis methods and applications.

266. Raisz, E., 1945, The Olympic-Wallowa Lineament: American Journal of Science, v. 243A, p. 479-485.

After drawing a landform map of the northwestern states, the author noted a topographic lineament stretching from Cape Flattery to the Wallowa Mountains. He named it the Olympic-Wallowa Lineament and describes its topographic features in this article.

267. Raymond, J.R., 1957, A pumping system for ground-water aquifer evaluation tests: HW-51171, Hanford Laboratories Operation, General Electric Company, Richland, Washington.

This report describes pumping and related equipment chosen for quick and accurate performance tests for determining aquifer characteristics at the Hanford Site.

268. Raymond, J.R., 1978, Hydrologic support to Department of Waste Isolation, RHO-completion report for subtask 2: Battelle, Pacific Northwest Laboratory, Seattle, Washington.

This report contains hydrologic and stratigraphic data from wells near the Yakima River and in Quincy Basin. Landsat imagery is included for structural interpretations.

269. Raymond, J.R. and Tillson, D.D., 1968, Evaluation of a thick basalt sequence in south-central Washington--geophysical and hydrological exploration of the Rattlesnake Hills deep stratigraphic test well: BNWL-776, Battelle, Pacific Northwest Laboratory, Seattle, Washington.

This report presents the data, findings, and interpretations of a detailed geophysical and hydrological exploratory study of the Rattlesnake Hills deep stratigraphic test well in south-central Washington.

270. Reichert, S.O. and Fenimore, J.W., 1964, Lithology and hydrology of radioactive waste-disposal sites, Savannah River Plant, South Carolina, in Engineering Geology Case Histories 1-5, Geological Society of America, p. 295-316.

This article discusses the techniques used to determine and map the lithology, structure, and hydrology of the areas chosen for radioactive waste disposal at the Savannah River Plant, South Carolina. Results obtained from using the techniques and conclusions regarding the radiological safety are also included.

271. Reichert, W.H., 1969, Compilation of geologic mapping in Washington through 1968: Open-file report prepared by the Washington State Department of Natural Resources, Division of Geology and Earth Sciences, Olympia, Washington.

This is an index to geologic maps for the State of Washington (through 1968).

272. Reidel, S.P., 1978a, Geology of the Saddle Mountains between Sentinel Gap and 119° 30' Longitude: RHO-BWI-LD-4, Rockwell Hanford Operations, Richland, Washington.

This report presents the results of a detailed study of the structure, stratigraphy, and geochemistry of the Saddle Mountains area.

273. Reidel, S.P., 1978b, The stratigraphy and petrogenesis of the Grande Ronde Basalt in the lower Salmon and adjacent Snake River Canyons: Ph.D. thesis, Washington State University, Pullman, Washington

This thesis deals primarily with the petrology, petrochemistry, and petrogenesis of Grande Ronde Basalt. Data on stratigraphy and flow correlations are prepared.

274. Richard, B.H. and Deju, R.A., 1977, Three-dimensional gravity investigation of the Hanford Site. RHO-BWI-C-5, Rockwell Hanford Operations, Richland, Washington.

This report presents the results of a gravity study conducted at the Hanford Site and provides mapped locations of anticlines and synclines in the area.

275. Richard, B.H., Lillie, J.T., and Deju, R.A., 1977, Gravity studies of the Hanford Reservation, Richland,

Washington: RHO-BWI-C-4, Rockwell Hanford
Operations, Richland, Washington.

In this report, the Cold Creek syncline is remapped to the west of a previously mapped location at the south end of the Hanford Site. The Umtanum anticline is mapped as being continuous to Richland. The Pasco syncline is not shown.

276. Rigby, J. and Tucker, G., 1978, Basalt (nuclear) waste isolation program: Washington State Department of Natural Resources, Division of Geology and Earth Resources, Washington Geologic Newsletter, v. 6, no. 2.

This article provides a brief summary of the projects being done for the U.S. Department of Energy's Basalt Nuclear Waste Isolation Program.

277. Rigg, G.B., 1958, Peat resources of Washington: State of Washington, State Department of Conservation, Division of Mines and Geology Bulletin No. 44.

This article discusses peat resources in Grant, Lincoln, and Spokane Counties, Washington that exist as deposits found in former scabland lake beds.

278. Ringe, D., 1970, Sub-loess basalt topography in the Palouse Hills, southeastern Washington: Geological Society of America Bulletin, v. 81, p. 3049-3060.

This article discusses the structural relief of sub-loess basalt in the Palouse Hills area of southeastern Washington.

279. Roberts, M., 1970, Bibliography of the geology and mineral resources of Oregon (fourth supplement): Oregon State Department of Geology and Mineral Industries Bulletin No. 67.

This bibliographical index of publications, theses, open-file reports, and unpublished materials focuses on the geology and mineral resources of Oregon for years 1956-1960.

280. Roberts, M.S., Steere, M.L., and Brookhyser, C.S., 1973, Bibliography of the geology and mineral resources of Oregon (fifth supplement): Oregon State Department of Geology and Mineral Resources Bulletin No. 78.

This bibliographical index of publications, theses, open-file reports focuses on the geology and mineral resources of Oregon for years 1961-1970.

281. Robinson, C.F., 1966, Stratigraphy and structural geology of Ahtanum Ridge, Yakima, Washington: M.S. thesis, University of Washington, Seattle, Washington.

This thesis discusses the stratigraphy and structure of the Ahtanum Ridge, which is on the western portion of the Columbia Plateau. General descriptions of units and structure and nomenclature of flows are included.

282. Robison, J.H., 1971, Hydrology of basalt aquifers in the Hermiston-Ordance area, Umatilla and Morrow Counties, Oregon: U.S. Geological Survey Atlas HA-387 (2 sheets).

Hydrological data on the basalt aquifers in the Hermiston-Ordinance area of Oregon are provided. Data on transmissivity, specific capacities and yields, and water quality are also included.

283. Rochlin, G.I., 1977, Nuclear waste disposal, two social criteria: Science, Jan. 7, 1977, v. 195, p. 23-29.

Rochlin points out that a zero defect repository is impossible, so decisions should be based on acceptable or defined risks. There is no guarantee that the repository could or would be repaired if it is breached in the future, so it should be in a geologically uninteresting area to minimize the likelihood of an accidental breach by future investigators. A second criterion would be honesty in our approach to locating a repository; all possible adverse impacts on future generations should be declared.

284. Rockwell Hanford Operations (R.A. Deju), 1977a, Summary of siting criteria for geological repositories of nuclear waste: Draft report, 5 p.

This paper provides criteria for the siting of nuclear waste repositories in geologic settings.

285. Rockwell Hanford Operations (Staff, Department of Waste Isolation), 1977b, The basalt storage program: RHO-SA-11, Richland, Washington, 34 p.

This report provides a general description of Rockwell's basalt storage program for radioactive wastes at Hanford.

286. Rockwell Hanford Operations (Staff, Basalt Waste Isolation Program), 1978, annual report--Fiscal year 1978: RHO-BWI-78-100, Richland, Washington.

This report summarizes the status of the basalt waste isolation program for fiscal year 1978.

287. Rogers, L.E. and Rickard, W.H., 1977, Ecology of the 200 Areas plateau waste management environs. A status report: PNL-2253, Battelle, Pacific Northwest Laboratory, Richland, Washington.

This report provides descriptions of the biological communities occurring in the 200 Areas of the Hanford Site. A partial bibliography (for years 1943-1977) of biological field studies on radioactivity in biota of the Hanford Site area is also included.

288. Rosenmeier, F.J., 1968, Stratigraphy and structure of the Table Mountain-Mission Peak area in the Wenatchee Mountains, central Washington: M.S. thesis, University of Washington, Seattle, Washington.

This thesis presents the results of modal analyses of an 85-square-mile study area located at the northwestern edge of the Columbia Plateau. Members of the Grande Ronde Basalt are named.

289. Ross, M.E., 1975, The structure of Yakima Basalts in a portion of the Grande Ronde River region of northeastern Oregon and southeastern Washington (abs.): Geological Society of America, Abstracts with Programs, v. 7, no. 5, p. 638-639.

Structural features of the Grande Ronde Basalt are discussed.

290. Rothe, G.H., 1978, Earthquake swarms in the Columbia River basalts: Addendum to Annual Technical Report 1968, Earthquake monitoring of the Hanford region: Ph.D. thesis, University of Washington, Seattle, Washington, 181 p.

This thesis discusses earthquake swarms in the Columbia River basalts and attempts to correlate earthquake activity with geologic structures in the area of Wooded Island.

291. Ryan, B.D., 1977, Fault studies in southern British Columbia.

Literature review, geologic mapping, and trenching were done on several faults in southern British Columbia to evaluate the age of fault movement as input to studies of the 1872 earthquake. Only two faults were considered to be active; Hell Creek and Jackson Mountain faults.

292. Ryan, M.P and Sammies, C.G., 1978, Cyclic fracture mechanisms in cooling basalt: Geological Society of America Bulletin, v. 89, p. 1295-1308.

This paper addresses the question of how hexagonal polyhedra are found and how vertical joints grow longer (crack tip deformation) in cooling basalts.

293. Sandia Laboratories, 1978, Environmental impact statement for the Waste Isolation Pilot Plant: Working draft for review.

This report addresses short- and long-term environmental impacts of operating a high-level radioactive waste repository at the WIPP site. Environmental considerations include health and safety, wildlife, land use, and pre-emption of resources.

294. Schlumberger Well Surveying Corporation, 1958, Well logs for Rattlesnake Hills Unit #1, Benton, Washington: Standard Oil Company of California: Reproduced by Rocky Mountain Well Log Service.

These well logs (gamma, neutron, S-P, resistivity) cover the interval from 600 to 10,600 feet depth in the Rattlesnake Hills.

295. Schlumberger Well Surveying Corporation, 1960, Well logs for Basalt Explorer #1, Lincoln, Washington: Development Associates: Reproduced by Rocky Mountain Well Log Service, Denver, Colorado.

These electric well logs (S-P, resistivity) are for the Explorer #1 boring in eastern Washington.

296. Schmincke, H.U., 1967, Stratigraphy and petrography of four Upper Yakima Basalt flows in south-central Washington: Geological Society of America Bulletin, v. 78, p. 1385-1422.

This article presents stratigraphic and petrographic data on the four upper flows (Umatilla, Pomona, Ward Gap, and Elephant Mountain) of the Saddle Mountains Basalt.

297. Schuster, J.E., 1973, Directory of Washington mining operations, 1971-1972: Washington State Department of Natural Resources Information Circular No. 48.

Directory of the State of Washington mining operations (years 1971-1972) covers metallic and non-metallic minerals and contains maps and information on mining company holdings and operations.

298. Science Applications, Inc., 1978, Hydrologic testing in borehole DC-2: RHO-BWI-C-36, for Rockwell Hanford Operations, Richland, Washington.

This is a summary report on packer (hydraulic conductivity) testing at Borehole DC-2 on the Hanford Site, as conducted by Science Applications, Inc. The data are used to evaluate flow systems and ground-water aquifers for radionuclide movement in the biosphere.

299. Seattle, Walla Walla and Portland Districts; U.S. Army Corps of Engineers, and State of Washington Department of Ecology, 1974, Flood-plain information reports and special flood hazards information reports for Washington State.

Annotated index to informational reports concerning locations and characteristics of floodplains in the State of Washington. Also contains an index map of flood control zones in the State of Washington.

300. Shannon & Wilson, Inc., 1973a, Regional geologic and seismic investigations, Boardman Nuclear Project: 0-618D, prepared for Portland General Electric Company, Portland, Oregon, 43 p.

This report presents the results of detailed fault and earthquake studies conducted for the Boardman Nuclear Project.

301. Shannon & Wilson, Inc., 1973b, Geologic studies of Columbia River basalt structures and age of deformation, The Dalles-Umatilla Region, Washington and Oregon, Boardman Nuclear Project: 0-618E, prepared for Portland General Electric Company, Portland, Oregon, 52 p.

This report contains information on faulting, folding, and volcanism in The Dalles-Umatilla region of Washington and Oregon. Information is presented on ages of deformation as determined from studies of past fault movement and stratigraphic relationships.

302. Shannon & Wilson, 1976, Volcanic hazard study potential for volcanic ashfall, Pebble Springs nuclear plant site, Gilliam County, Oregon: prepared for Portland General Electric Company, Portland, Oregon.

This report provides a summary of world-wide thickness, geochemistry, rates of accumulation, and physical properties of volcanic ashfall. Of particular importance are the data on cascade volcanoes, which show downwind ashfall thickness, grain size, water acidity, and dissolved solids content.

303. Shannon & Wilson, 1977a, Geologic studies in the 1872 earthquake epicenter region: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RD

This report presents results of literature review and detailed and reconnaissance-level geologic mapping to evaluate the geologic and tectonic conditions in the region of the 1872 earthquake and surrounding areas in the Cascades

304. Shannon & Wilson, 1977b, Geologic evaluations of structures in the Columbia Plateau: Washington Public Power Supply System, Ammendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RH.

The report presents the results of reconnaissance and detailed geologic mapping of stratigraphy and structure of Yakima Ridge structures in south-central Washington. These studies are used in evaluation of potential earthquake sources.

305. Shaw, H.R. and Swanson, D.A., 1969, Eruption and flow rates of flood basalts: Proceedings of the Second Columbia River Basalt Symposium, March 1969, Eastern Washington State College, Cheney, Washington, p. 271-299.

This report discusses basalt eruption, flow rates and gradients, and feeder dike characteristics of the flood basalts.

306. Sheppard, R.A., 1964, Geologic map of the Husum Quadrangle, Washington: U.S. Geological Survey Mineral Investigation Field Study Map MF-280.

This is a basic geologic map with cross sections of the Husum quadrangle.

307. Siems, B.A., 1973, Surface to subsurface correlation of Columbia River basalt using geophysical data in parts of Adams and Franklin Counties, Washington: Washington State University, College of Engineering, Bulletin 331, 63 p., Pullman, Washington.

Stratigraphic and geophysical data on the portion of the Columbia Plateau north of the Hanford Site are provided.

308. Siems, B.A., 1974, Stratigraphic identification and correlation of basalt aquifers using geophysical and chemical techniques: Washington State University, College of Engineering, Research Report No. 74/15-90, 33 p., Pullman, Washington.

This report presents the results of a preliminary study relating stratigraphic units to physical features through the use of geophysical logs and geochemical (MgO, TiO₂, K₂O percentages) techniques.

309. Siems, B.A. Bush, J.H., and Crosby, J.W., 1974, TiO₂ and geophysical logging criteria for Yakima Basalt correlation, Columbia Plateau: Geological Society of American Bulletin, v. 85, p. 1061-1068.

This article addresses geochemical methods of correlation for identifying basalt flow sequences from borehole data.

310. Siems, B.A., Crosby, J.W., and Anderson, J.V., 1974, Geophysical investigation of Washington's ground-water resources: Washington State Department of Ecology Technical Report No. 73-034, 45 p.

This report presents the results of a geophysical investigation of selected ground-water resources in the State of Washington.

311. Silar, J., 1969, Ground-water structures and ages in the eastern Columbia River Basin, Washington: Washington State University, College of Engineering Research Division, Bulletin 315, Project No. 141-01-11B-3998-2201, Pullman, Washington.

The hydrologic significance of ground-water structures in the eastern Columbia River Basin are discussed. Available data (through 1969) regarding age of water in shallow aquifers are summarized.

312. Skehan, J.W., 1965, The Olympic-Wallowa Lineament: A major deep-seated tectonic feature of the Pacific Northwest (abs.): EOS (American Geophysical Union Transactions) v. 46, no. 1, p. 71.

The Olympic-Wallowa Lineament is hypothesized to be a transition between the continental and oceanic crusts and may be a fault.

313. Slemmons, D.B., Carver, G. and Trexler, D.T., 1977, Remote sensing analysis of the 1872 earthquake epicentral region: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RG.

This study completes the remote sensing analysis in the 1872 earthquake epicentral region begun by Glass and Slemmons (1977). The purpose of study was to identify evidence for fault activity and search for

faults that may have had surface rupture from the earthquake.

314. Smith, W.D., 1947, Physical framework of the Pacific Northwest, in The Pacific Northwest: John Wiley & Sons, Inc., New York, p. 44-58.

This is a reference to the physiographic provinces of the Pacific Northwest.

315. Smith, R.B., Winkler, P.L., Anderson, J.G., and Scholz, C.H., 1974, Source mechanisms of microearthquakes associated with underground mines in eastern Utah: Bulletin of the Seismological Society of America, v. 64, no. 4, p. 1295-1317.

The relationship between earthquakes and coal mining, based on information obtained from a microseismic survey, is discussed. Data on the frequency of events and results of spectral analysis and source mechanism determination are presented.

316. Snively, P.D., MacLeod, N.S., and Wagner, H.C., 1973, Miocene tholeiitic basalts of coastal Oregon and Washington and their relations to coeval basalts of the Columbia Plateau: Geological Society of America Bulletin, v. 84, p. 387-424.

Three theories about the coeval and cosanguinous basalts of the Columbia River Plateau and coastal regions of Oregon and Washington are addressed. A considerable amount of chemical data and other information regarding the basalts are provided.

317. Staatz, M.H. and Morris, R.H., 1976, Resume of the regional geology of the Grand Coulee area, Washington: U.S. Geological Survey Open-File Report 76-782.

This report describes the structural geologic features of lower rock units of the Grand Coulee area.

318. Starr, W.A., Thompson, G.T., Jensen, M.C., and Butcher, W.R., 1971, Study A: Potential rate of development of irrigation in eastern Washington: Washington State Water Research Center, Washington State University and the University of Washington, Report No. 3A, 80 p.

This report presents a gross examination of the distribution of irrigable lands in eastern Washington and analyzes different methods of irrigation development.

319. Stevens, P.R., 1977, A review of the effects of earthquakes on underground mines, U.S. Geological Survey Open-File Report 77-313.

This report summarizes a literature search performed to assess subsurface damage from earthquakes. Mines in the epicentral region of large earthquakes can be damaged by transecting activated faults. Underground damage is generally less than aboveground damage from earthquakes.

320. Stone, W.A., Jenne, D.E., and Thorp, J.M., 1972, Climatography of the Hanford Area: BNWL-1605,

Battelle, Pacific Northwest Laboratory, Richland, Washington.

A wide variety of meteorological and climatological data on the Hanford Site is provided.

321. Summers, W.K. and Schawb, G.E., 1978, Bibliography of the geology and groundwater of the basalts of the Pasco Basin, Washington: RHO-BWI-C-15, W.K. Summers and Associates for Rockwell Hanford Operations, Richland, Washington.

This is an annotated bibliographic index to publications dealing with the geologic and hydrologic characteristics of the basalts in the Pasco Basin.

322. Summers, W.K. and Weber, P.A., 1978, Data for wells penetrating basalt in the Pasco Basin area, Washington: RHO-BWI-C-19, W.K. Summers and Associates for Rockwell Hanford Operations, Richland, Washington, 6 vol.

Hydrologic data, most of which are from driller's logs, are presented on the Pasco Basin.

323. Swanger, H.J. and Boore, D.M., 1978, Simulation of strong-motion displacements using surface-wave modal superposition: Bulletin of the Seismological Society of America, v. 88, no. 4, p. 907-922.

In this paper, a surface-wave modeling technique indicates that displacements of surface waves in sedimentary basins can be dominant for only a few focal depths. Both point sources and propagating sources are used in the analysis.

324. Swanson, D.A., 1967, Yakima Basalt of the Tieton River area, south-central Washington: Geological Society of America Bulletin, v. 78, p. 1077-1110.

This article discusses the geologic history, structure, stratigraphy, petrography, and hydrology of the northwest section of the Columbia Basin, Washington.

325. Swanson, D.A., 1969, Reconnaissance geologic map of the east half of the Bend quadrangle, Crook, Wheeler, Jefferson, Wasco, and Deschutes Counties, Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-568.

This detailed geologic map shows the structure and stratigraphy of areas in Oregon.

326. Swanson, D.A. and Wright, T.L., 1973, Extent, source, and structure of the Roza Member of the Yakima Basalt in southeast Washington (abs.): Geological Society of America, Abstracts with Programs, v. 5, no. 1, p. 113-114.

This abstract describes the location of source vents, flow thicknesses, and the number of flows of the Roza Member in southeastern Washington.

327. Swanson, D.A. and Wright, T.L., 1978, Some important facts and inferences concerning the Columbia River Basalt Group: Paper presented at Battelle Tectonics Symposium, February 14-16, 1978, Seattle, Washington.

The authors compare the different Columbia River basalt types in terms of formation, structure, and stratigraphy.

328. Swanson, D.A., Wright, T.L., and Helz, R.T., 1975, Linear vent systems and estimated rates of magma production and eruption for the Yakima Basalt of the Columbia Plateau: American Journal of Science, v. 275, p. 877-905.

This paper describes the north-northwest-trending vent systems and outcrops of Roza, Ice Harbor, Dodge and Uniontown flows.

329. Swanson, D.A., Wright, T.L., and Zietz, I., 1976, Geologic interpretation of an aeromagnetic map of the west-central Columbia Plateau, Washington and Oregon: U.S. Geological Survey Open-File Report No. 76-51.

This report contains an aeromagnetic map accompanied by interpretive discussions.

330. Swanson, D.A., Wright, T.L., Hooper, P.R., and Bentley, R.D., 1978, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geological Survey Bulletin 1457.

Revised stratigraphic nomenclature and descriptions of formations, members, and flows for the Columbia River Basalt Group are provided.

331. Swanson, D.A., Wright, T.L., Camp, V.E., Gardner, J.N., Helz, R.T., Price, S.A., and Ross, M.E., 1977, Geologic reconnaissance map of the Columbia River

Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geological Survey Open-File Report No. 77-100.

This map shows the extent of individual flows in the Grande Ronde, Wanapum, and Saddle Mountains Basalts, and folds and faults not previously mapped.

332. Sylvester, K.J., 1978, Geophysical investigations of the hydrogeology of the Goldendale-Centerville areas, Washington: M.S. thesis, College of Engineering, Washington State University, Pullman, Washington.

This thesis provides stratigraphic and hydrogeologic data for an area in the western portion of the Columbia Plateau. Locations of structural features and age of deformation are also provided.

333. Tabor, R.W., Waitt, R.B., Jr., Frizzell, V.A., Jr., Swanson, D.A., and Byerly, G.R., 1977, Preliminary map of the Wenatchee 1:100,000 quadrangle, Washington: U.S. Geological Survey Open File Map 77-531.

Compilation and correlation of mapping prepared by a variety of sources. The stratigraphy of basement units and Columbia River basalts of the Wenatchee area are described.

334. Tanaka, H. and Wildrick, L., 1978, Hydrologic bibliography of the Columbia River basalts in Washington: RHO-BWI-C-14, Washington State Department of Ecology for Rockwell Hanford Operations, Richland, Washington.

This bibliography contains some articles not included in other bibliographies. The majority of articles are from the late 1940, 1950, and 1960 decades. Very few articles are more recent than 1973.

335. T.A.P., Inc., 1974, Summary to the Idaho State airport system plan: Submitted to Idaho Department of Aeronautics, Boise, Idaho.

This document provides a summary of the Idaho airport system plan. Included are airport locations, airport categories, and projected airport usage.

336. Taubeneck, W.H., 1966, An evaluation of tectonic rotation in the Pacific Northwest: Journal of Geophysical Research, v. 71, no. 8, p. 113-212.

The Nevadan Orogeny and the Olympic-Wallowa Lineament as a non-hazardous tectonic feature are discussed. The Columbia River basalt feeder dikes in eastern Oregon and Washington are very well described.

337. Taylor, G.C., 1948, Ground water in the Quincy Basin, Wahluke Slope, and Pasco Slope subareas of the Columbia Basin Project, Washington. U.S. Geological Survey Open-File Report, 182 p.

This is a description of geologic units and groundwater aquifers, well logs, and spring data.

338. Tera Corporation, 1978, High-level waste repository site suitability criteria: Draft Environmental Impact Statement submitted to Lawrence Livermore Laboratory, Livermore, California.

This is an evaluation of environmental impacts associated with the issuance of prospective roles regarding the siting of nuclear waste repositories. It contains a discussion of alternative actions as well as an overall assessment of costs and benefits of the licensing procedure.

339. Thayer, T.P. and Brown, C.E., 1964, Pre-Tertiary orogenic and plutonic intrusive activity in central and northeastern Oregon: Geological Society of America Bulletin, v. 75, p. 1255-1262.

The pre-basalt tectonics in the Blue Mountains and the Mesozoic intrusives in northeast Oregon are discussed.

340. Thoms, R.E., Anderson, J.L., and Bentley, R.D., 1977, Geologic studies of the Saddle Mountains - Manastash Ridge and Umtanum Ridge structures: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RH, Chapter 80.

This report presents the results of geologic mapping to describe the structures of Saddle Mountains, Manastash Ridge, Umtanum Ridge, and Selah Butte. The results provide information on the geometry of the folds, extent of faulting, and age of deformation of the structures.

341. Tillson, D.D., 1970, Analysis of crustal changes in the Columbia Plateau area from contemporary triangulation and leveling measurements: Battelle, Pacific Northwest Laboratory, Richland, Washington.

This is an analysis of geodetic data on the Columbia Plateau as part of an effort to determine seismicity of the Hanford Site.

342. Tillson, D.D., Brown, D.J., and Raymond, J.R., 1969, River-water/ground-water relationships along a section of the Columbia River valley: ASCE Annual Meeting and National Meeting on Water Resources Engineering, New Orleans, Louisiana, February 3-7, 1969, Meeting Preprint 823.

Information on bank storage, ground-water levels, and areas influenced by changes in river water level in the Hanford Site area is provided along with hydrographs and a summary chart.

343. Tocher, D. and Patwardhan, A.S., 1975, Attenuation of peak acceleration in earthquakes (abs.): Geological Society of America, Abstracts with Programs, v. 7, no. 3, p. 426.

This paper presents compiled world-wide data on earthquake acceleration attenuation versus distance, and estimated peak acceleration versus distance.

344. Tucker, G.B., 1978, Compilation of columnar, cross, and type sections in the Columbia Basin and surrounding areas of Washington: Washington State Department of Natural Resources, Division of Geology and Earth Resources Open-File Report 78-3.

This is a tabular compilation of maps, cross sections, and references on geology, hydrology, and petrology of the Columbia Plateau in Washington.

345. Tucker, G.B. and Rigby, J.G., 1978, Bibliography of the geology of the Columbia Basin and surrounding areas of Washington with selected references to Columbia Basin geology of Idaho and Oregon: RHO-BWI-C-10, Washington State Department of Natural Resources, Division of Geology and Earth Resources for Rockwell Hanford Operations, Richland, Washington.

Published and unpublished references on the geology and geophysics of the Columbia Basin are contained in this extensive bibliography.

346. U.S. Army Corps of Engineers, 1975a, Report of the Chief Engineer on the national program of inspection of dams.

This listing of dams provides data on the dam height, reservoir capacity, and other specifications.

347. U.S. Army Corps of Engineers, 1975b, Washington Environmental Atlas, second edition: Document No. NTST 1105-1-1.

This atlas contains maps showing critical wildlife habitat in Washington State and descriptions of the types of habitats and species in each area.

348. U.S. Atomic Energy Commission, 1970, Hanford works boundary map. (EG-164-35).

This map is more recent than the USGS topographic maps and shows the location of State Highway 240 and changes in the Hanford Site boundary, as well as the locations and facilities on the Hanford Site.

349. U.S. Atomic Energy Commission, 1974a, Population density around nuclear power plant sites: Report T-160.

Rules and regulations regarding the population density around nuclear power plants are discussed.

350. U.S. Atomic Energy Commission, 1974b, Draft Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington: Report Wash-1538, v. 1.

This volume contains descriptions, charts, maps, and photographs of facilities at the Hanford Site, and discussion of the waste management operations, environmental impacts, and studies of the effects of radioactive wastes on local animal and plant populations. Descriptions of geology, hydrology, ecology, demography, seismicity, climate, and archaeological sites are included.

351. U.S. Atomic Energy Commission, 1974c, Draft environmental statement, waste management operations, Hanford Reservation, Richland, Washington: Report Wash-1538, v. 2, appendices.

These appendices contain data on Hanford Site facilities, demography and archaeology, geology, seismology, hydrology, meteorology, ecology, and environmental radiation doses.

352. U.S. Atomic Energy Commission, 1974d, Environmental statement related to construction and operation of Barnwell Nuclear Fuel Plant, Document No. 50-332.

This is an environmental statement for a nuclear fuel processing plant. Information on the radioactive releases from such a processing plant is provided.

353. U.S. Bureau of Reclamation, 1974, Geologic and seismic evaluation of Grand Coulee Dam and forebay, Columbia Basin Project, Washington: U.S. Bureau of Reclamation, Division of Design, Denver, Colorado, 77 p.

Information on geologic structure of the northern Columbia Plateau area and on the age of faulting are discussed. Maximum probable earthquakes and possible ground motions are estimated.

354. U.S. Committee, International Commission on Large Dams, 1958, 1963, 1968, World Register of Dams.

This listing of dams provides data such as dam height, reservoir capacity, and discharge rates.

355. U.S. Department of Agriculture, 1964, Soils of the western United States: A Joint Regional Publication by Agricultural Experiment Stations of Western States Land-Grant Universities and Colleges and by the Soil Conservation Service of U.S. Department of Agriculture, 69 p.

Soils, climate and vegetation, and possible land uses for the western United States are described.

356. U.S. Department of Commerce, Bureau of the Census, 1977, Population estimates and projections: Current Population Reports Series P-25, no. 660, 680, 695.

These reports contain demographic data for the States of Idaho, Oregon, and Washington for the years 1970, 1973, and 1975.

357. U.S. Department of Commerce, Bureau of the Census, 1978, Bibliography - Directory of Federal Statistics of Local Areas, Washington.

This is a bibliography of federal statistics on socioeconomic land uses and demographic impacts for Washington State.

358. U.S. Department of Commerce, 1979, Seattle sectional aeronautical chart: 1:500,000 scale.

All airports, low-altitude airways, navigational aids, controlled airspace, topography, and geography are depicted on this map covering the Columbia Plateau area.

359. U.S. Department of Defense, Mapping Agency, 1979a, Area planning AP/1B chart, military training routes, western routes: U.S. Defense Mapping Agency Aerospace Center, St. Louis, Missouri.

The map (scale of 1 inch = 30 nautical miles) shows military VFR and IFR training routes for the western U.S., including the Columbia River area.

360. U.S. Department of Defense, Mapping Agency, 1979b, Area planning training routes, North and South America: Department of Defense, Flight Information Publication AP/1B.

Flight information on military training routes in North and South America are presented.

361. U.S. Department of Energy, 1978a, Report of task force for review of nuclear waste management: Draft report, DOE/ER-0004/D, 165 p.

This is an assessment of current nuclear waste management programs, issues, and courses of action for formulating an administrative policy.

362. U.S. Department of Energy, 1978b, Environmental assessment - National Waste Terminal Storage Program - Near-Surface Test Facility, Hanford Reservation: Report DOE/EA-0052.

This is a compilation of test data obtained from conducting electrical heater tests and spent fuel tests for determining the suitability of basalt as a repository medium. The Near-Surface Test Facility at Gable Mountain is described.

363. U.S. Department of Energy, 1978c, Proposed format and content of license applications for deep geologic terminal repositories for radioactive material: Rockwell Hanford Operations, Richland, Washington.

This report provides basic guidelines for license applications for geologic radioactive waste repositories.

364. U.S. Department of Energy, 1978d, Environmental assessment--National Waste Terminal Storage Program (NWTSP)--Exploratory Borehole Drilling Program, wells

ARH-DC-4,-5,-6,-7,-8, DOE/EA-2048: ERDA document control no. EIA/WPR/77-3, Appendix of ARH-DC-2.

The drilling procedures used to obtain geologic and hydrologic data for assessing the environmental feasibility of a nuclear waste repository in the Columbia River basalt are provided.

365. U.S. Department of Energy, 1978e, Technical support for GEIS: Radioactive waste isolation in geologic formations; Volume 1 - Executive Summary: Prepared by Science Applications, Inc., Contract W-7405 eng 26, Report No. Y/OWI/TM-36/1.

This volume briefly presents the alternate repository preconceptual design studies that led to the generic repository designs, and the determination of resource requirements for repositories.

366. U.S. Department of Energy, 1978f, Commercial waste forms, packaging, and projections for preconceptual design studies: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 2. prepared by Science Applications, Inc., Report No. Y/OWI/TM-36/2.

This volume contains data bases for waste forms, packaging, and projections for commercial waste as defined by the Office of Waste Isolation and Battelle Pacific Northwest Laboratories.

367. U.S. Department of Energy, 1978g, Stratigraphies of salt, granite, shale, and basalt: Technical support for GEIS - Radioactive waste isolation in geologic

formations, v. 3. Prepared by Dames and Moore, Report No. Y/OWI/TM36/3.

This volume contains general stratigraphic information on salt, granite, shale, and basalt geologic formations for evaluating their suitability as repositories.

368. U.S. Department of Energy, 1978h, Baseline rock properties - granite: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 5. Prepared by Dames and Moore, Report No. Y/OWI/TM-36/5.

This volume discusses the geology, hydrology, and rock properties of granite as a possible medium for locating a radioactive waste repository.

369. U.S. Department of Energy, 1978i, Baseline rock properties - shale: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 6. Prepared by Dames and Moore, Report No. Y/OWI/TM-36/6.

This volume reviews the properties of shale and discusses in detail the shales from four different parts of the U.S. These four shales were considered to be most suitable as host rock for a nuclear waste repository.

370. U.S. Department of Energy, 1978j, Baseline rock properties - basalt: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 7. Prepared by Dames and Moore, Report No. Y/OWI/TM-36/7.

This volume discusses properties of basalt as a possible medium for the location of a nuclear waste repository.

371. U.S. Department of Energy, 1978k, Repository preconceptual design studies - salt: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 8. Prepared by Parsons, Brinckerhoff, Quade, and Douglas, Inc., Report No. Y/OWI/TM-36/8.

This volume presents a preconceptual design for a nuclear waste storage facility in salt.

372. U.S. Department of Energy, 1978-l, Repository preconceptual design studies - granite: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 10. Prepared by Parsons, Brinckerhoff, Quade, and Douglas, Inc., Report No. Y/OWI-/TM-36/10.

This volume presents a preconceptual design for a nuclear waste storage facility in granite.

373. U.S. Department of Energy, 1978m, Repository preconceptual design studies - shale: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 12. Prepared by Parsons, Brinckerhoff, Quade, and Douglas, Inc., Report No. Y/OWI/TM-36/12.

This volume presents a preconceptual design for a nuclear waste storage facility in shale.

374. U.S. Department of Energy, 1978n, Repository preconceptual design studies - BNPL waste forms in salt: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 16. Prepared by Parsons, Brinckerhoff, Quade, and Douglas, Inc., Report No. Y/OWI/TM-36/16.

This volume describes a preconceptual design for a nuclear waste storage facility in salt for various forms of radioactive waste.

375. U.S. Department of Energy, 1978o, Thermal analysis: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 19. Prepared by Science Applications, Inc., Report No. Y/OWI/TM-36/19.

This volume discusses the effects of thermo-nuclear waste heat generation on the waste matrix, the protective canisters, and the geologic formation.

376. U.S. Department of Energy, 1978p, Ground-water movement and nuclide transport: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 21. Prepared by Dames and Moore, Report No. Y/OWI/TM-36/21.

This volume discusses the effects of repository construction and consequent heat generation (thermal loading) on the movement of ground water in granite, shale, and basalt.

377. U.S. Department of Energy, 1978q, Nuclear considerations for repository design: Technical support for GEIS - radioactive waste isolation in geologic formations,

v. 22. Prepared by Science Applications, Inc., Report No. Y/OWI/TM-36/22.

This volume presents baseline design considerations, such as decay levels, characteristics of containers, shielding, and health and safety.

378. U.S. Department of Energy, 1978r, Environmental effluent analysis: Technical support for GEIS - radioactive waste isolation in geologic formations, v. 23. Prepared by Science Applications, Inc., Report No. Y/OWI/TM-36/23.

This volume discusses potential releases of radioactive and non-radioactive materials to the environment during construction, waste handling, and operational accidents.

379. U.S. Department of the Interior, 1972, The mineral industry of Washington: Bureau of Mines Minerals Yearbook.

This description of minerals in Washington State provides information on numerous sand, gravel, rock quarries, and diatomite, clay, and lime deposits on the Columbia Plateau.

380. U.S. Energy Research and Development Administration, 1976a, Evaluation and impact of potential flooding criteria on the Hanford Project: prepared by U.S. Energy Research and Development Administration, Richlands Operation Office, Richland, Washington.

A brief discussion prepared with a series of maps and data describes the historical, geographic, hydrographic, and programmatic relationships of hypothetical floods on the Columbia River, particularly as these floods would affect the Hanford Site.

381. U.S. Energy Research and Development Administration, 1976b, Alternatives for managing wastes from reactors and post-fission operations in the LWR fuel cycle, ERDA-76-43.

Alternatives are examined in considerable detail. Information on the ^3H and ^{85}Kr content of fuel assemblies after 5 years' decay is provided.

382. U.S. Environmental Protection Agency, 1977, EPA radiation protection programs; environmental radiation protection standards for nuclear power operations: Federal Register, v. 43, no. 195.

This document sets forth environmental radiation standards for nuclear power plant operations.

383. U.S. Environmental Protection Agency, 1978a, State hazardous waste programs; proposed guidelines: Federal Register, v. 43, no. 22.

These guidelines prescribe procedures by which states may apply for authorization and procedures by which such authorization may be withdrawn from hazardous waste management programs. This program is not for radioactive waste.

384. U.S. Environmental Protection Agency, 1978b, Criteria for radioactive wastes--Recommendations for federal radiation guidance: Federal Register, v. 43, no. 221.

These recommended criteria for federal radiation guidance include basic management principles and guidelines for development of generally applicable standards for radioactive waste sources.

385. U.S. Fish and Wildlife Service, 1965, Map of McNary National Wildlife Refuge.

This detailed map shows the location and boundaries of McNary National Wildlife Refuge.

386. U.S. Fish and Wildlife Service, 1974, Map of Columbia National Wildlife Refuge.

This detailed map shows location and boundaries of Columbia National Wildlife Refuge. Seven accompanying maps show land ownership within the Columbia National Wildlife Refuge.

387. U.S. Fish and Wildlife Service, 1976a, Map of Saddle Mountains National Wildlife Refuge.

This detailed map shows location and the boundaries of Saddle Mountains National Wildlife Refuge.

388. U.S. Fish and Wildlife Service, 1976b, Map of Turnbull National Wildlife Refuge.

This detailed map shows location and boundaries of Turnbull National Wildlife Refuge.

389. U.S. Fish and Wildlife Service, 1976c, National Fish Hatcheries and Wildlife Refuges - Washington.

This small-scale, schematic map shows general locations and boundaries of national wildlife refuges.

390. U.S. Fish and Wildlife Service, 1978a, National Fish Hatcheries and Wildlife Refuges - Idaho.

This map shows general locations of national wildlife refuges and hatcheries.

391. U.S. Fish and Wildlife Service, 1978b, National Fish Hatcheries and Wildlife Refuges - Oregon.

This is a general location reference map for national fish hatcheries and wildlife refuges in Oregon.

392. U.S. Forest Service, 1966, National Forests and National Grasslands - Region 1 Map.

This is a small-scale map showing general locations and boundaries of national forests and national grasslands.

393. U.S. Forest Service, 1976a, National Forest Wildernesses of the Pacific Northwest Region.

The small-scale and schematic format limits the usefulness of this map, which shows general locations of national forests and wilderness areas.

394. U.S. Forest Service, 1976b, National Forests of Region 6.

This map shows the locations and boundaries of national forests, national parks, national monuments, and national grasslands.

395. U.S. Forest Service, 1977a, Roadless and Undeveloped Area Evaluation II Map - Oregon.

Locations and boundaries are shown on a detailed map of the Rare II areas, new wilderness study areas, and national forests.

396. U.S. Forest Service, 1977b, Roadless and Undeveloped Area Evaluation II Map - Idaho.

Locations and boundaries for Rare II areas, new wilderness study areas, and national forests are shown.

397. U.S. Geological Survey, 1959 (revised 1963), Topographic Map of the Canyon City 1° x 2° Quadrangle: 1:250,000 scale.

This topographic map covers 44° to 45° latitude and 118° to 120° longitude.

398. U.S. Geological Survey, 1953 (revised 1971), Topographic Map of The Dalles: 1:250,000 scale.

This topographic map covers 45° to 46° latitude and 120° to 122° longitude.

399. U.S. Geological Survey, 1955 (revised 1963), Topographic Map of Grangeville: 1:250,000 scale.

This topographic map covers 45° to 46° latitude and 116° to 118° longitude.

400. U.S. Geological Survey, 1953 (revised 1964), Topographic Map of Pendleton: 1:250,000 scale.

This topographic map covers 45° to 46° latitude and 118° to 120° longitude.

401. U.S. Geological Survey, 1955 (revised 1963), Topographic Map of Pullman: 1:250,000 scale.

This topographic map covers 46° to 47° latitude and 116° to 118° longitude.

402. U.S. Geological Survey, 1955 (revised 1964), Topographic Map of Ritzville: 1:250,000 scale.

This topographic map covers 47° to 48° latitude and 118° to 120 longitude.

403. U.S. Geological Survey, 1953 (revised 1964), Topographic Map of Spokane: 1:250,000 scale.

This topographic map covers 47° to 48° latitude and 116° to 118° longitude.

404. U.S. Geological Survey, 1953 (revised 1963), Topographic Map of Walla Walla: 1:250,000 scale.

This topographic map covers 46° to 47° latitude and 118° to 120° longitude.

405. U.S. Geological Survey, 1957 (revised 1971), Topographic Map of Wenatchee: 1:250,000 scale.

This topographic map covers 47° to 48° latitude and 120° to 122° longitude.

406. U.S. Geological Survey, 1957 (revised 1971), Topographic Map of Yakima: 1:250,000 scale.

This topographic map covers 46° to 47° latitude and 120° to 122° longitude.

407. U.S. Geological Survey, 1951, Topographic Map of the Corral Canyon 15° Quadrangle: 1:62,500 scale.

408. U.S. Geological Survey, 1965, Topographic Map of the Coyote Rapids 15° Quadrangle: 1:62,500 scale.

409. U.S. Geological Survey, 1965, Topographic Map of the Eltopia 15° Quadrangle: 1:62,500 scale.

410. U.S. Geological Survey, 1965, Topographic Map of the Hanford 15° Quadrangle: 1:62,500 scale.

411. U.S. Geological Survey, 1965, Topographic Map of the Mesa 15° Quadrangle: 1:62,500 scale.

412. U.S. Geological Survey, 1965, Topographic Map of the Priest Rapids 15° Quadrangle: 1:62,500 scale.

413. U.S. Geological Survey, 1951, Topographic Map of the

Richland 15° Quadrangle: 1:62,500 scale.

414. U.S. Geological Survey, 1969, The geologic setting of the John Day country: USGS Informational Pamphlet 69-10 (R.-4).

The basic geology of the John Day and Monument, Oregon vicinity are presented with structural views showing faulting and folding. General description of rock units includes road logs of the area.

415. U.S. Geological Survey, 1972, Water resources investigations in Washington: Map A-30, Water Resources Division.

These maps, references, and hydrologic data include precipitation, runoff, and river discharge in the State of Washington.

416. U.S. Geological Survey, 1974, The Channeled Scablands of Eastern Washington: USGS Informational Pamphlet 72-2(R-1).

This pamphlet describes the Spokane flood and the formation of the Channeled Scablands in eastern Washington, including present drainage in areas of deep scour.

417. U.S. Nuclear Regulatory Commission, 1975a, Standard format and content of safety analysis reports for fuel reprocessing plants: USNRC Regulatory Guide 3.26, 110 p.

This report discusses the geography, hydrology,

meteorology, geology, and seismology in describing site characteristics for Safety Analysis Reports (SARs). This standard format and content are identified.

418. U.S. Nuclear Regulatory Commission, 1975b, Environmental statement related to operation of Davis-Besse Nuclear Power Station Unit 1, proposed by Toledo Edison Company: Office of Nuclear Reactor Regulation, Docket No. 50-346, NUREG-75/097.

This is a summary environmental impact statement presenting an evaluation and the NRC position on licensing of the Davis-Besse Nuclear Power Station Unit 1 of the Toledo Edison Company, Ohio.

419. U.S. Nuclear Regulatory Commission, 1976a, Preparation of environmental reports for nuclear power stations: Regulatory Guide 4.2, Revision 2, NUREG-0099.

This USNRC guide to the preparation of environmental reports for nuclear power stations delineates techniques and provides guidance on regulatory standards development.

420. U.S. Nuclear Regulatory Commission, 1976b, Rules and regulations; Part 20 - Standards for protection against radiation: Title 10, Chap. 1, Code of Federal Regulations - Energy, p. 20.1-20.18.

These rules and regulations cover the areas of permissible doses, precautionary procedures, waste disposal, notification requirements, and enforcement policies regarding health and safety aspects of radiation.

421. U.S. Nuclear Regulatory Commission, 1976c, Environmental survey of the reprocessing and waste management portions of the LWR fuel cycle. A task force report: National Technical Information Service Publication No. PB-258-316.

This is a preliminary, generic environmental discussion of waste management. Some of the various problems and possible means of finding solutions are discussed.

422. U.S. Nuclear Regulatory Commission, 1976d, Final generic environmental statement on the use of recycled plutonium in mixed oxide fuel in light water-cooled reactors (GESMO): NUREG-002.

This generic environmental statement includes a comprehensive treatment of many aspects of the nuclear fuel cycle. It contains estimates of annual releases from nuclear power reactors and the surface facilities associated with nuclear waste repositories.

423. U.S. Nuclear Regulatory Commission, 1977, Safety evaluation report, Pebble Springs Nuclear Plant Units 1 and 2: NUREG-0013, Supplement No. 3, Docket Nos. 50-514, 50-515, p. 2-1 to 2-3.

Section 2.5 of the Safety Evaluation Report Supplement provides for the Nuclear Regulatory Commission policy decision of the ashfall model to be used at Pebble Springs Nuclear Plant, near Arlington, Oregon, on the Columbia River.

424. U.S. Nuclear Regulatory Commission, 1978a, Workshops for state review of site suitability criteria for high-level radioactive waste repositories, analysis, and recommendations: NUREG-0354, v. 1.

This volume presents the views and recommendations of state officials regarding the preliminary site suitability criteria for high-level radioactive waste repositories.

425. U.S. Nuclear Regulatory Commission, 1978b, Rules and regulations--reactor site criteria: Title 10, Code of Federal Regulations, Energy, Part 100.

This description of reactor site criteria is used in evaluating the suitability of stationary reactor sites. Seismic and geologic criteria for nuclear power plants are provided.

426. U.S. Nuclear Regulatory Commission, 1978c, Licensing and regulatory policy and procedures for environmental protection: Title 10, Chapter 1, Code of Federal Regulations, Energy.

This code establishes the policy and procedures for processing environmental impact statements and related documents in connection with the NRC's licensing and regulatory activities.

427. U.S. Nuclear Regulatory Commission, 1978d, Storage of spent fuel in an independent spent fuel storage installation (ISFSI)--Proposed licensing requirements: Federal Register, v. 43, no. 195 10 CFR, Part 72.

These regulations specify procedures and requirements for issuance of licenses to store spent fuel in an independent spent fuel storage installation (ISFSI). Requirements for siting, general design criteria, and certain operational aspects of such an activity are presented.

428. U.S. Nuclear Regulatory Commission, 1978e, Workshops for state review of site suitability criteria for high-level radioactive waste repositories, analysis, and recommendations: NUREG-0354, v. 2.

A series of seminars on repositories was held with state and local government representatives to discuss the division of responsibility between federal and state agencies. The reactions of participants to various geologic, engineering, operational, and administrative problems were discussed. Comparisons were made concerning reactions in various geographic areas.

429. U.S. Nuclear Regulatory Commission, 1978, Licensing procedures for geologic repositories for high-level radioactive wastes: Federal Register, v. 43, no. 223, p. 53869-53872, plus addendum.

The responsibilities and interaction among various government bodies and repository operating agencies were proposed for discussion and comment. The general tone of the discussion indicated that the NRC would become involved in a decision-making/decision-approving capacity for any radioactive repository constructed or operated by or for the U.S. Department of Energy.

430. University of Washington, 1978, Earthquake monitoring of the Hanford region, eastern Washington: University of Washington, Geophysics Program, Annual Technical Report 1968, including Quarterly Technical Report 78-B.

This report lists seismograph stations and earthquakes recorded during the periods from January to June 1975 and April to June 1978. Theses by Sheng-Shang Bor and George Rothe are included.

431. Valentine, G.M., 1960a, Inventory of Washington Minerals, Part 1--Nonmetallic minerals: (Second Edition), State of Washington, Department of Conservation, Division of Mines and Geology, v. 1 - Text.

This report summarizes nonmetallic mineral resources and mining operations in the State of Washington, as of 1960.

432. Valentine, G.M., 1960b, Inventory of Washington Minerals, Part 1--Nonmetallic minerals: (Second Edition), Washington State Department of Conservation, Division of Mines and Geology, v. 2--Maps.

The economic minerals in the Columbia Plateau are clays, shales, minor coal, peat, diatomite, some common gemstones and fire opal, soda compounds, grinding pebbles, rock, sand, gravel, and poor-quality silica sand.

433. Vance, J.A., 1977, Fault studies in the North Cascades: Washington Public Power Supply System, Amendment 23,

WPPSS Nuclear Projects 1 and 4, Appendix 2RD, Chapter 50.

Studies concentrated on reconnaissance mapping of Straight Creek fault, Chiwaukum graben, Methow graben and the Ross Pan collapse zone. Conclusions are that the last major movement on the Straight Creek fault was in Oligocene time, that the Chiwaukum graben was active to Middle Miocene time and that the Methow graben was active to Late Cretaceous.

434. Vance, J.A., 1978, The Pre-Yakima basement of the Washington Cascades: Paper presented at Battelle Tectonics Symposium, Seattle, Washington, February 14-16, 1978.

The known events and deposits, pre-Columbia River basalt located northwest of the plateau, including pre-Miocene faulting, subduction, and volcanism, are summarized.

435. Van Denburgh, A.S. and Santos, J.F., 1965, Ground water in Washington: Its chemical and physical quality: Washington State Department of Conservation, Division of Water Resources, Water Supply Bulletin No. 24.

The chemical characteristics of Washington's ground water are described. Charts and maps are included.

436. Van Houten, F.B., 1961, Maps of Cenozoic depositional provinces, western United States: American Journal of Science, v. 259, p. 612-621.

This article gives general descriptions of

depositional basins at various times during the Cenozoic.

437. Von Neumann, J. and Morgenstern, O., 1947, Theory of Games and Economic Behavior: Princeton University Press, Princeton, New Jersey.

This is a textbook on game theory and its applications to economic behavior.

438. Wagner, N.S., 1954, Preliminary report on the geology of the southern half of Umatilla County, Oregon: The Ore-Bin, v. 16, no. 3, p. 13-17.

The pre-Tertiary basement of northeastern Oregon is discussed.

439. Wagner, N.S., 1955, Summary of Wallowa Mountains geology: The Ore-Bin, v. 17, no. 5, p. 31-35.

The pre-Tertiary basement of Wallowa Mountains is discussed. The Columbia River basalt in Minam Canyon has a maximum thickness of 3,000 to 4,000 feet.

440. Waite, D.A. and Newcomb, W.E., 1979, Integrated geological and environmental site-qualification criteria: Prepared by Battelle Memorial Institute, Columbus, Ohio, for the U.S. Department of Energy, Contract No. EY-76-C-06-1830.

This draft report was prepared to guide site qualification investigations until the Nuclear Regulatory Commission establishes its criteria for radioactive waste repositories. Siting criteria for

health/safety, environmental/socioeconomic, and engineering/economic considerations are listed and discussed.

441. Waitt, R.B., Jr., 1977, Guidebook to Quaternary geology of the Columbia, Wenatchee, Peshastin, and upper Yakima Valleys, west-central Washington: U.S. Geological Survey Open-File Report 77-753, 25 p.

Glacial deposits in the river valleys are discussed and a road guide is provided. Table of Quaternary deposits in this vicinity and their ages is presented.

442. Waitt, R.B., Jr., 1978, Post-Miocene stratigraphy and tectonism of parts of the Great Columbia Plain and adjacent Cascades, Washington: Paper presented at Battelle Tectonics Symposium, Seattle, Washington, February 14-16, 1978.

Post-Miocene tectonic and depositional events are summarized, beginning with a discussion of glacial, Ringold, and pre-Ringold structures. The development of present drainage with respect to rising structures is analyzed.

443. Waitt, R.B., Jr., 1979, Late Cenozoic deposits, land forms, stratigraphy, and tectonism in Kittitas Valley, Washington: U.S. Geological Survey Professional Paper No. 1127, 18 p.

This paper discusses the stratigraphy of the Columbia River basalt and the Quaternary deposits in the

Kittitas Valley. Evidence for recent tectonic deformation of this area is also presented.

444. Walker, G.W., 1973a, Contrasting compositions of the youngest Columbia River basalt flows in Union and Wallowa Counties, northeastern Oregon: Geological Society of America Bulletin, v. 84, p. 425-430.

A 900-meter-thick section correlative to the Wamapum and Saddle Mountains Basalts and Ellensburg Formation is described.

445. Walker, G.W., 1973b, Reconnaissance geologic map of the Pendleton Quadrangle, Oregon and Washington: U.S. Geological Survey Miscellaneous Geologic Investigation Map I-727, 1:150,000 scale.

This geologic reconnaissance map of the Pendleton Quadrangle also contains descriptions of mineral and water resources, geology, and engineering features of some lithologic units. There is a tectonic map insert.

446. Walker, G.W., 1973c, Preliminary tectonic map of Oregon east of the 121st meridian: U.S. Geological Survey Miscellaneous Field Studies Map MF-495, 1:500,000 scale.

This is a preliminary tectonic map of eastern Oregon.

447. Walker, G.W., 1977, Geologic map of Oregon east of the 121st meridian: U.S. Geological Survey Miscellaneous Investigations Map I-902, 1:500,000 scale.

This geologic map of eastern Oregon has separate tectonic and geomorphic map inserts.

448. Walker, G.W., 1974, Index to potassium-argon ages of Cenozoic volcanic rocks of Oregon: U.S. Geological Survey Miscellaneous Field Studies Map MF-569.

This is an index map showing locations and K-Ar ages of rhyolitic, intermediate, and basaltic Cenozoic volcanic domes, sills, and other intrusive bodies and some associated sediments.

449. Walters, K.L., 1972, Test-observation well near Almira, Washington: Description and preliminary results: U.S. Geological Survey Open-File Report, 20 p.

A test well in basalt approximately 10 miles south of Almira, Washington showed a specific capacity of 92 gpm per foot to a 546-foot depth and 96 gpm per foot to a 750-foot depth.

450. Walters, K.L. and Glancy, P.A., 1969, Reconnaissance of geology and ground-water occurrence in Whitman County, Washington: U.S. Geological Survey Water Supply Bulletin No. 26.

These geologic maps identify the Roza flow and gross areal geology. The regional dip is evident, but very little tectonic structure is shown.

451. Walters, K.L., Cline, D.R., and Luzier, J.E., 1972, Test-observation well near Odessa, Washington: Description and preliminary results: U.S. Geological Survey Open-File Report, 25 p.

Piezometer data from wells in seven individual aquifers are discussed.

452. Walters, K.L. and Grolier, M.J., 1960, Geology and ground-water resources of the Columbia Basin Project Area, Washington: State of Washington, Department of Conservation, Division of Water Resources, Water Supply Bulletin No. 8, v. 1.

This report consists of well records, driller's logs, and hydrographs, with brief descriptions of the Ringold Formation, Palouse Formation, and Columbia River basalt.

453. Warnic, C.C., Brockway, C.E., Doerkson, H.R., Gladwell, J.S., and Trihey, E.W., 1973, Regional problem analysis in the Pacific Northwest; Part B: Basalt groundwater aquifers: Washington State Water Research Center, Office of Water Research and Technology, Pullman, Washington.

Differences (confined versus unconfined) in the Columbia Plateau and Snake River Plain basalt aquifers are compared. The Snake River Plain is more permeable and of higher transmissivity.

454. Washington State Department of Natural Resources, 1973, Washington's Major Public Lands.

This is a map showing public land ownership in Washington State.

455. Washington State Department of Natural Resources, Geology and Earth Resources Division, 1969, Placer gold.

Placer gold has been found on sandbars along the Columbia and Snake Rivers.

456. Washington State Department of Parks and Recreation, 1977, Washington State Outdoor Recreation Guide: Northwest Experience, Moscow, Idaho.

This list of maps of Washington State Parks shows culturally important areas.

457. Washington Public Interest Research Group, 1978, Nuclear waste, a national waste repository at Hanford: Considerations for Washington State: University of Washington, Energy Research Group, Seattle, Washington, 50 p.

This study draws negative conclusions about the feasibility of safely transporting and disposing of nuclear wastes at the Hanford Site. Recommended actions included feasibility studies on basalt, various legislation for safety, and a moratorium on plant licensing. Costs for decommissioning and disposal of wastes should be included in power company cost estimates.

458. Washington Public Power Supply System, 1974, Preliminary safety analysis report, Amendment 9, for WPPSS Nuclear Projects No. 1 and 4.

This PSAR contains regional and site-specific geologic information for the Hanford Site area, includes detailed borehole logs, basalt flow correlations, geophysical investigations, and data on hydrology, seismicity, and meteorology.

459. Washington Public Power Supply System, 1977, Preliminary safety analysis report, Amendment 23, WPPSS Nuclear Project No. 1 and 4, v. 2A and 2B.

This amendment contains studies of local (Hanford Site area) and regional tectonics, the 1872 earthquake, remote sensing, structural geology, and microearthquake surveys.

460. Washington, State of, 1975, Water quality assessment report: Report 75-8, Washington State Department of Ecology, 2 volumes.

Volume 1 assesses present water quality and outlines the programs and goals of water quality management. Volume 2 contains maps (scale of 1:750,000) of Washington showing bacterial densities, water temperatures, turbidity levels, and dissolved oxygen. Classification and monitoring sites for all rivers in Washington are included.

461. Washington State Game Department, 1975, Columbia Basin recreation areas: Prepared in conjunction with the U.S. Bureau of Reclamation.

This pamphlet contains a schematic map showing wildlife recreation areas, national wildlife refuges, and state parks in the Columbia Basin region of eastern Washington.

462. Washington State Game Department, 1976, Wildlife recreation areas.

These maps, at various scales, show the boundaries of all the wildlife recreation areas in the State of Washington.

463. Washington State Game Department, (undated), Wildlife recreation areas.

This schematic map of wildlife recreation areas in the State of Washington provides short descriptions of each area, and includes Crab Creek, Priest Rapids, McNary, Rattlesnake Slope, and Wahluke Slope areas.

464. Washington State Highway Commission, 1973, Washington State Highways Road Map.

This is a highway map with a schematic format showing highways, national parks, and state parks.

465. Washington State University, 1972, Irrigation development potential and economic impacts related to water use for the Yakima River Basin: Report submitted to the Yakima Valley Natural Resources Development Association, Washington State University, Agricultural Research Center, Pullman, Washington.

Land use, soils, hydrology, and ecology of the Yakima River Basin are addressed in this report.

466. Waters, A.C., 1955, Volcanic rocks and the tectonic cycle: Geological Society of America Special Paper 62, p. 703-722.

This is a discussion of the petrogenesis of various types of volcanic rocks in the western U.S. With respect to the Columbia River basalt, the author

states that there was little or no differentiation of the magma and that flows erupted rapidly but with long periods of time between flows.

467. Waters, A.C., 1960a, Determining direction of flow in basalts: American Journal of Science, v. 258-A, p. 350-366.

Flow direction is determined by using columnar joints, spiracles, pipe vesicles and cylinders, and primary foreset bedding in palagonite.

468. Waters, A.C., 1960b, Two-fold division of the Columbia River basalt (abs.): Geological Society of America Bulletin, v. 71, p. 2082.

Petrographic and stratigraphic correlations were made on 28 stratigraphic sections of the Columbia River Basalt. The basalts are products of separate magmatic hearths and are not differentiates of a hypothetical uniform parent magma.

469. Waters, A.C., 1961a, Keechelus problem, Cascade Mountains, Washington: Northwest Science, v. 35, no. 2, p. 39-57.

The pre-Columbia River basalt geology near Mount Rainier is discussed. The Fife's Peak and Steven's Ridge Formations are differentiated.

470. Waters, A.C., 1961b, Stratigraphic and lithologic variations in the Columbia River basalt: American Journal of Science, v. 259, p. 583-611.

This article notes the distinct chemical differences between the Picture Gorge Basalt and the Yakima Basalt Subgroup. Tables and variation diagrams are included.

471. Waters, A.C., 1973, Problems of basalt correlation (abs.): Geological Society of America, Abstracts with Programs, v. 5, no. 1, p. 120.

An important correlation problem is the recognition of a sequence of flows in stratigraphic order. Especially helpful is Kuno's solidification index in petrography.

472. Watkins, N.D., 1964, Structural implications of paleomagnetism in Miocene lavas of northeastern Oregon, southeastern Washington, and west-central Idaho: Nature, v. 203, p. 830-832.

Inconclusive results show evidence of oroclinal rotation of Miocene lavas or crustal spreading during the Miocene.

473. Watkins, N.D., 1965, Paleomagnetism of the Columbia Plateaus: Journal of Geophysical Research, v. 70, no. 6, p. 1379-1406.

Evidence of tectonic rotation of the Columbia River basalts is shown to be compatible with the "orocline" hypothesis for the Pacific Northwest.

474. Watkins, N.D. and Baksi, A.K., 1974, Magnetostratigraphy and oroclinal folding of the Columbia River, Steens, and Owyhee Basalts in Oregon, Washington, and Idaho: American Journal of Science, v. 274, p. 148-189.

This review of previous literature on rotation contains considerable paleomagnetic work, charts, maps, and correlations with K/Ar dates.

475. Weis, P.L., 1968, Geologic map of the Greenacres Quadrangle, Washington and Idaho: U.S. Geological Survey Map GQ-734.

This geologic map depicts basic bedrock geology and describes information on the clay and glacial deposits and related features of the area.

476. Weis, P.L. and Richmond, G.M., 1965, Maximum extent of Late Pleistocene Cordilleran glaciation in northeastern Washington: U.S. Geological Survey Professional Paper 525-C, p. C126-C132.

Maximum southern ice extension is placed farther north than by previous authors.

477. Weissenborn, A.E., 1969, Geologic map of Washington: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-583.

This is a basic, large-scale geologic map of the State of Washington

478. Weston Geophysical Research, Inc., 1977a, Geophysical and seismological studies in the 1872 earthquake epicentral region: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RE.

This report presents results of a regional evaluation of seismic, gravity, and aeromagnetic data to determine

whether any correlation exists between data types with regard to trends or anomalies such as geophysical lineaments that could be associated with structures.

479. Weston Geophysical Research, Inc., 1977b, Geophysical evaluation of structures in the Columbia Plateau: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RL.

This report is of a geophysical study in which aeromagnetic and gravity data of the Rattlesnake Hills-Wallula-Saddle Mountains trend and the Chiwaukum graben were used. The results provide support data on the location and trend of subsurface structures.

480. Weston Geophysical Research, Inc., 1977c, Evaluation of microearthquake activity in eastern Washington: Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Project 1 and 4, Appendix 2RJ.

The report presents results and conclusions of an evaluation of microearthquake distribution in the Pasco Basin and eastern Washington. Microearthquakes appear to be of shallow focus and random, deeper focus. The shallow earthquakes appear as swarms and may reflect movement or shear planes and not through-going faults.

481. Wiggins, R.A., Frazier, G.A., Sweet, J., and Apsel, R.J., 1978, Simulations of earthquake ground motions: Proceedings, Seminar-Workshop on Strong Ground Motions, Rancho Santa Fe, New Mexico.

Computer codes have been developed to simulate ground motions near a strike-slip fault for frequencies in

the range of 1 to 20 Hz. This is useful for engineering design of response spectra for structures.

482. Williams, J.F., 1960(?), Well report--Basalt explorer, Number 1: Development Associates, Inc., Spokane, Wash.

The base of the Columbia River basalt near Odessa is about 4,300 feet below surface. Beneath it are 300 sediments named the "Irby shale" and "Odessa sand." Descriptions of rotary samples and cores are included. The well bottomed in granitic bedrock.

483. Withers, R., Turcotte, T., and Tocher, D., 1978, 1872 earthquake studies, Washington Public Power Supply System Nuclear Projects No. 1 and 4: Contract No. H.O. 52028, prepared by Woodward-Clyde Consultants for United Engineers and Construction, Inc.

Report presents results of microearthquake studies at six networks in central Washington. Studies concentrated on investigating microearthquake occurrences and regional stress orientation. The results provide understanding of regional tectonic stress fields which can be related to local and regional geologic structures.

484. Woodward-Clyde Consultants (San Francisco), 1975, Final Siting Report: Prepared for the Washington Public Power Supply System, Washington, v. 1 and 2.

This report summarizes an investigative approach and findings identifying and recommending sites suitable for nuclear or fossil fuel electric-generating stations in the Pacific Northwest.

485. Woodward-Clyde Consultants (San Francisco), 1976, Preliminary draft report of seismicity listing for the Pacific Northwest: Prepared for Washington Public Power Supply System.

This is a catalogue of earthquakes that have occurred between latitudes 44' and 54' north and longitude 110' and 128' west. Tables list earthquakes chronologically and by location.

486. Woodward-Clyde Consultants (San Francisco), 1977a, Draft report: Preliminary site selection factors for the NWTS program: Prepared for Union Carbide Corporation (Nuclear Division), under contract to U.S. Energy Research and Development Administration, 32 p.

Site selection factors, such as geologic events, repository-induced processes, impact of construction, and location are listed and described with reference to possible effects on a repository site.

487. Woodward-Clyde Consultants (San Francisco), 1977b, Preliminary geologic site selection factors for the NWTS program: Published report prepared for Union Carbide Corporation (Nuclear Division) under contract to the U.S. Energy Research and Development Administration, 59 p.

This report contains a description of geologic considerations pertinent to repository sites and a general approach to application and integration of the geologic factors in assessing the acceptability of candidate sites.

488. Woodward-Clyde Consultants (San Francisco), 1977c, 1872 earthquake studies: Microearthquake Study: Washington Public Power Supply System Nuclear Projects 1 and 4.

The microearthquake study presents the results obtained from a microseismic network in Washington. An evaluation of the data is included.

489. Woodward-Clyde Consultants (San Francisco), 1977d, Review of the North Cascade earthquake of 14 December 1872: Washington Public Power Supply System, Ammendment 23, WPPSS Nuclear Projects 1 and 4, Appendix 2RB.

This report discusses results of efforts to locate the epicentral region of the 1872 earthquake based on felt reports. The objective is to discuss factors which critically affect evaluation of the felt reports in terms of location of the epicenter, magnitude, and focal depth, and comparison of data to modern values of these parameters.

490. Woodward-Clyde Consultants (San Francisco), 1977e, Micro-earthquake survey and evaluation of stress orientation in central Washington. Washington Public Power Supply System, Amendment 23, WPPSS Nuclear Projects 1 and 4 Appendix 2RL.

This report presents the results of the evaluation of fault plane solution to determine principal tectonic stress axes of the Columbia Plateau. Microearthquake locations and network operations are also presented for networks from Ross Lake, Washington to Milton-Freewater, Oregon.

491. Woodward-Clyde Consultants (San Francisco), 1978a, 1872 earthquake studies: Straight Creek fault zone study: Washington Public Power Supply System Nuclear Projects No. 1 and 4.

The Straight Creek fault zone study presents maps and a detailed examination of Quaternary faulting along the Mesozoic Straight Creek fault zone in the northern Cascades, Washington.

492. Woodward-Clyde Consultants (San Francisco), 1978b, Evaluation of residual risk for earthquake risk management and mitigation by public and private organizations: Research proposal submitted to the National Science Foundation, Division of Problem-Focused Research Applications.

This report contains a program proposal for development and verification of methodology for the evaluation of residual risks from earthquakes.

493. Woodward-Clyde Consultants (San Francisco), 1978c, Culturally important areas composite data map: Woodward-Clyde Consultants working project file, WPPSS, 3D-1C.

This map shows locations and boundaries of culturally important areas of the Pacific Northwest, including wild and scenic rivers, wilderness areas, primitive areas, and scenic areas.

494. Woodward-Clyde Consultants (San Francisco), 1978d, Earthquake epicenter plot map of the Columbia Plateau area.

This map shows historical earthquake epicenters, both instrumentally recorded and located using Richter scale and non-instrumentally recorded earthquakes using the Modified-Mercalli scale.

495. Woodward-Clyde Consultants (San Francisco), 1978e, Annotated wild and scenic rivers under study data map: Woodward-Clyde Consultants working project file WPPSS, 3E-3a.

This map shows locations of wild and scenic rivers. The coverage is incomplete.

496. Woodward-Clyde Consultants (San Francisco), 1978f, Culturally important areas data and interpretive map(s): Woodward-Clyde Consultants working project file WPPSS, 3F-4, (1:250,000 scale).

These maps show locations and boundaries of state parks, state wild and scenic rivers, and federally designated culturally important areas (>5,000 acres) in the Pacific Northwest. Coverage of the study area is incomplete.

497. Woodward-Clyde Consultants (San Francisco), 1978g, Protected ecological areas data map(s): Woodward-Clyde Consultants working project file WPPSS, 3F-3, (1:250,000 scale).

These maps show locations and boundaries of national and state wildlife refuges and wildlife recreation areas. Coverage is incomplete and graphically schematic for some areas.

498. Woodward-Clyde Consultants (San Francisco), 1978h, Project quality assurance manual: Repository site selection study: Prepared for Rockwell Hanford Operations, Richland, Washington.

This document describes the project quality assurance program, including project organization, audit procedures, project documentation, and control and project procedures.

499. Woodward-Clyde Consultants (San Francisco), 1979, Siting study technical report: Candidate sites for coal-fired power plants: Prepared for Washington Public Power Supply System, Richland, Washington.

The subjects of this study are geology, hydrology, topography, demography, land use, ecologically important areas, culturally important areas, air quality, and potentially hazardous areas. This report presents the investigative approach and findings of a study conducted to identify candidate sites for coal-fired power plants in the Pacific Northwest. The report describes the methodology used in the screening process, and graphically portrays the results of applying various criteria to the study area. Specific data are not included.

500. Yates, R.G., Becraft, G.E., Campbell, A.B., and Pearson, R.C., 1966, Tectonic framework of northeastern Washington, northern Idaho, and northwestern Montana: Canadian Institute of Mining & Metallurgy Special, v. 8.

Rock types and provinces north of the Columbia Plateau are described. Several small-scale geologic maps are included.

APPENDIX B
KEY WORD INDEX

APPENDIX B
KEY WORD INDEX

The following key word index was developed to provide an additional access into the annotated references listed in Appendix A. The numbers under each key word or topic refer to the numerical listing of the annotated references in Appendix A. Thus, by referring to those numbered references under a particular key word of interest and then referring to Appendix A, one can locate the significant literature pertinent to the key word and also a summary of the article. The key words listed were developed from the literature screening forms used in the site identification study and, in general, reflect the data needs, concerns, and considerations of the study.

Bibliographies

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APPENDIX C
INDEX OF COMPILED DATA

APPENDIX C

INDEX OF COMPILED DATA

The following index of compiled data is a reproduction of the file index for use in the site identification study for the Hanford Site. It includes primarily data maps, compiled data maps, and screening overlays developed to date for the screening process in the Pasco Basin and Hanford Site.

4310 Geology

4311 Structure - compiled notes

4311.1 Structure overlays of regional
1:500,000-scale map

4311.5 Structure overlay of Hanford,
1:62,500-scale map

4313 Stratigraphy

4313.1 Stratigraphy notebook

4313.2 Grande Ronde Basalt notebook and
1:1,000,000-scale overlay showing
location of measured sections

4313.3 Subsurface data overlay of regional
1:500,000-scale map

4313.3.1 Hanford deep well logs,
compiled notes

4313.4 Quaternary stratigraphy, compiled
notes

4313.4.1 Regional Quaternary
stratigraphy overlay
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4313.4.2 Hanford Quaternary
stratigraphy 1:62,500-
scale overlay

4313.5 Surficial deposit thickness, compiled
notes

4313.5.1 Regional surficial deposit
thickness 1:500,000-scale
overlay

- 4313.6 Total basalt thickness, regional
1:600,000-scale overlay and compiled
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- 4313.7 Cross sections 1:250,000-scale and
compiled notes
- 4316 Geologic history - tectonics, pre-mid Miocene,
Columbia Plateau region set of overlays at
1:1,000,000-scale and compiled notes
- 4340 Environment
 - 4341 Demography and airports - compiled notes
 - 4341.1 Population data map, regional 1:500,000-
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 - 4341.2 Population data overlay, Hanford
1:62,500 scale
 - 4341.3 Airports data map, regional 1:500,000
scale
 - 4342 Biology/ecology - compiled notes
 - 4342.1 Protected ecological areas, regional
1:500,000-scale overlay
 - 4342.2 Protected ecological areas, Hanford
1,62,500-scale overlay
 - 4342.3 Culturally important areas, regional
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- 5510 Hanford area 1:250,000-scale base map and compiled notes
for selection of candidate areas
 - 5510.1 Generation of new faults and fault
rupture screen
 - 5510.2 Terrain ruggedness screen
 - 5510.3 Transportation screen
 - 5510.4 Aircraft impact screen
 - 5510.5 Operational radiation release screen
 - 5510.6 Protected ecological areas screen
 - 5510.9 Ground motion screen; compilation of
candidate area screens

- 5520 Hanford area 1:62,500-scale maps and compiled notes for screening of subareas
 - 5520.1 Priest Rapids 15' quadrangle
 - 5520.1.1 Flooding
 - 5520.1.2 Terrain
 - 5520.1.3 Erosion/denudation
 - 5520.1.4 Fault rupture
 - 5520.1.9 Compilation of subarea screens
 - 5520.2 Coyote Rapids 15' quadrangle
 - 5520.2.1 Hazardous facilities
 - 5520.2.2 Flooding
 - 5520.2.3 Terrain ruggedness
 - 5520.2.4 Fault rupture
 - 5520.2.9 Compilation of subarea screens
 - 5520.3 Hanford 15' quadrangle
 - 5520.3.1 Landslides
 - 5520.3.2 Flooding
 - 5520.3.3 Terrain ruggedness
 - 5520.3.4 Erosion/denudation
 - 5520.3.5 Fault rupture
 - 5520.3.9 Compilation of subarea screens
 - 5520.4 Mesa 15' quadrangle
 - 5520.4.1 Terrain ruggedness
 - 5520.4.2 Erosion/denudation
 - 5520.4.9 Compilation of subarea screens
 - 5520.5 Corral Canyon 15' quadrangle
 - 5520.5.9 Compilation of subarea screens
(on same sheet as base)
 - 5520.6 Richland 15' quadrangle
 - 5520.6.1 Hazardous facilities
 - 5520.6.2 Flooding
 - 5520.6.3 Terrain ruggedness
 - 5520.6.4 Erosion/denudation
 - 5520.6.5 Induced seismicity
 - 5520.6.9 Compilation of subarea screens

- 5520.7 Eltopia 15' quadrangle
 - 5520.7.1 Terrain ruggedness
 - 5520.7.2 Erosion/denudation
 - 5520.7.3 Induced seismicity
 - 5520.7.9 Compilation of subarea screens
- 5530 Hanford Site locality and candidate site identification
 - 5530.1 Overlays of topographic base map
(1:62,500 scale) showing site localities
on Hanford
 - 5530.2 Notes, forms, files, etc. used in
selection of site localities
 - 5530.3 Notes on ranges of conditions at site
localities
 - 5530.4 Overlays and cross sections depicting
ranges of conditions at site localities

APPENDIX D
SUPPLEMENTAL STUDIES

APPENDIX D

SUPPLEMENTAL STUDIES

Supplemental studies for developing information needed for the various tasks of the site locality identification study were undertaken when the existing available literature lacked the necessary specific data. These studies generally involved a review of the existing literature to extract the needed data. They also involved the development of assumptions and subsequent data analyses to reach conclusions to provide the specific information needed for use in the siting study. The following two examples of such special studies deal with an evaluation of operational radiation releases from a repository and a preliminary evaluation of earthquake ground motion in the subsurface.

D.1 EVALUATION OF OPERATIONAL RADIATION RELEASES

Safety-related radiological studies figure prominently in the licensing of all nuclear facilities. Accordingly, radiological considerations typically appear in methodologies for site identification studies that may lead to the selection and application for licensing of a nuclear facility. In the present case of a site identification study for a deep geologic repository for high-level radioactive wastes in basalt, an evaluation was conducted to estimate the nature and magnitude of operational radiation releases from a repository. The results of this study were applied to the development of guidelines for the identification of a candidate repository site.

D.1.1 Structuring the Problem

The objective of the radiological study was to develop a guideline for site identification that considered potential human exposure to operational releases of radiation from a repository. A comparable and analogous model for such guidelines is available from nuclear power plant identification studies. In these studies, a minimum distance from population concentrations is frequently used to limit the area under consideration for sites. Such population setback guidelines, while often applied as conservative "rules of thumb," are based on an anticipated amount of radiation release, an average atmospheric diffusion potential (to account for dispersion of releases), and on U.S. Nuclear Regulatory Commission (NRC) positions on acceptable radionuclide concentrations, population doses, and population densities around nuclear power reactors.

The phenomenon under study has several important features; a fixed source of radioactive emissions with a known emission rate operating over a known area and a knowable population density. Because these features are the same for reactors, repositories, and other nuclear facilities, an approach for developing a repository siting guideline modeled after reactor siting guidelines was selected.

The steps in the approach were:

- Estimate the maximum annual emissions expected from a repository during its operating phase

- Based on calculated diffusion of expected emissions, estimate the distance from a repository at which radionuclide concentrations would fall within established standards, both for environmental radiation and population dose
- Compare these results with NRC guidelines for population distribution around reactors (generally, a low population zone of about a 3-mile radius is acceptable)
- Select a conservative population setback distance for use in screening.

The greatest uncertainty in this approach occurs in the first step; estimating the operational releases at a repository site. At the time this evaluation was initiated, the size of the repository (its radioactive inventory), and the engineering characteristics of the repository were largely unknown; in addition, a spent fuel reprocessing facility is not considered in the site identification study.

The estimate of the emissions from a repository was based on assumptions regarding spent fuel pin and waste canister leakage rates applied to a total canister inventory estimate based on Rockwell Hanford Operations' preconceptual design adjusted for thermal loading considerations. The logic of this approach is shown schematically in Figure D-1. The method of computing the radioactive inventory of the repository was adapted conservatively from Generic Environmental Statement - Mixed Oxide (GESMO) (USNRC, 1976d) and USERDA (1976b). The estimate of radionuclide emissions from a reprocessing plant was taken from the environmental statement prepared for the Barnwell Reprocessing Plant in South Carolina (USAEC, 1974d). The analysis

FIGURE D-1

**APPROACH TO EVALUATION OF OPERATIONAL
RADIATION RELEASE FROM A REPOSITORY**

focused mainly on two gaseous radionuclides, ^{85}Kr and ^3H , iodine (^{129}I and ^{131}I) was also considered.

D.1.2 Results

Estimates of maximum annual release of radioactive effluents from a repository, a reprocessing plant, and a 1,000-megawatt electric power reactor are presented in Table D-1. The significant releases concern ^{85}Kr and ^3H . The expected releases of these radionuclides are two to three orders of magnitude greater for a repository than for a reactor. Dispersion calculations incorporating these values were performed for various dispersion scenarios, solving for the amount of release that would be necessary to yield the maximum permissible concentrations (MPC's) allowed by federal regulations. The results of these calculations are shown in Table D-2.

Under all dispersion scenarios examined, the expected release from the repository would be insufficient to yield concentrations in excess of the MPC's at a distance of 0.6 mile (1 km) from the point of release. If a 3-mile (5-km) population setback around a repository were applied (a distance typically used in reactor siting), the amount of radionuclides released would have to increase by several orders of magnitude before radionuclide concentrations at the site boundary could exceed the standards. Therefore, a 3-mile (5-km) setback is a conservative guideline for use in screening.

Table D-3 contains assumptions and calculations used to estimate releases from a repository. Table D-4 presents estimates of the inventory of two radionuclides (^{85}Kr and ^3H) during 25 years of repository operation. Table D-5 presents decay factors used in computing radioactivity in the

TABLE D-1

ANNUAL RELEASE OF SIGNIFICANT RADIONUCLIDES IN GASEOUS EFFLUENTS

CURIES/YEAR

Nuclide	1,000 MWe Reactor ^a	Repository ^b	Surface Facilities ^c	Reprocessing Plant ^d
³ H	43 - 1100	1.3 x 10 ⁴	Negligible	7 X 10 ⁵
¹⁴ C	8 - 9.5	-	-	1360 ^e
⁸⁵ Kr	290 - 470	5 X 10 ⁴ = 1.4 X 10 ⁵	Negligible	1.4 X 10 ⁷
⁸⁷ Kr	3 - 200	-	-	-
⁸⁸ Kr	23 - 240	-	-	-
³³ Xe	3200 - 12000	-	-	-
^{35m} Xe	1 - 740	-	-	-
³⁵ Xe	86 - 1100	-	-	-
³⁸ Xe	1 - 1400	-	-	-
²⁹ I	-	-	-	0.05
³¹ I	0.03 - 0.3	-	-	0.5
³³ I	0.02 - 1.1	-	-	-

- a) U.S. Nuclear Regulatory Commission, "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors (GESMO)", NUREG-002, 1976. Tables IV C-17 & IV C-19.
- b) Woodward-Clyde Estimates, conservatively based on GESMO; ERDA-76-43.
- c) GESMO, TABLE IV H-14.
- d) U.S. Atomic Energy Commission, "Environmental Statement Related to Construction and Operation of Barnwell Nuclear Fuel Plant," Docket No. 50-332, 1974.
- e) GESMO, TABLE IV E-8.

TABLE D-2

10 CFR 20 MAXIMUM PERMISSIBLE CONCENTRATIONS

	$\mu\text{Ci/ml}$			
Kr ⁸⁵	3×10^{-7}	$T^{1/2} = 10.76\text{y}$	$\beta - 0.67 \text{ } \mu\text{ev}$	$\gamma 0.514 (0.41\%)$
H ³	2×10^{-7}	$T^{1/2} = 12.26\text{y}$	$\beta - 0.0185 \text{ } \mu\text{ev}$	$\gamma \text{ none}$

If we take various χ/Q 's from Table IV J(A)-2 of GESMO, we can calculate releases that will equal 10 CFR 20 MPC's.

330 feet (100m) from ground-level release	(6.4E-5)	$1.48 \times 10^5 \text{ ci/yr}$
1000 feet (300m) " " " "	(1.4E-5)	$6.75 \times 10^5 \text{ ci/yr}$
1600 feet (500m) " " " "	(5.4E-6)	$1.75 \times 10^6 \text{ ci/yr}$
3300 feet (1000m)*" " " "	(1.5E-6)	$6.30 \times 10^6 \text{ ci/yr}$
3300 feet (1000m)*" 330 feet (100m) stack	(1.6E-8)	$5.63 \times 10^8 \text{ ci/yr}$

* This may be interpreted to say that a 0.6-mile (1-kilometer) setback will bring all expected releases from a repository within the MPC levels expressed in 10 CFR 20. A 3-mile (5-kilometer) setback typically applied to power reactors is, therefore, a guideline to use in screening.

TABLE D-3

RADIOACTIVE RELEASE CALCULATIONS

2010 Inventory X f1 f2 f3 f4 f5 = 2010 Release

f1 - fuel pins leaking = .1

f2 - fraction of radionuclide escaping cladding in year = .5

f3 - canisters leaking = .1

f4 - fraction of radionuclide escaping canister in year = .5

f5 - fraction of sealed boreholes leaking = .1

$$\begin{aligned} \text{2010 Release } (^{85}\text{K}) &= 5.5 \times 10^8 \times .1 \times 5 \times 10^{-1} \times .1 \\ &= 1.4 \times 10^5 \text{ Ci/yr} \end{aligned}$$

$$\begin{aligned} \text{2010 Release } (^3\text{H}) &= 5.0 \times 10^7 \times .1 \times 0.5 \times .1 \times 0.5 \times .1 \\ &= 1.3 \times 10^4 \text{ Ci/yr} \end{aligned}$$

TABLE D-4

 ^3H AND ^{85}Kr INVENTORIES IN A REPOSITORY

Based on number of assemblies and activity per assembly and 5-year delay to emplacement.

Time Interval	^3H		^{85}Kr	
	Ci	Ci (as of 2010)	Ci	Ci (as of 2010)
1985*	3.76E	9.0E5	4.3E7	8.1E6
1986	8.3E5	2.1E5	9.5E6	2.0E6
1987	9.4E5	2.5E5	1.1E7	2.5E6
1988	1.1E6	3.3E5	1.3E7	2.5E6
1989	1.3E6	4.1E5	1.5E7	3.9E6
1990	1.5E6	4.7E5	1.7E7	4.7E6
1991	1.6E6	5.6E5	1.9E7	5.5E6
1992	1.8E6	6.5E5	2.1E7	6.5E6
1993	2.0E6	7.5E5	2.3E7	7.6E6
1994	2.2E6	8.6E5	2.5E7	9.0E6
1995	2.3E6	1.0E6	2.7E7	1.0E7
1996	2.5E6	1.1E6	2.9E7	1.2E7
1997	2.7E6	1.3E6	3.1E7	1.3E7
1998	2.9E6	1.5E6	3.3E7	1.5E7
1999	3.1E6	1.7E6	3.6E7	1.7E7
2000	3.3E6	1.9E6	3.8E7	2.0E7
2001	3.6E6	2.2E6	4.2E7	2.3E7
2002	2.9E6	2.5E6	4.5E7	2.7E7
2003	4.2E6	2.8E6	4.8E7	3.1E7
2004	4.4E6	3.1E6	5.1E7	3.5E7
2005	4.7E6	3.5E6	5.4E7	3.9E7
2006	4.7E6	3.8E6	5.4E7	4.2E7
2007	4.7E6	3.9E6	5.4E7	4.5E7
2008	4.7E6	4.2E6	5.4E7	4.8E7
2009	4.7E6	4.5E6	5.4E7	5.1E7
2010**	5.9E6	5.9E6	6.8E7	6.8E7

TOTAL-5.0E7

TOTAL-5.5E8

* 1980 in Table 2.3 ERDA-76-43 (2010 - no leaks)

(2010 - no leaks)

** 2005 in Table 2.3 ERDA-76-43

Note: $3.7\text{E}6 = 3.7 \times 10^6$

TABLE D-5

DECAY FACTORS USED IN CALCULATING RADIONUCLIDE INVENTORIES

<u>Years From Emplacement</u>	Decay Factor	
	<u>^3H</u>	<u>^{85}Kr</u>
25	.24	.20
24	.26	.21
23	.27	.23
22	.29	.24
21	.31	.26
20	.32	.28
19	.34	.29
18	.36	.31
17	.38	.33
16	.40	.36
15	.43	.38
14	.45	.41
13	.48	.43
12	.51	.46
11	.54	.49
10	.57	.53
9	.60	.56
8	.64	.60
7	.67	.64
6	.71	.68
5	.75	.72
4	.80	.77
3	.84	.83
2	.89	.88
1	.95	.94

repository over time. Table D-6 presents the results of a check using dose calculations. This check was performed to verify that maximum releases from a repository would not exceed federal standards for whole body dose to the public in an annual period. The results show that operational releases from a repository would yield a whole body dose amounting to a small fraction of the federal standard.

D.1.3 Conclusions

Based on an evaluation of operational radiation releases from a repository, a population setback distance of three miles (five kilometers) was selected for use as a screening guideline in the repository site identification study. This value is conservative in terms of expected releases, and in terms of applicable federal standards.

D.2 LITERATURE SURVEY AND PRELIMINARY EVALUATION OF GROUND MOTION IN THE SUBSURFACE

D.2.1 Purpose

A literature search was performed in order to determine the available data from which to make a preliminary evaluation of the effects of vibratory ground motion on underground facilities. This evaluation complemented development of ground motion guidelines which were used in the screening process. The evaluation was based on the consideration of published literature in geology, rock mechanics, mining, engineering, and seismology.

D.2.2 Sources of Data

A preliminary survey of available in-house references was done as well as utilization of the GEOREF computer access technical

TABLE D-6

PRELIMINARY DOSE CALCULATION FOR ^{85}Kr FOR IMMERSION

GESMO IV J (A-9)

$$D = R \times \chi/Q \times D_C$$

D = Dosage

D_S = Dose to skin

D_{WB} = Dose to whole body from immersion

R = Release rate, Ci/sec

χ/Q = Atmospheric dispersion factor, sec/m³

D_C = Dose conversion factor, R/Ci + sec/m³

$$D_S = 1.4 \times 10^5 \frac{\text{Ci}}{\text{yr}} \times \frac{1}{3.15 \times 10^7} \frac{\text{yr}}{\text{sec}} \times 1.5 \times 10^{-6} \frac{\text{sec}}{\text{m}^3} \times 4.3 \times$$

$$10^{-2} \frac{\text{R-m}^3}{\text{Ci-sec}} = 2.9 \times 10^{-10} \text{ R/sec} = 2.9 \times 10^{-7} \text{ mR/sec} \times 3.15 \times$$

$$10^7 \text{ sec/yr} = 9.1 \text{ mR/yr}$$

$$D_{WB} = 5.1 \times 10^{-4} \frac{\text{R-m}^3}{\text{Ci-sec}} \times 1.4 \times 10^5 \frac{\text{Ci}}{\text{yr}} \times 10^3 \frac{\text{mR}}{\text{R}} \times 1.5 \times$$

$$10^{-6} \frac{\text{sec}}{\text{m}^3} = 0.1 \text{ mR/yr}$$

10 CFR 10 MPC

$$3 \times 10^{-7} \mu\text{Ci/ml} = 3 \times 10^{-7} \text{ Ci/m}^3$$

$$D_S = 4.3 \times 10^{-2} \frac{\text{R-m}^3}{\text{Ci-sec}} \times 3 \times 10^{-7} \frac{\text{ci}}{\text{m}^3} = 1.3 \times 10^{-8} \text{ R/sec} \times$$

$$10^3 \frac{\text{mR}}{\text{R}} \times 3.15 \times 10^7 \frac{\text{sec}}{\text{yr}} = 410 \text{ mR/yr}$$

$$D_{WB} = 5.1 \times 10^{-4} \frac{\text{R-m}^3}{\text{Ci-sec}} \times 3.0 \times 10^{-7} \frac{\text{Ci}}{\text{m}^3} \times 10^3 \frac{\text{mR}}{\text{R}} \times 3.5 \times 10^{-7}$$

$$\frac{\text{sec}}{\text{yr}} = 4.8 \text{ mP/yr}$$

information service for relevant sources. A total of approximately 50 pertinent references was located, many of which were contained in a special report to the U.S. Department of Energy by Pratt and Others, 1978, on earthquake damage to underground facilities. The references contained herein include secondary as well as primary references and are annotated in the project bibliography. The primary references will be discussed in the results and conclusions section.

D.2.3 Results and Conclusions

The most recent work on earthquake damage to underground facilities has consisted primarily of data compilations from world-wide studies on mine and tunnel damage due to earthquakes. Based on this preliminary literature survey, it was found that very little is presently being done by way of instrumentation of underground facilities for the express purpose of using recorded earthquake motion for developing seismic design specifications and criteria. The application of acoustic emission and microseismic recording techniques to underground workings such as rock and coal mines and underground gas storage facilities is discussed in a review article by Hardy (1977). A few studies have examined the problem of the recording and analysis of ground motions in mines from small earthquakes actually occurring in association with mining activities (Armstrong, 1969; Kaufman and Others, 1978; McGarr, 1971; Smith and Others, 1974; McGarr and Wiebols 1977). These studies have shown that ground motions associated with tremors in mines can be recorded and located, earthquake magnitude can be determined, local stress patterns can be obtained, spectral analysis of wave forms can be performed and regions of anomalous stress in the mine vicinity can be identified. In particular, McGarr and Others, 1978, have

obtained peak accelerations of as much as 1.2g from mine tremors for events of local magnitudes -1 to 2.6 and in the hypocentral distance range of 165 feet (50 meters) to 1 mile (1.6 kilometers). The recorded accelerograms typically have frequencies of several hundred hertz.

One of the most complete surveys of available data draws heavily upon ground motions recorded during nuclear explosions (Pratt and Others, 1978). The principal conclusions are given below:

- Little data exist of damage in the subsurface due to earthquakes. This in itself attests to the lessened effect of earthquakes in the subsurface, since mines exist in areas where strong earthquakes have done extensive damage to surface structures.
- More damage is reported in shallow, near-surface tunnels than in deep mines. Data are sparse for mines deeper than 1,600 feet (500 meters).
- In mines and tunnels, large displacements occur primarily along pre-existing faults and fractures or at the surface entrance to these facilities.
- Data indicate vertical structures such as wells and shafts are also not as susceptible to damage as are surface facilities. Even in the Alaska earthquake of 1964 ($M_s = 8.5$), few wells were damaged in Anchorage except those sheared by landslides.
- Data were insufficient to assess the exact influence of rock type on damage; however, the effects are less in well-consolidated materials than in alluvium. Stevens (1977) has compiled data principally from the

United States and covering earthquakes occurring during pre-instrumental time. He suggests also that the severity of ground motion in a mine located in competent rock is less than one located in less competent, weathered, or unconsolidated rock. Little data are available to strictly test this hypothesis. Geologic structures, such as faults, appear to be a dominant factor in damage to underground facilities.

- Frequencies most likely to cause damage to subsurface facilities are significantly higher (50 to 100 hz) than the frequencies (2 to 10 hz) that cause damage to surface facilities.
- Acceleration, velocity, and displacement data from nuclear explosions may give near-source upperbound limits for large earthquake ground motion when a facility is very near the epicenter.
- More analysis is required before seismic criteria can be formulated for siting of nuclear waste repositories.

One of the shortcomings of comparing earthquake vibratory ground motion with nuclear explosions of the same magnitudes is that there is a richness of longer period surface waves in earthquake ground motion (Pratt and Others, 1978). In their work, Pratt and Others (1978) do not suggest how the empirical data from nuclear explosion measurements (surface and subsurface) may be scaled to simulate earthquake ground motions. They do suggest, however, that near-source ground motion in the subsurface from explosions may provide limits on ground motion to be expected to earthquakes. On the other hand, analytical techniques, such as Boore (1977) and Swanger and Boore (1978),

are available that handle surface-wave generation from nuclear explosions. Other more general, complicated, and computationally expensive techniques (Wiggins and Others, 1978) are available which allow the inclusion of body waves, surface waves, and geologic layering in models to simulate earthquake ground motion at various distances and depths.

Brekke and Glass (1973) have examined geologic and seismologic factors involved in siting nuclear power plants under ground. With respect to earthquake damage to underground facilities, they only considered empirical results from Japanese studies on mines and tunnels (Kanai and Others, 1959; 1966). It was found that Brekke and Glass (1973) identified the need to have more analytical studies done that would provide insights as to the effects of cavity resonance, wave dispersion, frequency of incoming ground motion, and the response of single and multiple underground openings to seismic waves.

Although the data bases were different, and frequently there was no detailed information on subsurface geologic conditions, the references reviewed indicated that subsurface vibratory ground motions were less at depth in tunnels, mines, and wells than at the surface. The principal damage in subsurface facilities was attributed to displacement during earthquakes along faults that transected the facilities.

This literature review has revealed an inadequate research base for the purpose of specifying seismic design criteria or for the assessment of seismic risk.